A R C O M

ASSOCIATION OF RESEARCHERS IN **CONSTRUCTION MANAGEMENT**

TWENTY-NINTH ANNUAL CONFERENCE **2013** September 2-4

Reading

Volume 1

Association of Researchers in Construction Management (ARCOM)

Proceedings of the 29th Annual Conference

Edited by Simon D Smith and Dominic D Ahiaga-Dagbui

First published 2013

ISBN: 978-0-9552390-7-6 (2 Vols.)

Published by
ARCOM, Association of Researchers in Construction Management
c/o School of Construction Management and Engineering
University of Reading
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Reading
RG6 6AW, UK

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FOREWORD

Welcome to Reading for the 29th edition of the Association of Researchers in Construction Management's annual conference. After our very successful event in Edinburgh, Scotland in 2012 we return to England and to Reading for the second time in ARCOM's history. In 1998, ARCOM held its 14th conference at the University of Reading and now, 15 years later, we return.

The conference initially attracted a very high amount of interest, possibly the largest ever, with more than 350 abstracts submitted. But we are fortunate at ARCOM that we are able to focus on research quality and, after an intensive three-stage review process over approximately five months the Scientific Committee determined that 126 papers were finally acceptable for inclusion in these conference proceedings.

I have made a big point about 'quality' over the last 18 months in my time as both conference editor and ARCOM chair. ARCOM has matured over 29 years and we are able to shift our attention not just from supporting and showcasing the very wide range of research that is undertaken in the development, delivery and maintenance of the built environment but now to promote excellence in the design, execution and reporting of research. I should emphasise the word 'research'. Not only is it a key part of this organisation's name but it is something that ARCOM above all else wants to promote. This means that every paper in the proceedings should be the result of work that has attempted to increase our understanding and knowledge through a process of rigourous and systematic investigation.

Of course the type of work that constitutes systematic and rigorous investigation comes in many different forms. This to me is what makes the research on our field so exciting and vibrant – we are the product of a vast range of disciplines, of methods and methodologies and of problems and applications. The result is that the proceedings you hold contain papers on very empirical and positivist numerical simulations that rub shoulders with works of a much more interpretive and constructivist nature. This ontological and epistemological diversity is something that is rarely seen in other fields.

And as we turn to the venue for this year's conference we can reflect on how this diversity has matured and changed in the fifteen years since our last outing in Reading. I have just picked up the proceedings from 1998, edited and prepared by Professor Will Hughes, and am struck by the quite clear shift from a predominance of numerical and objective work in 1998 to more interpretive and discursive nature in 2013. Both types of work are in evidence at each end of these fifteen years but the balance has changed. It is interesting to note, however, that some of the same subjects of investigation have remained. We see works on procurement processes, on innovation and on decision-making in the design process. We see such general areas of Information Management, Procurement and Risk remain. But of course we also now see the new or more highly developed subjects of Sustainability, Health and Safety and Building Information Modelling, subjects that were simply not conceived or were not the focus of attention. Perhaps most satisfiying though, as I look at the Table of Contents from the 14th conference, is that many of the authors from then are also authors today. Some names are very familiar to us and some have shifted from 'first-author' to second or third, which of course in our field

implies they have moved from PhD student to Supervisor. And, to conclude, this is perhaps the most lasting legacy of ARCOM, that it is an arena for support and development, for sustained progress and tenacity of investigation, and maintains a core of enthusiastic and highly motivated people that should ensure that in 2028, at ARCOM's 44th Annual Conference, similar reflective observations will be made.

I shall plagiarise myself from 2012: go forward and enjoy. Engage in debate, make new friends, renew old acquaintances, advance and further our field and have a good time doing so!

Dr Simon D Smith and Dominic D Ahiaga-Dagbui, University of Edinburgh, UK
ARCOM 2013 Conference Editors

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BUILDING INFORMATION MODELLING

SUPPORTING FUTURE-PROOF HEALTHCARE DESIGN BY NARROWING THE DESIGN SPACE OF SOLUTIONS USING BUILDING INFORMATION MODELLING

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BIM has been characterized by the UK Government's chief construction adviser as unstoppable regarding its rise in construction and he further positioned BIM as mandatory for public projects in the UK by 2016. Moreover, large scale public projects such as healthcare facilities must be seen as a process, being able to meet the constantly changing demands imposed on healthcare infrastructure. Facilities should be designed as change-ready rather than to meet fixed requirements, therefore, the designer should accommodate as large section of design space potential solutions instead of mistakenly narrowing the response of the project to only one solution. Scenario based design was employed as research and design method for the proposed software modules which would extend the Activity Database (ADB). Two modules are proposed that will enable designers to improve their spatial design decisions for both new and refurbishment projects through partially automated knowledge extraction. Additionally, the integration of flexibility and standardisation concepts has been addressed. The proposed design approach is intended to provide rich knowledge representation at the early stages of the design process in less time and effort.

Keywords: decision theory, healthcare, information extraction, information technology, standardisation.

INTRODUCTION

The UK Government and industry provides standards and guidance for the design and construction process of healthcare facilities in order for the design process to address the needs of all the stakeholders (patients, medical staff, owners etc.) by defining procurement methods (NHS 2011), construction strategies (Cabinet Office 2011), overlay plans of work (RIBA 2012), and technologies to be used (CIMCIG Admin 2012). These result in more standardised processes and products. Additionally, programmatic requirements and best practice for the design of healthcare facilities are provided through Health Building Notes (HBN), Health Technical Memoranda (HTM), Activity Database (ADB) and in the DH Schedule of Accommodation. Additionally, the Department of Health commissioned the Procure21+ framework "to improve the procurement process for publicly funded schemes and create an

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Krystallis I, Demian P and Price ADF (2013) Supporting future-proof healthcare design by narrowing the design space of solutions using building information modelling *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 3-12.

environment where more value could be realised from collaboration between NHS Client and Construction Supply Chains" (NHS 2011).

In cognitive science, parallels have been frequently drawn between design and playing chess. Conceptual design has long being recognised as an ill-defined process (Reitman 1964, Simon 1974). An early design problem does not have a clear statement, the constraints are not clearly defined but fairly general objectives are set which leaves the designer with large choice of solutions representing a chess-like design approach which "is rather like playing with a board that has no divisions into cells, has pieces that can be invented and redefined as the game proceeds and rules that can change their effects as moves are made" (Lawson 2004: 20).

Global austerity measures are causing reduction of investments in all sectors, and the construction sector is no exception, however, owners are seeking other ways to overcome the financial crisis by investing in the application of the sustainability agenda; and for a building to be sustainable designers recognise that it has to also be flexible and adaptable (Krygiel and Nies, 2008). Yet, introducing sufficient flexibility to future-proof the design of healthcare facilities is still a rather abstract process. While a specialized (mostly architectural) body of research has identified various types of flexibility that a facility can satisfy, there is little research regarding how this can be captured in the design process through design standardisation.

Design standardisation can help to make flexibility quantifiable. With BIM technology there is potential to increase the procedural designer's knowledge to manage, apply, edit and test "chunks" of design information; rather than manipulate meaningless lines as one used to do in using previous CAD systems. The proposed design methodology is focused on two design aspects: to allow the user to test, during the conceptual stage, "what if scenarios" for future refurbishment in order to better future-proof the project; and to allow an automated comparative analysis to take place in existing refurbishment projects between an existing space and proposed alternatives in terms of cost, timescale duration and best matching attributes. Adoption of the proposed design methodology will allow parts of conceptual design to be standardised and automated in terms of narrowing the design space of solutions while better exploiting the power of IT. Eventually, this will allow testing more "what if scenarios" in significantly less time and with less effort. In this paper the theory underpinning the proposed design methodology is described whereas in the next phase this concept will be tested in various case studies.

Literature Review

Theories in Layout Planning

Different cognitive processes may be used to generate spatial layouts. Eastman (2001) described two extremes for design generation. The first extreme is external representation, where the design is composed and refined by the designer by controlling the symbols and structure of it. The other extreme is internal representation, where the designer builds up the design in his/her head until it satisfies the set criteria and then proceeds to the external representation. Recent advances in research seek to understand how the design process unfolds, and the role of computer systems in that process. This often leads to the design of human-computer interaction. Two paradigms describe two different worldviews: the computer-supporting-human paradigm and the computer-controlling-human paradigm. The latter, often referred to as emulating design (Cross 1999) can be compared to the computational process that

chess-playing machines adopt. Efforts to adopt such a process failed in the history of design cognition. The example below can best describe such efforts.

In the mid-90s, a project "Can a machine make aesthetic judgments?" (Glaze et al. 1996) aimed to establish rules of aesthetically "bad" design since the research team concluded it was not possible to establish rules of aesthetically "good" design. The researchers collected amateur designs and submitted them to expert graphic designers to critique them. The team subsequently converted the comments on the "bad" design features into "rules", and later the team tested these rules by using themselves as "human-computers" (i.e. the team followed the instructions in a machine-like way). Finally, the team applied the rules to a new sample of drawings and compared the "machine" results with those of the human experts' critiques of the new drawings. The interesting point was that only a small number of rules could be applied to the new sample in order to eliminate common "bad" design features. What was even more interesting was that even the experts were found to be inconsistent in applying their own rules. The explanation given by the expert designers was that though the "rules" were correct, their applicability was not a standard in every case.

This experiment presents the notion that there are some things such as "aesthetic judgments" (or for the purpose of this study "flexibility judgements") in design where the "human attribute" cannot be emulated by the computer to a satisfactory degree. Consequently, there is a need to understand why people design first rather than try to automate how they design (Cross 2001). The first paradigm, often referred to as supporting design, accepts the computer to be the agent where, instead of controlling the design process it supports the thinking of designers by providing different capabilities, such as being web-based, learning and/or being pro-active (Lawson 2005) and that envision brings BIM into discussion.

Parametric Object-based Modelling

IT and specifically design computing has increased users' expectations. Parametric Object Modelling (POM) is linked to creativity in architectural practice and as the results of the survey by Ahmad et al. (2012) suggest, POM has the potential to enhance the whole process of design decision making and problem solving. POM engines use parameters to determine the behaviour of a graphical entity (the object) and define relationships between other modelling objects.

Object CAD technology may provide the same graphical and geometrical representation output as a parametric building modeler; but that does not mean that the information of the CAD model will be as rich as in the BIM model. "Current file-based CAD and object CAD tools may be used to some degree to support BIM, but require myriad supporting technologies and the aggregation of information across diverse, independent applications" (Autodesk white paper 2007:5). As a consequence, CAD and Object CAD technology cannot offer real time coordination (simultaneously updating a change in all views of the model) when a change in the design occurs and as a result integrity and confidence in decision making are put to question (Autodesk white paper 2007). POM offers a whole new approach to design, beyond CAD and Object CAD. For example, instead of capturing a wall by a set of lines using standard tasks such as offset, mirror etc., the designer can create an object by choosing it from a predefined library of object classes and instantiating that object. This parametric design paradigm has led to the creation of a library whereby whole healthcare rooms can be inserted into a design model, with their objects attributes, engineering

requirements and clinical functions through the Activity Database's (ADB) add-on for BIM platforms.

The ADB add-on for BIM platforms

The ADB toolkit (first introduced in 1970s by the Department of Health (DH), the Social Services and in collaboration with the Regional Hospital Boards) contains information intended for use by healthcare estates and facilities professionals. The database comprises information regarding departments, rooms, assemblies and components and can be used in both the initial stages of the project, as well as in later stages (detailed design). Through ADB, the DH provides design standards that satisfy the department's requirements. The ADB add-on for BIM software allows the designer working in a CAD or BIM environment to insert a room with all its components directly in the layout. There is a list of all departments and all room types. It allows the designer to check the BIM model against the ADB Project Database. This automatically checks the room's equipment and if there are any mismatches the software will highlight them on the layout. Additionally, the designer can create schedules out of the layout in terms of room schedule or in terms of room equipment. Additionally, the existing ADB information architecture represents all rooms using a clear and precise set of attributes (ADB add-on white paper 2012).

During design, the designer can manipulate data of more than 1200 room variations – a vast amount of information to be managed, the add-on does not offer a method that will limit the design space of solutions within the BIM system. The designer is expected to exploit processes outside the BIM environment, such as retrieve information from previous projects, or to rely on his/her previous design experience or other design precedents (Lawson 2004) to identify possible solutions. This research offers insight to narrow the design space of information management where the system offers partially design knowledge according to the designer's preferences.

METHODOLOGY

Two modules are proposed to extend the ADB add-on that will enhance the information extraction experience within BIM. Scenario based design (SBD) was employed as method to develop the proposed modules. The modules extend the ADB add-on by: organising attributes of rooms and components into categories and subcategories, and sorting solution spaces based on the cost of applied changes or by the time they need to be fulfilled or by the number of attributes/filters that are satisfied. The two modules are described on the following sections. Due to limited space, only one refurbishment problem scenario is presented here. Problem scenarios referring to "what if scenarios" for testing future refurbishments during conceptual design are not discussed in this paper. Problem scenarios are the means to describe a user's engagement and her interaction with the system and "a key result of requirement analysis" (Rosson and Carroll 2002: 12).

Problem Scenario: The healthcare estates manager and the owner of "Town A Hospital" want to change a clinic's utilities room because it is of no use to the staff. They first open the BIM model to check whether the design team that built the facility some years ago included in the study any alternative scenario for the space in question but they do not find such information. They want to substitute the existing space with another space but they do not know what the best options for that particular space are, so they communicate with company X that has established its name in the field of healthcare design. Alex, who works for company X, receives an email with the BIM

model of the healthcare facility for which an alternative layout was requested. She opens the BIM model and wonders about the choices she has to change the space in question to another space. She refers to the ADB room database but she gets stuck as there are more than 1200 room variabilities that she needs to check against the existing space. She then goes to Bob, the senior designer and asks him based on his experience working on previous healthcare projects if he ever faced a similar task of alteration of a space with analogous requirements. Bob tells her to open the file of "project B" they worked on 3 years ago.

Alex goes through the files of the project and she finds the original layout and the revised refurbished layout. She sees in the first layout a room similar to the utilities room in her current project that was later changed to another room type, but she cannot find what made this choice the best available solution so she goes back to Bob. Bob tells that was the option the owner preferred from a list of space solutions provided to him. Bob then forwards her an Excel spread sheet where the problematic room was checked against other rooms based on a list of engineering requirements (such as cost of refurbishment, clinical functions, environmental conditions, area constraints, duration of change etc.). Alex opens the file and marks down the nominated rooms and their cost refurbishment and forwards the file to the healthcare estates manager to decide what room is more suitable for the hospital's needs and budget.

THEORETICAL FRAMEWORK FOR FUTURE-PROOFING THE CONCEPTUAL DESIGN PROCESS

The discussion of this section presents the theoretical framework upon this study was based (Figure 1). The goal of narrowing the design space of solutions emerged from the concepts of decision making in design. Simon (1996) described design as a problem itself that requires answers. According to Newell (1979:5) "a problem space consists of a set of symbolic structures (the states of the space) and a set of operators over the space". Additionally, there is no linear process from problem to solution (Lawson 2004) and since there is more than one problem spaces (Newell 1979) design seems to be the only means to drive to "satisficing" solutions (Simon, 1996). Krishnamurti (2006) described a design space as the sum of the problem space, solution space and design problem.

The problem space is shaped only by the potential solutions that satisfy the established requirements. The solution space on the other hand is formed by all potential solutions for a given design problem. The design process consists of procedures used to develop candidate solutions from requirements. Akin (2001) analysed the design process as the sum of the design knowledge and design strategy, where strategy refers to the search the designer carries out and knowledge stands for all the means the designer uses to represent the multiplicity she needs and finds useful. Such representations could be the designer's actions, processes, design states etc.

Moreover, Fricke (1996) categorised strategy into Function oriented, where the designer focuses on one problem area, solving it from abstract to concrete level and then continues to seek answers to the following problems, and Step-wise process-oriented, where the designer considers all the relevant problem areas and holds a more abstract level of solutions before becomes more concrete. Regarding knowledge, from on-going research (Ahmad et al. 2013) it is recognised that "satisficing" healthcare design solutions will emerge from the application of flexibility, design standardisation and the information management abilities of BIM.

Application of Future-proofing Conceptual Design Process

Having discussed, in the previous section, the concepts driving the proposed process, the application have been discussed in this section (Figure 2). As previously mentioned, there is more than one design problem; consequently, for the design of healthcare facilities, such problems regarding information could be caused by many factors, for example: the information the design team receives from the brief with the client and the information the design team receives from computer systems, such as the vast information that is contained within the ADB add-on (Stage 1).

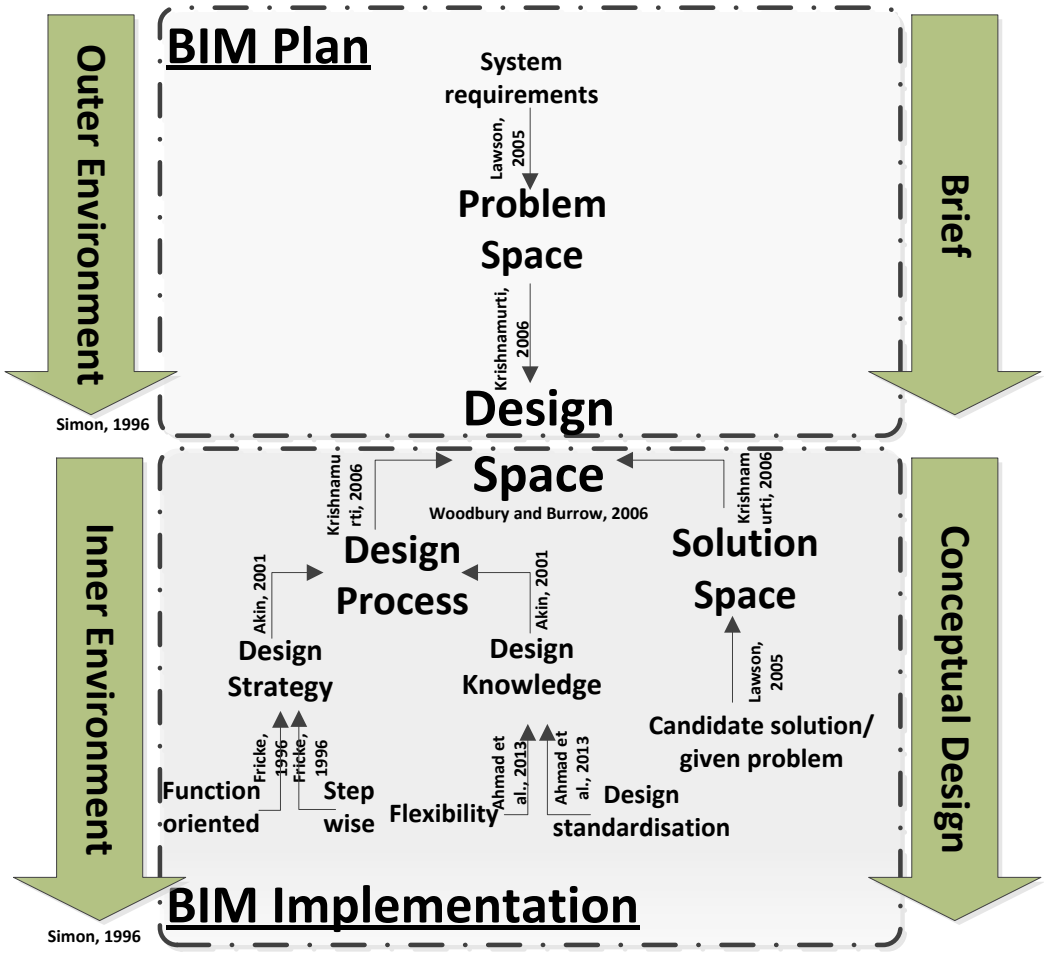

Figure 1: Theoretical framework-future-proof Healthcare design by narrowing the design space of solutions.

Future-proofing healthcare design towards "satisficing" solutions within BIM is achieved by adopting a function-oriented strategy, e.g. solving one problem (room or space) at a time (Stage 2). Automated design knowledge, the other component of the design process, is exercised by investigating two space attributes: flexibility and design standardisation (Stage 3). Design standardisation is applied in terms of managing the vast information that exists within the BIM system and BIM attributes are classified based on numerical and textual values. The BIM system identifies common information that is contained within the ADB rooms, such as attributes with the same textual values (e.g. Type A carpet) and numerical values such as width of a room. This process allows the grouping of ADB attributes into category filters and sub filters (Module 1). From literature, it is concluded that flexibility is clarified as the total force of two other forces-effects. The identified relationship between these two

effects can be analysed with change effect being the independent variable and timescale duration effect being the dependent variable. Slaughter (2001) categorised flexibility in regard to change and three categories emerged, namely change in people/flow, spatial change and structural change. Alternately, De Neufville et al. (2008) categorised flexibility in regard to time, hence the three categories that emerge are short-term, mid-term and long-term. The three stages of change effect provide knowledge regarding the duration of a substitution of two spaces. For example, a change from Type A Office to Type B Office can be short term if involves only a change of people. On the other hand, if it evolves demolition of walls to extend the area then it is a spatial change (Module 2).

Another way to measure the proposed alternative solutions is to assign refurbishment costs to substitutions between the existing space that is nominated to be substituted and the proposed alternative solution spaces that emerge from Module 1. For example, the utilities room that was to be substituted would be checked against the list of rooms that emerge from Module 1 (Stage 3a) and then the user will prompt the computer to sort out the alternative list of solutions from least expensive to most expensive substitution. Therefore, the independent variable this time is change effect and the dependent variable is cost effect (Module 2).

The mechanisms that emerged from the function oriented strategy and the automated design knowledge drives finally towards a space of solutions, that is a list of proposed ADB rooms that results to a narrowed design space of satisfactory solutions (Stage 4) and finally the design team along with the owner of the project can conclude in choosing the most effective alternative spaces that emerge through the aforementioned process.

Modules for Supporting Design Space

The existing ADB information architecture represents all rooms using a clear and precise set of attributes. In a BIM model, ADB information is captured within the rooms or the components of the rooms. The two modules described below were developed to address the issues that emerged in the problem scenario where Alex the designer was struggling to find a quick and reliable solution as she could not handle all this vast information that was contained within ADB. The first module is the option to categorise attributes based on what they represent. For example, the spatial category will include the subcategories, length, width, height, area and volume. The user will be able to choose one or more subcategories of that category, so that when the query search presents a list of results, only spaces that satisfy all the preselected options will appear. Through that action the user can filter the vast amount of proposed rooms that is available in the ADB database. For instance, Alex might want to keep the same flooring material (material attribute) and the medical equipment (components attribute) to the room the estates manager wants to substitute, so she clicks only on those filters that satisfy the briefing requirements. She then runs the query and only rooms with the same selected attributes will appear as possible solutions. That means that the designer has to be careful about what filters apply otherwise the results will not satisfy the brief requirements.

Module 2 allows the user to compare the items (rooms) which are proposed by the first module against three criteria: cost of change, timescale of change and best matching attributes. One way to test which option fits best is to consider the cost of converting the existing room type to the proposal being considered. Cost of changes can be assigned from a database that will contain cost linking data of rooms. The

database would contain data that derive from the following procedure: the existing room will have to be checked against all other proposed rooms in terms of refurbishment changes. No actual costs will be provided as detailed costing can only emerge in detailed design, instead a matrix will be created that will contain cost factors among changes of spaces. The matrix can be pre-computed and then the database can be inserted in a BIM platform e.g. Revit though the Revit API. Beyond cost, the second criterion to consider when assessing nominated spaces would be to estimate how much time will take for the refurbishment to be completed.

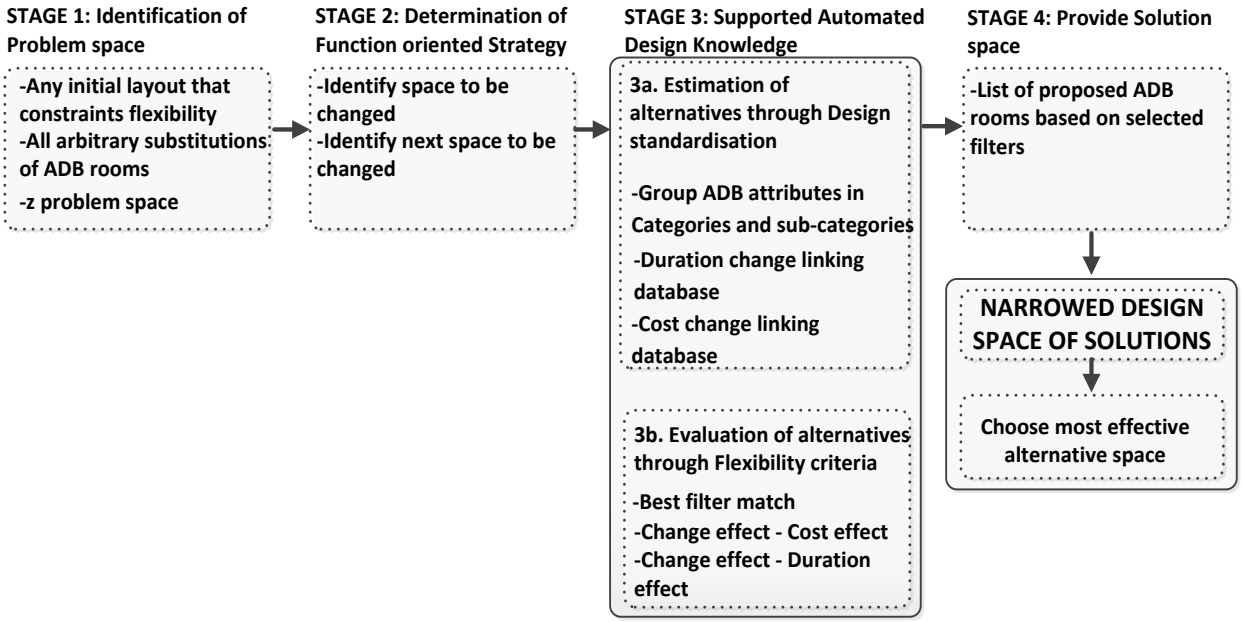

Figure 2: The process of narrowing the design space of solutions in a BIM add-on to the Activity Database (ADB).

As discussed earlier, flexibility is analysed in a change frame format and in a time frame format. Another database can be created therefore to provide knowledge regarding the duration for a change to be completed. The ADB room coding list (Department of Health, 2012) contains information of the room categories and sub categories. These room subcategories are further analysed into room variabilities. The tree map hierarchy of the ADB room coding list will provide the first knowledge about the factors of duration regarding a change. Due to shallow structure of hierarchy a further analysis will be applied, in other words a change will be assigned to one of the three aforementioned types of changes and then further categorised to short, mid or long term change and using First Order Logic the process can be automated. Lastly, the third option to sort out the proposed alternative solutions is by ranking the items regarding how many filters and sub filters are fulfilled. Hence spaces that fulfil all selected filters will appear on a higher rank than spaces that fulfil fewer filters. The proposed Human-Computer Interface experience is based on the principles of the aforementioned theoretical framework.

The first module applies principles/notions/concepts from the function oriented design strategy as described by Fricke (1996), and the need to support knowledge extraction within conceptual and refurbishment design through design standardisation. The second module applies rules from the concept of flexibility (change frame vs. time frame and change frame vs. cost frame).

CONCLUSIONS AND FUTURE RESEARCH

Previous attempts to apply design standardisation and emulate standard design processes failed to provide satisfactory results or have not yet matured to address the problems that emerge during conceptual design. Some designers adopt top-down processes whereas others prefer bottom-up processes (Lawson 2005). Construction projects are becoming more and more complex, and the amount of information the designer is expected to handle is exhausting. Therefore, information extraction becomes more important than ever. This research presents an innovative method to extract spatial information that usually needs to be extracted manually by the practitioner when making design decisions. The proposed design methodology narrows the design space of satisfactory solutions by integrating the concepts of flexibility and design standardisation. This is based on three approaches: consider the cost of making a space change, providing knowledge regarding which alternative space is more cost efficient; consider the duration needed for a change, providing knowledge regarding which alternative space is more time efficient; and provide knowledge regarding which of the proposed alternatives satisfies the most criteria-filters that have been set by the user, based on existing ADB metadata. These three approaches become criteria in the ADB add on for BIM to sort out proposed solutions. These proposed solutions emerge after introducing design standardisation in ADB rooms via extracting the information they contain. This is achieved by automatically identifying common design components and attributes. Finally, the parameter of inserting cost links and timescale duration links within the ADB rooms applies value engineering at the early design stages of the project.

Further on-going research will provide adequate support for the proposed modules. Both aforementioned modules need to be developed and tested in various case studies to evaluate and test their performance. The filter categories need to be justified by the end users. The Engineering Requirements of the filters will be collected through interviews with various stakeholders. Architects specialised in healthcare design, BIM and the ADB plug in will be interviewed in both new and refurbishment projects they participated. Clients will be asked regarding the quality of feedback they would like to receive in the early stages of a project. For the cost database, professionals will be asked about cost refurbishment changes and what procedures they follow to estimate them.

REFERENCES

ADB add-on white paper, (2012) The ADB 2012 Revit Add-on vs 3.1.0, Retrieved January 9, 2013, from Space for Health: http://www.spaceforhealth.nhs.uk.

Ahmad, A M Demian, P and Price, A D F (2012) Creativity with Building Information Modelling Tools. In: D. Greenwood, (ed.) "First UK Academic Conference on BIM". 5-9 September 2012, Newcastle, 152-163.

Ahmad, A M Krystallis, I Demian, P and Price, A D F (2013) Using BIM to Design Flexible Spaces and Apply Design Standards in Healthcare Facilities, Unpublished manuscript, School of Civil and Building Engineering, Loughborough University.

Akin, O (2001) Variants in design cognition. In: C. Eastman, W. Newstetter and M. McCracken, (eds.) " Design knowing and learning: Cognition in Design Education". New York: Elsevier.

Autodesk white paper, (2007) Parametric Building Modeling: BIM's Foundation. Retrieved March 19, 2012, from Autodesk.com: http://images.autodesk.com/adsk/files/bim_parametric_building_modeling_jan07_1_.pdf

Cabinet Office, (2011) "Government Construction Strategy". London: Cabinet Office.

CIMCIG Admin, (2012) BIM is unstoppable says Paul Morrell. Retrieved November 24, 2012, from Chartered Institute of Marketing: http://www.cimcig-blog.org.

Cross, N (1999) Natural intelligence in design. "Design studies", 20(1), 25-39.

Cross, N (2001) Can a machine design?. "Design Issues", 17(4), 44-50.

de Neufville, R Lee, Y S and Scholtes, S (2008) Flexibility in hospital infrastructure design. In: "IEEE Conference on Infrastructure Systems", 8-10 November 2008, Washington.

Department of Health, (2012) ADB 2012 Room Coding List. Retrieved March 2, 2013, from Gov.uk: https://www.gov.uk/government/publications/activity-database-2012-software-release.

Eastman, C (2001) New Directions in Design Cognition: Studies of Representation and Recall. In: C. Eastman, C. Newstetter and M. McCracken, (eds.)" Design Knowing and Learning: Cognition in Design Education". Kidlington: Elsevier Science.

Fricke, G (1996) Successful individual approaches in engineering design. "Research in Engineering Design", 8(3), 151-165.

Glaze, G Johnson, J and Cross, N (1996) Elicitation of rules for graphic design evaluation. In: J. S. Gero and F. Sudweeks, (eds.) "Artificial Intelligence in Design: AID96". Netherlands: Springer.

Krishnamurti, R (2006) Explicit design space?. "AIE EDAM", 20(2), 95-103.

Krygiel, E and Nies, B (2008) "Green BIM: successful sustainable design with building information modeling". Indianapolis: Wiley Publishing.

Lawson, B (2004) "What designers know". Oxford: Architectural Press.

Lawson, B (2005) Oracles, draughtsmen, and agents: the nature of knowledge and creativity in design and the role of IT. "Automation in construction", 14(3), 383-391.

Newell, A (1979) "Reasoning, problem solving and decision processes: the problem space as a fundamental category". Pittsburgh: Carnegie-Mellon University.

NHS, (2011) "The ProCure21+Guide-Achieving Excellence in NHS Construction". Leeds: Department of Health.

Reitman, W R (1964) Heuristic decision procedures, open constraints, and the structure of ill-defined problems. In: M.W. Shelley and G.L. Bryan, (eds.) "Human Judgments and Optimality". New York: Wiley.

RIBA, (2012), BIM Overlay to the RIBA Outline Plan of Work, Royal Institute of British Architects, London: RIBA Publishing.

Rosson, M B and Carroll, J M (2002) Scenario based design. In J. Jacko, and A. Sears, (eds.) "The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications". New Jersey: Lawrence Erlbaum Associates.

Simon, H A (1974) The structure of ill structured problems. "Artificial intelligence", 4(3), 181-201.

Simon, H A (1996) "The sciences of the artificial". 3ed. MIT Press.

Slaughter, E S (2001) Design strategies to increase building flexibility. "Building Research & Information", 29(3), 208-217

EVALUATING THE BENEFITS OF BIM FOR SUSTAINABLE DESIGN – A REVIEW

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The application of Building Information Modelling (BIM) to construction projects has the potential to enhance the quality of information provided for making critical design decisions regarding a building's environmental impact. However, the provision and utilisation of such information has yet to be effectively exploited in most instances and disconnections between BIM methodologies and sustainable design practices within construction companies are evident. But the fundamental aspects of integrative design, multiple stakeholder collaboration, common goal-setting, the quick efficient presentation of complex concepts to enable fast and effective decision-making, and an emphasis on dialogue between stakeholders are as fundamental to sustainable design processes as they are to BIM enabled construction. Differing perceptions and misaligned expectations of the benefits and expected outcomes of BIM and sustainable design adoption go some way to prevent a synthesis between the two approaches. There have been attempts to develop methods to calculate and quantify the benefits of BIM and related information system adoption but existing methods of analysis lack industry acceptance and fail to provide a principal framework methodology that can measure comparable data across multiple projects. An in-depth review of existing literature surrounding frameworks and methodologies to evaluate and analyse the benefits of BIM and sustainable design is presented. The issues surrounding the implementation of BIM alongside sustainable design practices and the inherent problems associated with attempting to evaluate benefits in a purely quantitative fashion are reviewed. Limitations of past research studies in BIM benefits measurement are discussed and the development of a broader framework that incorporates both quantitative measurement and a more qualitative understanding of the process of integrating BIM and sustainable design to measure the potential of BIM for sustainability are suggested.

Keywords: BIM, sustainable design, benefits evaluation.

INTRODUCTION

The built environment is recognised by policy-makers and stakeholders as having a significant role to play in reducing carbon emissions and achieving sustainable development (DEFRA, 2005; IPCC, 2007). Assessment and certification methods are consistently extolled as an important means by which to achieve such targets with the predominant and most established method used within the UK being the Building Research Establishment Environmental Assessment Method (BREEAM). However,

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Dowsett RM and Harty CF (2013) Evaluating the benefits of BIM for sustainable design: a review *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 13-23.

the effectiveness of these tools at engendering the ideal notions of sustainability advocated by some authors is refuted due to the failure to address underlying industry-wide organisational issues and a lack of a definitive understanding of what sustainability really is and means to the construction industry.

Within this paper sustainable design is defined as the processes and practices of design that contribute to sustainable patterns of living throughout the built environment, based on the dominant 'triple-bottom-line' approach. A paradigm shift from static notions of building performance to the regenerative contribution the built environment can make to the social, ecological and economic health of the place in which it functions is the ideal. To achieve this, common understanding amongst diverse stakeholders is required; a move from an isolated and static understanding of building performance in terms of design to an expansive and dynamic dialogue that encourages an understanding of the implications of the building lifecycle on occupant lives and business success will engage and maintain stakeholder commitment (Clements-Croome et al. 2004; Cole 2011; du Plessis & Cole 2011).

However, the highly fragmented design and construction process consisting of differentiated stakeholders with disparate approaches and specific project goals that are influenced by varying professional practice codes make interdisciplinary work difficult at early stages of design (Feige et al. 2011). Consequently the adversarial culture associated with traditional construction promotes self-interest and a necessity for voluntary and institutional mechanisms to ensure compliance in terms of sustainability. The current culture allows stakeholders to make decisions that reflect their own interests and select the approach that gives the best solution for them to meet organisational performance rather than building performance within the context of place. With current legislation stipulating the minimum requirements for sustainability, this is invariably perceived by project teams as supplementary to the primary goals of on-time and within budget. Cole (2012) refers to Robinson (2004) and the suggestion that for sustainability to become a meaningful concept it will require 'new concepts and tools that are integrative and synthetic, not disciplinary and analytic; and that actively creates synergy, not just summation'.

An exposition of the role of BIM as a process to facilitate a change in the prevailing perceptions and practices of sustainable construction, and why the development of performance measurement frameworks requires more than the assessment of discrete technical performance for it to become meaningful and beneficial to both organisational performance and building performance is now presented.

NORMALISATION OF SUSTAINABILITY VALUES THROUGH ASSESSMENT METHODS

A common theme throughout much of the literature is that the ideal notions of sustainability are subject to interpretation and the normative effect of standardised assessment methods such as BREEAM, in part, determine practitioner perceptions of sustainability and facilitate, or conversely impede dialogue amongst stakeholders over core values that shape and change the expectations of the environmental performance of buildings.

Schweber (2013) considers the effect of BREEAM as a process and its ability to change prevailing perceptions and practices regarding sustainable construction. The presiding debate centres on the notion that along with top-down policy debate concerning the most comprehensive definition of sustainability within a wider

domain, the specification of new standards and assessment methods within the construction industry contribute to a bottom-up definition. How such standards and assessment methods achieve this and to what extent were analysed through the systematic comparison of assessment processes across eight case studies from three firms who offer BREEAM assessments and one large engineering consultancy firm who contributed to the study in their capacity as project managers. Each firm provided two cases; one considered successful and one where lessons could be learnt and three types of relationships between assessment method and design and construction processes were determined: projects in which high integration occurred, projects in which moderate integration occurred, and projects in which BREEAM was considered a bolt-on process that had relatively little impact on the design and construction processes. Data consisted of 49 semi-structured interviews with assessors, clients, architects, project managers, design managers, and specialist engineers, and documentation produced by the assessment process. And the findings suggest that while BREEAM provides an established measurement framework for a building's environmental impact with relative ease of comprehension for those unfamiliar with sustainable design, the technique required to aggregate complex, heterogeneous and technically discrete specifications into a single score fails to engage clients in dialogue over the core values associated with specific design decisions that constitute a 'green building'. Also, the highly bureaucratic demands associated with some credits that require client involvement, such as community engagement, undermine client engagement with the process as a whole and although BREEAM was successful in translating complex ideals of sustainability to project team members who would otherwise not engage in such discussions, practitioners familiar with sustainable design generally perceived the assessment method as inadequate in embodying the new rationality purported by many authors (Du Plessis & R. J. Cole 2011; Moffatt & Kohler 2008).

The study also identifies the lack of accountability associated with some credits over which the design team have no control yet the linear technical approach to building assessment results in a loss of that credit, thereby weakening the internalisation of BREEAM as a measure of practitioner practice or challenge to existing perceptions. The study concludes that it is important to consider the impact of tools and assessment models and the taken for granted perceptions of standards on 'best' practice. It would appear that the assessment regime defines and permits decision-making toward minimum standards that fit best within existing organisational practice and that the value of BREEAM as an assessment model to achieve goals in line with revised definitions of progressive sustainability definitions may be limited.

BUILDING INFORMATION MODELLING

There have been a number of management methods and change frameworks to address inefficiencies within the construction industry in a bid to achieve 'best' practice, many of which were developed in response to reviews and reports (Green 2011). A key driver for UK mandated BIM strategy is the 2011 Government Construction Strategy, that calls for the replacement of "adversarial cultures with collaborative ones" and demands "cost reduction and innovation within the supply chain" as well as criticising the industry for failing to take advantage of the "full potential offered by digital technology". It would appear that BIM enabled construction work has come closest to a mandated collaborative working methodology; facilitating the redesign of organisational functions and processes toward integrative design, multiple stakeholder collaboration, common goal-setting,

the quick efficient presentation of complex concepts to enable fast and effective decision-making, and an emphasis on dialogue between stakeholders (Ahmad et al. 1995). Aspects of working methods that are purportedly required to meet already established BREEAM assessment criteria and a paradigm shift in the approach to sustainability advocated by many commentators (Du Plessis & Cole 2011; Cole 2011; Cole 2012). Using BIM may change the regime in which decisions are defined and permitted in line with progressive sustainability goals but there is a significant need to understand BIM as a 'systemic' (Taylor & Levitt 2004) and 'unbounded' (Harty 2005) innovation to avoid ineffective implementation because the perceived benefits of adopting IT enabled collaborative tools can only be realised when the antecedent conditions required to successfully implement IT are in place and the organisation is in a state of 'readiness' to synergise (Taylor, 2007).

Successful implementation at project-level requires organisational-level strategic planning that considers issues of technical support in terms of hardware and software rationalisation for cost effective use, critical management support in terms of challenging embedded processes, a supportive workplace environment in the form of BIM champions to share experience and skill, and an understanding of users' individual-characteristics so that the framework processes offered can be effectively applied (Peansupap & Walker 2006). Consequently, considerable mutual adjustment is required to enable successful technology adoption in inter-organisational collaborations and teams to bridge the boundaries between design, construction and operation, which is determined by a variety of factors: stakeholders attitude toward the technology, corporate culture, relationships between companies, project characteristics, industry-wide issues of legal standards currently employed, communication density, organisational barriers and individual's resistance to change (Dossick & Neff 2010; Nitithamyong & Skibniewski 2006; O'Brien 2000). These are factors that may affect the outcomes specified in many BIM assessment methods as well as sustainability assessment methods.

BUILDING INFORMATION MODELLING PERFORMANCE ASSESSMENT

Methods to measure implementation success referenced in this paper predominantly have a myopic focus on financial performance indicators with the majority of existing studies conducted in the US where there is no mandated BIM strategy. As such, these studies predominantly examine benefit measurement methods for the purpose of constructing a business case for practitioners and owners to invest. And although case studies realise benefits they provide no formalised repeatable measurement framework to determine best practice and/or process improvement.

The McGraw Hill Report is based on an internet survey of 2,228 completed responses from 598 Architects, 326 Engineers, 817 Contractors, 118 owners, 73 Building product manufacturers and 296 other industry respondents to gauge the practitioner perception of the value of BIM. 77% of users perceived a positive ROI on their investment, 87% were experiencing a positive ROI and 93% believed there is more value to be realised in the future. The report also contains four case studies one of which, for an 11-storey 540,000 square-feet biomedical facility, bases its success on an integrative approach, engaging early with the design team with contractor and owner inclusion and an extensive design and preconstruction process to develop a data management process. It led to a reduction in RFI's of 37% and a reduction of change orders of 32% throughout the project compared with the similar non-BIM enabled

previous project. The project team also experienced an estimated 50% reduction in labour and work schedule as a result of BIM though the specific role of BIM is not discussed.

The second case study, for a Health Science Centre, determined the success of BIM through completion within budget. The project was awarded on a second round tender and BIM was used to model the project in advance to give a firm understanding of project costs to compete in a 'hard bid environment'. An understanding of the organisational processes that took place to make the technology adoption successful would provide a valuable contribution to the industry as a whole.

The third case study, for a medical health centre, reported success in terms of improved scheduling and cost savings however the project narrative offers a more interesting insight into the processes required to achieve the identified success measures; faster decisions and streamlined processes as a result of the technology were predicted but there was resistance against technology specification in fear of constraints around creativity and productivity. A clear strategy of interdisciplinary information exchange was determined without software specification. Prior to commencement of on-site activities the project team had produced over 25,000 electronic design documents and eight servers were used to enable 50 companies creating files across the US to have real-time data access from any location.

The final case study of a high-explosives material pressing facility measured success through clash detection of extensive process piping, operating equipment and electrical and control systems. Cost savings of $10 million were attributed to the technology. The project specification was to optimise spatial coordination so it is logical that the performance measure was the number of clash detections.

Indicating a need for a consistent cost-benefit benchmarking framework associated with BIM process enhancements and innovations as a motivator for adoption Becerik-Gerber & Rice (2010) conducted a survey to gauge the perceived value of BIM in the U.S building industry with specific focus on tangible benefits and costs at project-level. 424 respondents answered questions regarding; the size and type of projects BIM was used on; the type of software used; the tasks the software is used for; the number of projects it is used on; and the ratio of total cost spent on software, hardware, maintenance and training to overall net revenue. Hardware and software costs contributed most to overall expenditure whereas the majority of respondents reported spending less on software upgrades, hardware maintenance costs and training. Around 41% of total respondents realised an increase in overall project profitability with firms having more experience reporting higher returns. 48%, 47%, and 58% of respondents reported scheduling improvements during the design, bid preparation and construction phases, respectively. What effect independent variables such as software upgrades, hardware maintenance and training have on the dependant variables such as perceived project profitability is unknown and maybe a significant interdependent variable.

Giel et al. (2010) conducted a study based on the premise that a company's capacity to finance virtual design and construction (VDC) goals is determined by the owner's willingness to pay additional fees. Two case studies were conducted and compared based on BIM-preventable change orders and the associated schedule differences: Case Study One compared two commercial warehouse projects of around $8 million and 365 days duration with savings of 36.7% in the non-BIM project and 16.2% in the BIM project; Case Study Two compared two concrete condominium projects of

around $40 million and around 600 days duration with ROI's of 1653.9% and 299.9%. However it is difficult to determine whether the scheduling improvements were entirely attributable to the use of a BIM-based model.

Barlish & Sullivan (2012) recognise the highly contextual domain in which BIM benefits measurement is set and the void of a balanced repeatable framework for BIM implementation that considers both monetary and managerial outcomes. The paper offers a reductive and positivist analysis that purposefully ignores the qualitative aspects of BIM implementation in order to develop a BIM GO/NO-GO decision mechanism through net benefit analysis. The framework is in response to the numerous IS evaluation methods that are reactive and prescriptive, relying on individual perceptions of value and a matrix of potential BIM benefits was composed from a review of existing literature. The most quantifiable and generalizable returns were determined; schedule, change orders, and RFIs. Returns on investment of reduced change orders and improved scheduling were 70% and 53% respectively and alongside quantifiable calculations the study conducted individual interviews with Project Managers and Coordinators to gauge the contextual information of BIM implementation rather than the interdependency. They reported an increase in contractor attendance at coordination meetings, a diminishing BIM software learning curve and decreased contractor accountability from BIM utilisation. Whether accountability was decreased as a result of increased attendance was not examined nor if the diminishing learning curve could be diminished further through increased expenditure on training.

In summary the metrics chosen in each study only provide an indicator of improvements; they do not provide a narrative of improvements, interdependencies of process change and benefits as a result of technologies, training or information quality, and/or lessons learnt. For example, Perceived ROI though important to understand the industry perception of the benefits of BIM, cannot replace actual ROI and the variables that can be adjusted to improve it. Also, measures identified are specific to different disciplines; RFIs are used as a measure of improved quality of information however the number will vary depending on project and participant context; productivity through drafting and documentation though a direct benefit to design teams are not as effective for contractors whose work focusses less on modelling or drafting (Lee et al. 2012). Consequently, shortened project duration is often used as a metric to determine success during construction, however there are many other factors that contribute to improved scheduling such as construction methods and equipment, number of personnel on site, and management quality (Lee et al. 2012).

‘What gets measured, gets attention’ (Eccles 1991) and can obstruct good judgement (Pfeffer & Sutton 2000) and the oversimplification of complex problems into localised improvement initiatives can reduced overall performance (Owen & Huang 2007) so it is important that the relevant measures identified contribute to the quality and productivity of the IS function and the larger organisational performance by providing feedback to manage and improve IS function to meet the needs of the organisation/project (Myers et al. 1997). Perhaps it is more pertinent to develop benchmarks that are used as a proxy to determine efficiencies, or lack thereof, to track and mitigate implementation failure. In which case metrics alone cannot determine the success of BIM; qualitative analysis of its role must supplement quantitative factors to develop an iterative measurement and analysis framework of existing performance to improve BIM capabilities and achieve differentiation.

BUILDING INFORMATION MODELLING & SUSTAINABLE DESIGN

During the design and preconstruction stages of a building the most significant decisions regarding sustainable design features can be made (Azhar et al. 2011). Linking new approaches to simulation and analysis within sustainable design to enhanced coordination of information via BIM throughout the construction process allows both reduction of rework and waste and the realisation of 'designed-for-performance' new buildings and infrastructure through dialogic engagement of stakeholders.

(Krygiel & Nies 2008) suggest BIM can assist in the following areas of sustainable design: building orientation (selecting a good orientation can reduce energy costs), building massing (to analyse building form and optimize the building envelope), day-lighting analysis, water harvesting (reducing water needs in a building), energy modelling (reducing energy needs and analysing renewable energy options can contribute to low energy costs), sustainable materials (reducing material needs and using recycled materials), and site and logistics management (to reduce waste and carbon footprints). Design options for sustainability can be tracked and studied in a model along with spatial data to geographically locate and import building site information to place it within context and to contribute to an understanding of issues relating to climate, surrounding systems and resources. The building can then be adjusted and engineered using real coordinates to reduce the impact on and utilise sustainably the surrounding environment to reduce energy requirements, for example solar orientation (Hardin 2011).

Literature regarding the integration of sustainability tools with BIM has shown improvement in assessment processes and effectiveness through comprehensive and efficient data extraction that reduces the time, effort and cost of an assessment, multi-disciplinary sustainable design decisions made at the design stage that enable relatively fast and inexpensive improvements to be made relative to changes made during and after construction, and a reduction in human error through the use of standardised and authorised information. Azhar et al. (2011) demonstrated the relationship between BIM and the LEED rating process making four conclusions: no explicit relationship exists between the LEED® certification process and BIM-based sustainability analyses due to inadequate software integration; up to 17 LEED® credits and 2 prerequisites may be documented using results generated by BIM-based sustainability software directly, semi-directly or indirectly; compared to traditional methods BIM-based sustainability software saves substantial time and resources; discrepancies between the software and manual results were mainly due to an inadequately developed model.

During the life cycle of a large commercial structure Scheuer & Keoleian (2002) found that approximately 95% of energy consumption and emissions occur in the operational phase. Through the use of highly energy efficient materials and building operation optimisation technologies the impacts to life cycle energy and emissions consumption from the operational phase can be shifted back to the material production and construction phase (Blanchard & Reppe 1998). Integration of LCA software and BIM software to automate this process will not only for allow efficiencies in LCA assessment procedures but also enable design changes to be made prior to construction and assist building management in the optimisation of a building's environmental footprint throughout its operation (Russell-Smith & Lepech 2012).

There are a number of other BIM-based tools and systems that have been and are being investigated and developed to tackle a range of sustainability concerns across the entire construction process from design inception to Facilities Management and lifecycle analysis (Azhar et al. 2009; Capper 2012; Che et al. 2010; Geyer 2012; J. Park & Kim 2012; Schlueter & Thesseling 2009). And whilst these technologies may assist in achieving the outcomes stipulated by sustainable assessment methods, the mechanistic and linear approach required to achieve credits fails to capture, and may even prevent, the more humanistic and developmental benefits BIM may bring in terms of dialogic stakeholder engagement, common understanding and internalisation of sustainability values that add value to the end user through continuous analysis and discussion of sustainability throughout the design and construction process with relevant stakeholders.

CONCLUSIONS

The metrics chosen in most studies only provide an indicator of improvements; they do not provide a narrative of improvements, interdependencies of process change and technologies, training or information quality, and/or lessons learnt. Static notions of best practice neglect aspects of cultural environment, and social interaction and negotiation that could affect not only the outcomes but also the constructs themselves.

Practitioners are therefore encouraged to follow routine algorithms within a dominant culture of compliance rather than to adopt innovative solutions to the inherently complex problems of organisational development and sustainable design that standardisation should support. Exemplary buildings are achieved but they are accomplished in spite of the current traditional methods not because of them. BIM methodologies and tools, through the standardisation of practices and processes, may free practitioners from the bureaucracy of traditional construction capacitating meaningful dialogic stakeholder engagement, practitioner discretion over design and improved decision-making by eliminating the restrictive conditions associated with traditional construction. But if performance analysis remains reduced to abstracted, mechanistic best practice algorithms, the organisational development and sustainable design benefits that BIM enabled construction can offer may not be realised.

Mechanistic conceptions of measurement methods across a disparate group of construction practitioners are difficult to achieve when the change required to improve is constrained by embedded practice and professional structure and different path dependencies themselves have different embedded practices and professional structures. BIM methodologies and tools go some way to address these issues but to realise the benefits, assessment methods must be more holistically diagnostic in order to identify the conditions required to successfully implement appropriate techniques relevant to the organisation and projects. By accounting for these conditions, BIM may produce renewed expectations and broader ranges of opportunities that should inevitably produce improved organisational capabilities and subsequently value-added sustainable design.

REFERENCES

Ahmad, I, Russell, J, & Abou-Zeid, A (1995). Information technology (IT) and integration in the construction industry. Construction Management and Economics, 13, 163–171.

Azhar, S, Brown, J, & Farooqui, R (2009) BIM-based sustainability analysis: An evaluation of building performance analysis software. In Sulbaran, T & Sterling C (Eds) "Proceedings of the Associated Schools of Construction (ASC) 45th annual international conference", 1-4 April 2009, University of Florida.

Azhar, S, Carlton, W, Olsen, D, & Ahmad, I (2011). Building information modeling for sustainable design and LEED® rating analysis. Automation in Construction, 20(2), 217–224.

Barlish, K, & Sullivan, K (2012). How to measure the benefits of BIM - A case study approach. Automation in Construction, 24, 149-159.

Becerik-Gerber, B, & Rice, S (2010). The perceived value of Building Information Modeling in the U.S. building industry. Journal of Information Technology in Construction, 15, 185–201.

Blanchard, S, & Reppe, P (1998). Life cycle analysis of a residential home in Michigan. School of Natural Resources and Environment, University of Michigan.

Capper, G (2012). Incorporating embodied energy in the BIM process. In: " CIBSE ASHRAE Technical Symposium", 18-19 April 2012, Imperial College London, 1–11.

Intergovernmental Panel on Climate Change (IPCC). (2007) Climate Change 2007: Mitigation of climate change. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge.

Che, L, Gao, Z,Chen, D, Nguyen, T (2010). Using building information modeling for measuring the efficiency of building energy performance, In: Tizani (Ed.), "Proceedings of the International Conference on Computing in Civil and Building Engineering", 30 June-2 July, Nottingham, Nottingham University Press.

Clements-Croome, D. J, John, G, Loy, H, & Wu, S (2004). Building Performance of Intelligent Buildings. In: "CIB World Building Congress 2004" Toronto, Canada. 1-10

Cole, R (2012). Transitioning from green to regenerative design. Building Research & Information, 37–41.

Cole, R (2011) Motivating stakeholders to deliver environmental change. Building Research & Information, 39(5), 431–435.

Department for Environment, Food and Rural Affairs (DEFRA). (2005). Securing the future: Delivering UK sustainable development strategy. London: HMSO.

Dossick, C & Neff, G (2010) Messy Talk and Clean Technology : Requirements for Inter-organizational Collaboration and BIM Implementation within the AEC Industry. Working paper proceedings: Engineering Project Organizations Conference, South Lake Tahoe, CA.

Du Plessis, C & Cole, R (2011) Motivating change: shifting the paradigm. Building Research & Information, 39(5), 436–449

Eccles, R (1991) The performance measurement manifesto. Harvard business review, 69(1), 131–7.

Feige, A, Wallbaum, H, & Krank, S (2011) Harnessing stakeholder motivation: towards a Swiss sustainable building sector. Building Research & Information, 39(5), 504–517.

Geyer, P (2012) Systems modelling for sustainable building design. Advanced Engineering Informatics, 26(4), 656-668.

Giel, B, Issa, R, & Olbina, S (2010) Return on investment analysis of building information modeling in construction. In W. Tizani (Ed.), Proceedings of the International Conference on Computing in Civil and Building Engineering. 30 June-2 July, Nottingham, UK: Nottingham University Press, Paper 77.

Green, S (2011) Making sense of construction improvement: A critical review. Oxford: Wiley-Blackwell.

Hardin, B (2011) BIM and construction management: proven tools, methods and workflows. Sybex.

Harty, C (2005) Innovation in construction: a sociology of technology approach. Building Research & Information, 33(6), 512–522.

Krygiel, E & Nies, B (2008). Green BIM: successful sustainable design with building information modeling. Sybex.

Lee, G, Park, H, & Won, J (2012) D3 City project — Economic impact of BIM-assisted design validation. Automation in Construction, 22, 577-586.

Moffatt, S & Kohler, N (2008) Conceptualizing the built environment as a social–ecological system. Building Research & Information, 36(3), 248–268.

Myers, B, Kappelman, L, & Prybutok, V (1997) A comprehensive model for assessing the quality and productivity of the information systems function: Toward a theory for information systems assessment. Information Resources Management Journal, 10(1), 6–25.

Nitithamyong, P & Skibniewski, M. J (2006) Success / Failure Factors and Performance Measures of Web-Based Construction Project Management Systems : Professionals' Viewpoint. Journal of Construction Engineering and Management, 80–87.

O'Brien, W (2000) Implementation issues in project web-sites: a practitioner's viewpoint. Journal of Management in Engineering, 16(3), 34-39.

Owen, J. H & Huang, N (2007) Local improvements that degrade system performance: case studies and discussion for throughput analysis. International Journal of Production Research, 45(10), 2351–2364.

Park, J & Kim, J (2012) Building information modelling based energy performance assessment system: An assessment of the Energy Performance Index in Korea. Construction Innovation, 12(3), 335–354.

Peansupap, V & Walker, D (2006) Innovation diffusion at the implementation stage of a construction project: a case study of information communication technology. Construction Management and Economics, 24(3), 321–332.

Pfeffer, J, & Sutton, R (2000) The Knowing-Doing Gap. Harvard Business School Press.

Robinson, J (2004) Squaring the circle? Some thoughts on the idea of sustainable development. Ecological Economics, 48, 369–384.

Russell-Smith, S & Lepech, M (2012) Activity-Based Methodology for Life Cycle Assessment of Building Construction. In: " CIBSE ASHRAE Technical Symposium", 18-19 April 2012, Imperial College London, 1–13.

Scheuer, C, & Keoleian, G (2002) Evaluation of LEED using life cycle assessment methods. NIST GCR, pp.79.

Schlueter, A, & Thesseling, F (2009) Building information model based energy/exergy performance assessment in early design stages. Automation in Construction, 18(2), 153–163.

Schweber, L (2013) The effect of BREEAM on clients and construction professionals. Building Research & Information, (March), 37–41.

Taylor, J & Levitt, R (2004) Understanding and managing systemic innovation in project-based industries. Innovations: Project management research, 1–17.

Taylor, JE (2007) Antecedents of successful three-dimensional computer-aided design implementation in design and construction networks. Journal of Construction Engineering and Management, 133(12), 993–1002.

McGraw Hill (2009) The business value of BIM: Getting Building Information Modeling to the Bottom Line, SmartMarket Report, 2008

BIM COLLABORATION: A CONCEPTUAL MODEL AND ITS CHARACTERISTICS

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Relationship management has become an important issue for both academics and practitioners in construction project management. Few study provide a clear picture of what specifically constitute collaboration in a construction project in the existing literature and the practical approach. Limit research focus on developing a collaboration theory in construction management. The advent of Building Information Modeling (BIM) has been proved to be helpful for improving project coordination and productivity. However, widely adoption of BIM does not change the fragmented nature of construction sector. An understanding of how to promote such collaborative relationships in BIM enabled projects is crucial to achieve the full potential of BIM. By analysing the characteristics of collaboration from a management perspective and investigating current BIM implementation strategy, this research develops a conceptual model of collaboration in BIM enabled projects and identifies main factors of collaboration. The model categorizes collaboration into three dimension, they are collaboration team characteristics, collaborative environment, and collaborative process. Model also presents high level of collaboration can result better project outcomes and participants satisfaction. This model can be generalized to construction sector and standardized to collaborative process for future BIM implementation.

Keywords: BIM, collaboration, project management

INTRODUCTION

Many studies show that inter-organizational collaboration can improve competitive advantage of firms, facilitate innovation, promote coordination and productivity and other tangible and intangible collaborate benefit (Amabile et al. 2001; Dyer and Singh 1998; Gray 1985; Simonin 1997; Tjosvold 1986). Interorganizational relation studies focus on the relationships among organizations. Analysing relationship helps people understand the characteristics, motivations, rationale and outcome of interorganizational relationships. More and more social events and business move toward complexity and multi-disciplinary. Interorganizational relationships exist in terms of strategic partnership, alliancing and networking in many sectors (Cropper et al. 2008). Collaborative relationship is vital to the process of project delivery in construction. Developing collaborative interaction cross professions has become a key issue for both academics and practitioners in recent years. Studies report the poor productivity and fragmentation in construction industry. There are some improvement and applications of collaboration strategy in construction sector including alliancing, partnering and PPP etc. However, project participants have different objectives and

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Lu W, Zhang D and Rowlinson S (2013) BIM collaboration: a conceptual model and its characteristics *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 25-34.

interests to the project, and they are subsequently fulfilling their responsibility and maximizing their interests and benefits accordingly. Thus, construction project organizations are, in essence, moving away from integration or collaboration toward a fragmented approach. Nevertheless, some key elements of collaboration have been addressed. Although practitioners agree to promote the collaboration and establish a partnership among the project parties by innovative procurement strategies and contract arrangements, the full collaboration challenges appear to be enormous, as evidenced by many researchers. American scholars report significant losses due to less collaboration effectiveness result in either losses of project performance or unsatisfactions of participants (Gallaher and Chapman 2004).

Previous studies have focused on relations between individuals' relationship and project performance in a construction project, such as the link between individual cooperation and project performance (Anvuur and Kumaraswamy 2007), the link between relationship management strategy and project performance (Phua and Rowlinson 2004) and partnering (Bresnen and Marshall 2000). However, little attention has been given to inter-organizational collaboration in BIM enabled construction projects. There is no clear evidence of successful collaboration approaches of BIM adoption, or the reasons BIM collaboration may potentially fail. Furthermore, the existing literatures and practical BIM applications do not provide a clear indication of what specifically promotes the collaboration in BIM enabled project and why collaboration is vital to the success of BIM implementation in a construction project. Some professionals view BIM as a collaborative technology or software, whereas others treat BIM more expansively and are aggressive in developing collaborative relationships with all the project stakeholders. BIM is accepted for its efficient and effective utilities in project delivery. However, high levels of integration do not represent high levels of collaboration. Furthermore, characteristics of high levels of collaboration are critical to project success such as willingness to cooperate and willingness to share knowledge (Jassawalla and Sashittal 1998). In addition, some companies have implemented BIM to a greater degree than others. Therefore, it is important to identify the characteristics of BIM collaboration that companies can promote and to explore how these relate to their project success.

The key objective of this research is to develop a conceptual framework of interorganizational collaboration in BIM enabled projects and investigate the factors contribute collaborative BIM adoption. Based on the literature review of interorganizational works in other sectors and the importance of collaboration in construction management, this study demonstrates a conceptual model of interorganizational collaboration in BIM enabled projects. In particular, we discuss the characteristics and functions of collaborative strategy that impact to the project performance. Developing such a measurable framework of collaboration will enable us to determine whether higher levels of interorganizational collaboration are associated with better project performance and more satisfaction of BIM implementation.

THEORETICAL BACKGROUND OF COLLABORATION

One challenge of collaboration study is that any definition is contingent on the level at which collaboration is situated in an organization or what people believe about the appropriate level of collaboration. Interorganizational relations exist among two or more persons representing different organizations in a relevant way. In this study, we focus on the collaboration at inter-organizational level. This perspective includes the

building of whole picture involving all the project participants and phases in a BIM enabled project. This view addresses the importance of cross-discipline collaboration from early stage of construction project to the end of project. Therefore, this study provides an explicit structure to manage the entire inter-organizational relationship systematically. For this point of view, professionals establish a working relationship based on a mutual objective, but conflictual relationships and problems may rise during the work. Different collaboration attitudes and various personalities of professionals stimulate various relationships. These relationships may create either positive or negative influence to the final project outcomes. Collaboration on organizational level would capture these interactions and, based on the research output, people can assess the influence to project performance from these interactions.

In reviewing the different studies of interorganizational relations in different sectors, theorists explain the relationship from social, political, economic and management perspectives (Cropper et al. 2008; Wood and Gray 1991). A key theoretical foundation for collaboration research is the relationship management literature. Blois (2002) identifies that transaction cost analysis (TCA) is frequently inappropriate adopted for analyzing exchange relationship. TCA proposes transaction as the unit of analysis. However, relational contract theory refers to the parties involved in an exchange. The parties can either be individuals or organizations. Macneil criticizes Williamson's TCA as discrete transactions. He (1981) claims that even a repository transaction involves contractual relations. Dwyer et al. (1987) differentiate discrete exchange from relational exchange in a buyer-seller relationship according Macneil's argument. Macneil (1981) differentiates discrete transactions from relational contracts. Relational exchange exists in an on-going relationship over time. It is based on its collaboration history and future. The potential of future collaboration relies on cognitive perception, trust and planning. Participants in relational exchange can achieve social satisfaction when engaging in a relational exchange (Dwyer et al. 1987). To the broader extent that relational exchange is multi-dimensional and depends on the nature of relational contract. Blois (2002) studies business to business exchanges and he identifies that 'exchange' and 'relationship' represent aggregations of numerous activities undertaken by all involving organizations. Thus, there is 'relationship' between organizations. Few scholar pays attention to processes of inter-organizational relations and how these relations emerge, evolve and terminate over time. Ring and Van de Ven (1994) develop a process framework of cooperative inter-organizational relationships focusing on formal, legal and informal social-psychological processes. They identify that process as the central to managing inter-organizational relationships. Gray (1985) claims that many problems beyond the control by any single organization which is viewed as indivisible problem. Furthermore, Gray (1985) analyses the conditions that facilitate the three phases of collaboration: problem-setting, direction-setting and structuring.

Althogh they developed a collaboration framework from the perspective of education, cross profession collaboration is similar to construction industry. Academic practitioner research collaboration is temporary and project based. Construction project is also project based. It is different from general collabroation studies in other sectors, individuals as the representatives of their mother company work with other professionals in a construction project temporarily form a project organization. In this project organization, each profession work with each other and rely on the output from other professionals. At the same time, they always consider the outcome of their contribution and the interest of their represented company. Furthermore, the

organization is dynamic, some individuals may leave project before completion, but the impacts of their activities beofre may affect to the outcome of final project. We borrow definition of collaboration from Jassawalla and Sashittal, they describe it as "the coming together of diverse interests and people to achieve a common purpose via interactions, information sharing, and coordination of activities" (Jassawalla and Sashittal 1998:239). Amabile et al. (2001) claim that there is little research about corss-profession collaboration. They build up a cross-profession collaboration theory and claim three determinants of successful collaboration: Collaborative Team Characteristics, collaboration environment characteristics, and collaboration processes (See Figure 1). Each determinant contains sub-categorized factors that influence its extent. We borrow their concepts and principles to construction industry. Hence, we discuss the characterists of BIM implementation in construction and explain how these factors influence the success of a BIM enabled project.

Figure 1. Collaboration Determinants and Outcomes by (Amabile et al., 2001)

BIM COLLABORATION

BIM is a collaborative approach to construction that involves integrating the various disciplines to build a structure in a virtual and visual environment. The essence of BIM implementation is collaborative working process in construction work. Therefore project participants could generate the maximum benefit of collaborative arrangements increasing efficiency and effectiveness (Succar 2009). The process allows project team to work effectively, particularly when identifying potential problems before they start to build on site. AIA defines BIM as "a digital representation of physical and functional characteristics of a facility"(AIA 2007:53). As such it serves as a collaborative platform for all stakeholders to share their knowledge resource and information. Sufficient information increases communication effectiveness. Effective communication allows stakeholders to exchange accurate, update and clarified information for decision makers to form a reliable decision. AIA also identifies that "BIM is a shared digital representation founded on open standards for interoperability" (AIA 2007:53). Therefore, BIM demands collaboration in order to unleash the utility of BIM implementation and maximize stakeholders' return on investment. Succar (2009) demonstrates three stage of BIM: object-based modelling, model-based collaboration and network-based integration. It is important to know that

BIM project requires a specific process of activities. The process involves high level of transactions on data, information and knowledge. A successful BIM project highly relies on effective collaboration among project participants including owners.

BIM becomes one way to cope with the cooperation, integration and coordination challenges faced in construction. However, very little study investigates BIM from the perspective of project management. Many study recommend construction industry to move toward Integrated Project Delivery (IPD), but few identify that IPD as the ultimate objective of construction project delivery method strongly demands closer collaboration and more effective communication (Eastman et al. 2011). BIM has been proved that enhance collaboration and information sharing comparing those traditional construction processes. BIM is linked to higher level of efficiency in terms of communication and collaboration (Bryde et al. 2013; Grilo and Jardim-Goncalves 2010; Lee 2008; Olatunji 2011). Sebastian (2011) confirms that multi-disciplinary collaboration can be achieved through optimal use of BIM, but changing roles of key parties, new contractual relationships and re-engineered processes challenges need to be overcome. Further, Bryde, Broquetas, and Volm (2013) identify that coordination defects are the second largest negative impact to project performance after software issue in 35 construction projects BIM enabled projects. Collaboration issue cannot be demonstrated by any single contract theory or economic theory. Few study expose the complexities of collaboration in BIM implementation. All the project participants need to be aligned with self-interest, mother company's requirement and project objective. So this is not an issue of individual collaboration in a team or an organizational collaboration issue in a joint venture. Collaborative process is one of the key factors for BIM success. The full potential of BIM can be realize by considering knowledge, technology and relationship. Many researches focus on the discussion of BIM technology. Few research address the importance of collaborative process of BIM implementation.

MODEL DEVELOPMENT OF BIM COLLABORATION

Based on Amabile's collaboration framework, our model suggests that each of the determinants of BIM collaboration has sub-categorized factors (See Figure 2). First, four preconditions of collaborative team characteristics are identified, they are professional knowledge, collaboration skill, attitudes and motivation and BIM acceptance. The most important features of professional knowledge in BIM project apear to be their profesional experience and the understanding knwoledge of BIM (BIM acceptance). Simonin (1997) argues that organizations change their approach to collaboration according their experiences with past partners. Complementarity of professional knowledge contribution across diciplinaries assure the proceeding of construction project and inter-organizational collaboration. Their BIM acceptance is the perception how they contribute to the utilization of BIM and motivate to collaborate with other professionals within BIM context. Collaboration skill referes to experience of collaboration with others and individual social skills with other team members in a project organization. When project adopts new technolgy such as BIM and use this technology, adoption triggers new challenges of organizaton inculding structures and power relations (Jacobsson and Linderoth 2010). BIM acceptance is important that participants have mutual perception of BIM implementation in a project. To what extend participant's BIM acceptance can influence the effectiveness of BIM collaboration. Attitudes and motivation appear to be individual intestest in learning BIM and incentive of using BIM. Regarding attitudes, trust is found to be the most important determinants paired with mutual respect and common understanding

that determine the appropriate team members (Jones and George 1998). Few attention given to cultural issues, We beieve cultural differences do exist but it doesn't impact the formation of collaborative project organizaiton. Because Hong Kong as an international city has a well delveloped history and achieves certain norm among profesionals no matter they are foreigners or new commers in construction industry in Hong Kong. They all can find their role and interact with other team members in a short period. In other words, the vacancy can automatically be filled by the appropriate person due to highly competitive and open maket. So, professsionals in construction industry work together as a temprorary organization to deliver construction projects, they have enough experience to break the cultural barriers and build up a common aggreement with each other. However, cultural issue may become important when dealing with other collaboration parties and industries.

Second, actions of individuals may impact cooperative inter-organizational relationships. Environmental conditions also influence the success of inter-organizational collaboration (Ring and Van de Ven 1994). Few scholars identify the importance of collaboration environment characteristics, despite a collaborative context is more likely to success (Amabile et al. 2001). Jassawalla and Sashittal (1998) demonstrate a framework of interorganizational collaboration. In this framework, organizations create macro-environmental forces and organizational forces impact the extent of collaboration achieved. The degree of institutional support that individuals receive from their home institutions can determine their willingness to contribute their time and resources to the project. In BIM enabled projects, BIM maturity varies from projects and organizations. Sometimes, BIM maturity is also constrained by technology itself (Porwal and Hewage 2013). Contract strategy is an important moderating variables in BIM collaboration. This will directly lead the success of BIM implementatin as a whole. Practically, we find people adopt BIM under traditional procurment strategy such as design-bid-build which eliminate BIM as a visualization tool at earlier tendering stage. Some other cases we encountered that advisarial contract bind the motivation of individuals to collaborate with other company representatives due to economic consideration and provide minimum contribution according contract responsibility. However, the situation changes significantly in a relational contract environment. Professionals work together as a team and more willing to communicate and solve problem together and creatively. Therefore, we investigated specific contract strategy as a contextual characteristic for our research.

Last, an operational platform with appropriate technology is likely to facilitate professionals to communicate and collaborate. Gray (1985) developed a process model of collaboration: problem setting, direction setting and structuring. In this model, specific goals are set, clear roles and tasks are assigned to participants. Collaboration can be enhanced in this sustainable long-term activity. (Gray, 1985); Ring and Van de Ven (1994) identify the importance of process development in an inter-organizational collaboration. Furthermore, this process is dynamic and evolving over time. BIM collaboration is mainly utilized through its process. This results high demand of software interoperability and clear role and responsibility for each party (Porwal and Hewage 2013). Although it is difficult, interorganizational collaboration depends on specific input and effort contributed by individual members to have a common understanding of roles and responsibilities in different organizations (Patel et al. 2012). Greenwood and Wu (2012) also confirm the link between communication and collaborative working. Based on these two sub-conditions, process could be

fluently developed through a well communication context. Both formal and informal communications are crucial to the success of project delivery (Li et al. 2009). Patel et al. (2012) demonstrate a framework of collaboration model. In their model, several factors are identified positively relate to the collaborative working. They claim that collaborative decision making involve both formal structured judgement and informal alternative exploration. Decision-making strongly relies on collaborative process and experience of participants. Satisfied decision-making can increase the individual satisfaction and commitment. Uncertainty and conflicts emerge in construction process. Different decision may cause negative relationship. For this reason, decision making in collaborative process is important. When project has high levels of collaborative relationship and participants are willing to share information and communicate, conflict decreases.

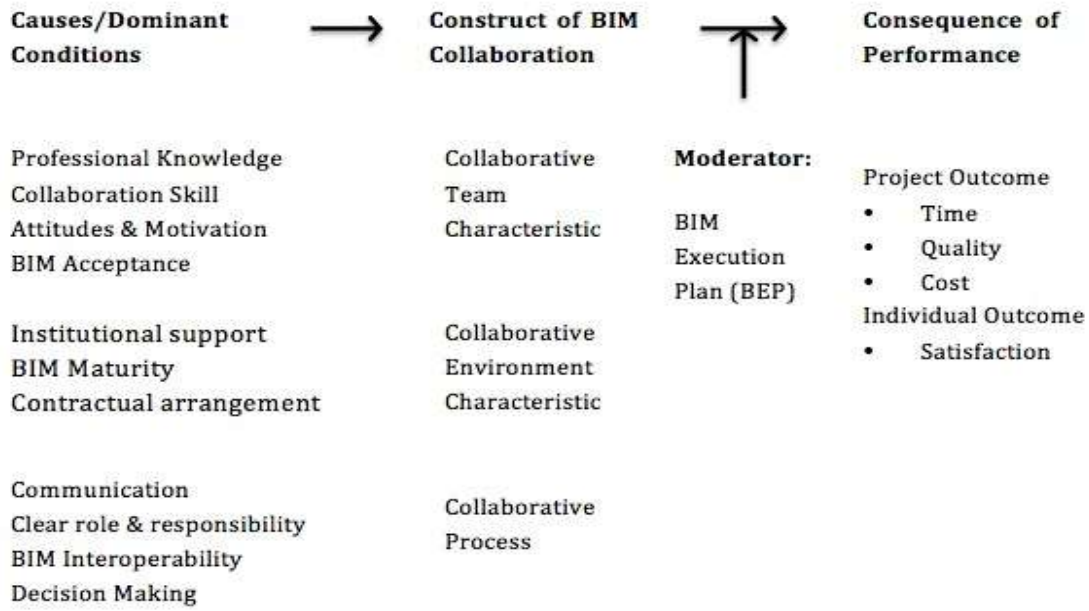

Figure 2. Model of BIM Collaboration and Outcomes

BIM execution plan (BEP) is reported as a priority before BIM implementation. A well defined BEP is able to assure the compliance of project objectives and requests (BSI 2013). Further, McAdam (2010) identifies BEP as the key to the information management. BEP sets out protocols for interoperability, project delivery milestones, dimensional accuracy and other details. He also claims that BEP specifies roles and responsibilities for team members and makes BIM collaboration successful. It is clear that there are correlated relationships between BEP and BIM collaboration success. Because there are more positive effects, we herewith hypothesize a positive moderating effect for BIM collaboration. According to our interviews, a well-prepared BEP can reduce the uncertainty and clarify the role and responsibility in most of BIM enabled projects.

In terms of consequence of collaboration, Chan and Ho (2001) test the relationship among overall project performance, interorganizational teamwork and participants' job satisfaction. Well developed construts of BIM collaboration facilitates better project performance as the consequence of colaboration. Together with individual outcome such as satisfaction to the project and personal achievement through the participation can confirm the positive impacts of BIM collaboration. Many researchers measure time, cost and quality as the measurements of project performance (Blois and Ivens 2006; Bresnen and Marshall 2000; Grilo and Jardim-Goncalves 2010; Phua and

Rowlinson 2004). Greenwood and Wu (2012) test different degrees of collaborative working relative to project performance and identify that higher level of collabroative working is more likely to produce higher levels of project performance. Other researchers also address that working relationships have positive impact on project performance in terms of project time cost and quality. This research conceptualizes the formalization of how to collaboration in BIM enabled projects. If participants are able to collaborate through construction project, they are able to perform more productively and project is more successful. In certain way, company will transmit those benefits to individual benefit such as incentives and more investments in technology and training. This demonstrates us how it can align idividual satisfaction to the project success.

DISCUSSION AND CONCLUSION

The goal of this study is threefold: 1) to develop a concetual model of BIM collaboration, 2) to investigate whether the BIM collaboration is link to project performance and individual satisfaction, and 3) to identify BEP as a moderator of BIM collaboration and project performance. Based on literature review, past researches support for our conceptual model of BIM collaboration for the dominant conditions. We identify key BIM characteristics in terms of three BIM collaboration determinants: collaborative team characteristic, collaborative environment characteristic and collaborative process.. We then structure the dominant conditions as measurements to assess the extent to which those constructs are perceived. This is an important contribution which fill the gap between BIM technology and project mangement theory. First, this represents a theoritical foundation for promoting BIM collaboration. Second, this demonstrates a framework of measuring BIM collaboraton. Third, there are many researches promoting collaboration both in constructon industry and other disciplines. BIM is also discussed intensively from the perspective of technology. This research bridges both by providing a guide for examination. Last, we highlights the importance of collaboration issues in BIM enabled projects and indicates the relation to project performance and individual outcome.

BIM provides people a new working logic in construction. The constructs capture the degree of BIM collaboration. If project team is able to work more collaboratively and understand the value of BIM collaboration, they can perform more effectively on their task delivery and information sharing. Project then can be completed more efficiently. As a result, all the stakeholders can benefit from time saving, cost saving and good quality. The collaborative process within BIM implementation is essential for the exchange of project information and professional knowledge. All the parties can satisfy with project performance according to such efficient and effective interaction. Given the essential role that collaboration plays in construction project, it is important that we understand the collaborative process within BIM enabled projects that leads higher efficiency and better performance. An examination of these collaborations using ideas and theories borrowed from previous researchers with be helpful to identifying strengths and weakness in BIM implementation and will provide the basis for a model of an effective BIM implementation. Beyond collaboration analysis, a better understanding of the BIM process has potential benefits for a number of project participants that adopt BIM technology to problem solving, including coordination, communciation, resource and knowledge sharing and innovation.

Of all the discussions, it is worthwhile that future studies focus on more individual specific and company specific characteritics contribute to BIM collaboration. BIM

collaboration study should be dynamic and cross professions. It is also possible that technology changes and improves over time. It also should be noted that contractual arrangement should be customized according to the BIM adoption in order to maximize the utilization of BIM.

REFERENCES

Amabile, T M, Patterson, C, Mueller, J, Wojcik, T, Kramer, S J, Odomirok, P W and Marsh, M (2001) Academic-practitioner collaboration in management research: A case of cross-profession collaboration. "Academy of Management Journal", 44(2), 418-431.

Anvuur, A M and Kumaraswamy, M M (2007) Conceptual model of partnering and alliancing. "Journal of Construction Engineering and Management", 133(3), 225-234.

Blois, K (2002) Business to business exchanges: A rich descriptive apparatus derived from Macneil's and Menger's analyses. "Journal of Management Studies", 39(4), 523-551.

Blois, K J and Ivens, B S (2006) Measuring relational norms: some methodological issues. "European Journal of Marketing", 40(3), 352-365.

Bresnen, M and Marshall, N (2000) Partnering in construction: a critical review of issues, problems and dilemmas. "Construction Management and Economics", 18(2), 229-237.

Bryde, D, Broquetas, M and Volm, J M (2013) The project benefits of Building Information Modelling (BIM). "International Journal of Project Management", 31(1), 56-63.

Chan, P C and Ho, C K (2001) Effect of interorganizational teamwork on project outcome. "Journal of Management in Engineering", 17(1), 34-40.

Dwyer, F R, Schurr, P H and Oh, S (1987) Developing Buyer-Seller Relationships. "Journal of Marketing", 51(2), 11-27.

Eastman, C M, Teicholz, P, Sacks, R and Liston, K (2011) "BIM handbook a guide to building information modeling for owners, managers, designers, engineers, and contractors". Hoboken, Newjercy: Wiley.

Gallaher, M P and Chapman, R E (2004) Cost analysis of inadequate interoperability in the US capital facilities industry. Gaithersburg: National Institute of Standards and Technology.

Gray, B (1985) Conditions facilitating interorganizational collaboration. "Human relations", 38(10), 911-936.

Greenwood, D and Wu, S W (2012) Establishing the association between collaborative working and construction project performance based on client and contractor perceptions. "Construction Management and Economics", 30(4), 299-308.

Grilo, A and Jardim-Goncalves, R (2010) Value proposition on interoperability of BIM and collaborative working environments. "Automation in Construction", 19(5), 522-530.

British Standards Institution (2013) "PAS1192-2 Specification for information management for the capital/delivery phase of construction projects using building information modeling". London: British Standards Institution.

Jacobsson, M and Linderoth, H (2010) The influence of contextual elements, actors' frames of reference, and technology on the adoption and use of ICT in construction projects: a Swedish case study. "Construction Management and Economics", 28(1), 13-23.

Jassawalla, A R and Sashittal, H C (1998) An examination of collaboration in high-technology new product development processes. "Journal of Product Innovation Management", 15(3), 237-254.

Jones, G R. and George, J M (1998) The Experience and Evolution of Trust: Implications for Cooperation and Teamwork. “The Academy of Management Review”, 23(3), 531-546.

Li, H, Lu, W S and Huang, T (2009) Rethinking project management and exploring virtual design and construction as a potential solution. “Construction Management and Economics”, 27(4), 363-371.

Macneil, I R (1981) “Economic analysis of contractual relations: its shortfalls and the need for a rich classificatory apparatus”. Nw. UL Rev., 75, 1018.

McAdam, B (2010) Building information modelling: the UK legal context. “International Journal of Law in the Built Environment”, 2(3), 246-259.

Patel, H, Pettitt, M and Wilson, J R (2012) Factors of collaborative working: A framework for a collaboration model. “Applied Ergonomics”, 43(1), 1-26.

Phua, F T T and Rowlinson, S M (2004) How important is cooperation to construction project success? A grounded empirical quantification. “Engineering, Construction and Architectural Management”, 11(1), 45-54.

Porwal, A and Hewage, K N (2013) Building Information Modeling (BIM) partnering framework for public construction projects. “Automation in Construction”, 31(1), 204-214.

Ring, P S and Van de Ven, A H (1994) Developmental processes of cooperative interorganizational relationships. “Academy of management review”, 19(1), 90-118.

Sebastian, R (2011) Changing roles of the clients, architects and contractors through BIM. “Engineering, Construction and Architectural Management”, 18(2), 176-187.

Simonin, B L (1997) The importance of collaborative know-how: An empirical test of the learning organization. “Academy of Management Journal”, 40(5), 1150-1174.

Succar, B (2009) Building information modelling framework: A research and delivery foundation for industry stakeholders. “Automation in Construction”, 18(3), 357-375.

IMPACTS OF BIM ON TALENT ACQUISITION IN THE CONSTRUCTION INDUSTRY

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Building information modelling (BIM) is rapidly reshaping the construction industry. Profound transformations have taken place in organizational structure and business operation in construction companies when adapting to BIM implementation. During the transition, companies are facing an essential question: how to align intellectual preparation with the challenges and business opportunities associated with BIM and stay competitive in the market? Efficient talent acquisition seems to be among the list of priorities. Use of dedicated BIM job titles and the emergence of the "BIM department" as an independent functional unit in organizations justify the need for a closer scrutiny of the current strategies for talent acquisition in the construction industry. This research investigated the impacts of BIM on key aspects of talent acquisition, including: identifying (gap analysis of talent shortage and needs), profiling (job description), qualifying (job requirements), sourcing (intellectual pool), recruiting (candidate screening and interviews) and retention/management. Conclusions were drawn from the data gathered via an online survey. The survey findings suggest that the construction industry is still at the beginning stage of formulating holistic strategies for BIM talent acquisition, in comparison with a boom in global BIM adoption and market demand for BIM talent. This research has exposed some fundamental issues companies are facing or will face in BIM talent acquisition. It is also intended to initiate critical thinking among the professional community to adapt existing talent acquisition strategies to the BIM context. Last but not least, the research suggests that enhanced collaboration between industry and academia should significantly improve the education, cultivation and acquisition of BIM talent.

Keywords: building information modelling, talent acquisition, technology innovation, transformation

INTRODUCTION

According to the Bureau of Labour Statistics (BLS) of the U.S. Department of Labour, the demand for highly skilled construction professionals (architects, engineers and constructors) is expected to outpace the supply over the next twenty years (Smith and Tardif 2009: 101). This forecast bears special implications at a time when building information modelling (BIM) is gaining accelerated uptake in global construction industry. It is consistent with what many industry professionals and research scholars

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Wu W and Issa R (2013) Impacts of BIM on talent acquisition in the construction industry *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 35-45

have observed that BIM-savvy people will be in high demand and the lack of adequately trained personnel is hindering the use and adoption of BIM in the industry (Sacks and Barak 2010, Becerik et al 2011). BIM generates new business opportunities but at the same time it raises the bar for competition. As more facility owners are embracing BIM, the project procurement process has started to incorporate BIM competency as desired qualifications in selecting project teams. Pioneers like the U.S. General Service Administration (GSA) have mandated basic spatial program BIM models as submittals for approval since 2007. On future transitions that BIM compels in the industry, Patrick MacLeamy (Chairman, buildingSMART International, Chairman and CEO, HOK) commented: "I think there's going to be a huge shake-out…Either change and get with this program, or go out of business" (McGraw-Hill Construction 2012a: 15). To stay competitive, companies have to be mentally and intellectually prepared for the upcoming transformation. A key task is to align human resources with organizational development challenges as they relate to understanding the need for BIM talent, finding it and then placing employees properly within the existing system (Joseph 2011). Therefore, this research aims to investigate: 1) how BIM is reshaping the skillset requirements for construction professionals; 2) what the current practices of acquiring BIM talent in construction companies are; and 3) what other transformation, such as enhanced industry-academia partnership in college-level BIM education, is needed to satisfy the growing market demand for competent BIM talent in the construction industry.

BACKGROUND

Challenge: workforce shortage

The supply/demand equation for the global construction industry workforce has been imbalanced, with countries including the US, UK and Canada claiming a "crisis of skilled workforce shortages". Labour research has suggested that this crisis may be associated with the workforce aging, low attraction of profession to youth, lack of craftsman skills among younger generations, and challenges from new information and communication technology (ICT) implementation (ETA 2004, ConstructionSkills 2008). Within this context, despite the global economic downturn, BIM adoption is still accelerating. In North America, industry-wide adoption has surged from 28% in 2007, 49% in 2009 to 71% in 2012 (McGraw-Hill Construction 2012a: 7). In the UK, NBS (2012: 9) reported that from year 2010 to 2011, construction professionals using BIM were more than doubled (from 13% to 31%). This rapid uptake of BIM is largely attributed to proven business benefits from its implementation, e.g. increased profits and positive Returns on Investment (ROI). Owners who are BIM-educated and -sophisticated are usually more engaged with its implementation and able to reap the highest business value (McGraw-Hill Construction 2012a: 7). These owners are more likely to seek out to award projects to BIM-capable companies who rely on the professionals they hire to deliver the projects to meet outcome expectations. BIM's biggest opportunity in the future will be the direction that new personnel take BIM technology (Hardin 2009: 297). BIM-savvy people will be in high demand, and the projected supply/demand equation will place acute pressure on the industry to acquire or cultivate competent BIM talent to increase knowledge-worker productivity across the industry to meet the rising demand (Smith and Tardif 2009: 101).

Challenge: organizational resistance to change

In the short term, institutions of higher learning will be unable to satisfy the workforce demand of BIM, which means employers will have to rapidly develop BIM and

integrated project delivery (IPD) skills internally. Organizations that choose to repeat the conventional wisdom of the CAD era that employees will simply "pick up the skills on the job", will find themselves at a significant disadvantage (Smith and Tardif 2009). To adopt and implement BIM at its full potential will demand organization-wide strategic planning and stakeholder engagement to embrace and foster technology insertion, process change and cultural transitions.

From a technology innovation standpoint, adoption of BIM is often compared with CAD, which was introduced to the construction industry over an extended period. In contrast, the deployment of BIM is fast-paced (at least twice as fast as CAD, according to Neeley 2010) and considered to be "disruptive". This view is informed by the implicit switch from 2D to 3D working and by the opportunities that the dual (software and process) view of BIM will create to further address some of the problems inherent in the construction section, e.g. fragmentation (Watson 2010: 4). As such, BIM provides a vehicle for addressing the fragmentation of the industry and a platform for greater collaboration and information sharing across the entire construction supply chain (buildingSMART Australasia 2012: 26). From a business innovation perspective, BIM is "transformative", meaning that there is impetus for dramatic changes in the business practices (Jordani 2008, Mihindu and Arayici 2008). Companies are urged to manage change (operational and cultural, according to Smith and Tardif 2009: 35) and transition (Deutsch 2011: 8) to carry BIM implementation strategy through and foster its development. The impacts of BIM on organizational structure and construction companies' day-to-day business operations are extensive as well as intensive.

The resistance to change in organizations is most challenging when top management and senior personnel refuse to adopt new practices but would rather stay in their "comfort zone", which typically occurs in the course of new technology insertion and intellectual transition (Eastman et al 2008: 202). The financial and liability risks of innovation are common excuses for companies to deter their steps down the path to adopt BIM. As Smith and Tardif (2009: 58) noted, there are pioneers, innovators, followers and laggards distributed over the typical technology adoption life cycle. Yet companies that are adverse to the financial/liability risks of technology innovation because they are not convinced by the immature market might eventually find themselves at significant loss of business opportunities and market competitiveness. They did not realize or chose to overlook the cost of not doing BIM, as Yori (2011) warned the industry. "Business-as-usual" may eventually turn into "no BIM, no business". LeFevre (2011) endorsed this idea with genuine financial data in real construction companies and accentuated that the business case for BIM had already been made. He also explicitly pointed out that "changing mindsets is the biggest challenge" in BIM transformation.

Impact: BIM talent skillset requirements

Transformative industry trends like BIM and BIM-related greater collaboration and integrated project delivery require workers to draw upon different skills than traditional positions do. The increasing need in construction for greater productivity is like to drive more rapid adoption of these trends, which will require a different way of looking at the skills a worker has to offer (McGraw-Hill Construction 2012b: 8). New job titles prefixed with "BIM", e.g. "BIM Manager" and "BIM Coordinator", and the advent of new organizational function units such as "BIM/VDC department" reflect the impetus to rethink the profiling and planning of workforce oriented to BIM tasks.

This is important to understand, because BIM is revolutionary shift away from drawing production in the CAD era (Eastman et al 2008). The set of skills needed is usually beyond the scope that is traditionally defined for CAD professionals. Barison and Santos (2010) conducted an overview of BIM specialists, which provided a preliminary outline of the areas of responsibilities, and contributed to better defining the professional skills required to performing BIM related functions in construction companies.

In the case when "dedicated BIM talent" (usually associated with BIM-prefixed job titles) is the target, the acquired BIM talent should not be an "add-on" to existing organizational structure, or a "plug-in" for existing business process in the companies. Rather, they should be organically integrated into the corporate structure, interdependent on current human resources (HR), facilitate and eventually transform the business process to be BIM-cohesive and BIM-productive. To facilitate the "naturalization" of BIM talent, top management should drive the change to place BIM into company's vision and identify BIM related business opportunities. The HR department should be educated about BIM to accurately create the job descriptions. The business department should review the core business services provided and the workflow associated to identify the gap between the desired BIM deliverables and existing capacities, so they could eventually determine the type of BIM talent (e.g. knowledge based, skill/project based, or corporate support & services based) that needs to be acquired (Joseph 2011).

In the case when companies choose to convert/redefine traditional positions to become BIM-capable, it is critical to create the baseline and targeted skillset requirements for the "converted BIM talent", to identify the relationship and gaps, and to make training plans. For instance, estimator as a traditional profession is subject to significant impacts from the implementation of BIM. Model-based quantity take-off (QTO) and "5-D BIM" have brought up heated conversation and debates in the professional community over whether estimating as a profession should be completely redefined. Another eye-catching discussion is centring on the comparison between a "CAD Manager" and a "BIM Manager". Quite a few companies have been counting on their CAD managers to take on the new challenges to lead their BIM expedition, and have been successful. Despite the few commonalities, the two job titles are actually fundamentally different in terms of the desired qualification, responsibilities and expectations (Kiker 2009).

Impact: BIM education and career preparation

For many, BIM training begins in academia. Education, particularly in universities, is where the ability to create new mindsets and exposure to new media is most effective (Hardin 2009: 298). BIM education is considered as a solution to quicken the BIM learning curve thus companies can recruit ready-made BIM talent when the students graduate (McGraw-Hill Construction 2008). Therefore, the effective inclusion of BIM into college curricula has become both a pedagogic and practical aspiration needed in preparing future BIM talent for the construction industry (Crumpton and Miller 2008, McGraw-Hill Construction 2009).

The classic gap between academia and industry does exist in college BIM education. In spite of the pervasive presence of BIM in college curricula, academic programs are struggling to meet industry and student expectations on knowledge coverage and problem-solving skills learned from the curricula (Clevenger and Rush 2011, Wu and Issa 2013). BIM is most productive when implemented in a multidisciplinary,

collaborative environment. However, in academia, the segregation of departmental units makes it very difficult to imitate this working environment. Students are typically trained with focus on technical skills. The lack of exposure to the essential BIM workflow and managerial aspects of delivering BIM projects is a major drawback of existing college BIM curricula and undermines students' learning outcomes. Wu and Issa (2013) also found that no incentives were in place to encourage college students to pursue BIM oriented career path. Similarly, companies tended to overlook college students as a potential BIM talent pool, and very few of them had considered college students in their BIM workforce planning. Despite the insufficient interaction between industry in BIM talent acquisition and college BIM education, industry and academia still share a common vision of desired skillset requirements for future BIM professionals. This can be the foundation to enhance partnership and collaboration between industry and academia in future BIM education, talent cultivation and acquisition.

BIM TALENT ACQUISITION: CURRENT PRACTICE

The literature review confirmed the impacts of BIM on skillset requirements for future construction professionals and the needs for companies to adapt their strategies in talent acquisition to prepare for the transforming market. Yet there is very little published research that has evaluated existing practice in BIM talent acquisition in the construction industry. Without an established baseline case, it is difficult to assess the strengths and weakness of the current system, or to identify possible opportunities and solutions for improvement.

Survey Methodology

In order to address the three research objectives (ROs), an online survey was designed to gather information on the following aspects of BIM talent acquisition: demand, job profile and qualification, talent source, recruiting, talent retention and management, and future outlook. A total of 840 email invitations were sent through the recruiters' listserv from Rinker School of Building Construction at University of Florida and the buildingSMART alliance member listserv. Ninety-nine (99) completed questionnaires were collected, with a response rate of 11.8%. The low response rate is commonly seen in online surveys (Nulty 2008) and one of major limitations of this research. This yields a +/- 6.4% margin of error at 95% confidence level. The survey used various types of question design, including Multiple Choice, Matrix Table and Likert Scale. Skip logic was employed when certain questions were looking for participants with specific background. As a result, some questions might have fewer than 99 responses.

Survey Results

Architectural firms (24.2%), contractors (23.3%, including construction managers, general contractors and specialty contractors) and consulting firms (15.2%) are the top 3 groups of participants in this survey. Various engineering firms (civil, MEP and environmental) responded (14.2%) except for structural engineers. Other respondents include owners (8.1%), product manufacturers/distributors (2.0%), software vendors (1%) and others (12.1%). Most respondents are either directly involved (as final decision-makers, leading or supporting recruiters) with talent acquisition (41.4%), or have medium or high influence on it (39.4%).

Identifying BIM talent demand

To determine the demand for BIM talent, the survey focuses on: 1) how often do companies participate in projects that mandate use of BIM, which constitutes as a

challenge; and 2) how much BIM contributes to the annual revenue, which is an incentive. As shown in Figure 1, between the years 2008 and 2012, companies' business portfolio has been drastically transformed from BIM-marginal (low frequency of projects that mandated BIM, see the dashed trendline) to BIM-essential (high frequency of projects that mandated BIM, see the solid trendline). Notice that only exponential trendlines for "less than 10%" and "more than 75%" were illustrated in Figure 1. The purpose is to make the greatest contrast and show the rapid shift from low frequency to high frequency of mandated use of BIM in projects. Similar methodologies were used in subsequent Figures 2-4. During the same period of time, as shown in Figure 2, contribution by BIM to companies' annual revenue was increasing steadily, following an upward trend similar to that in Figure 1.

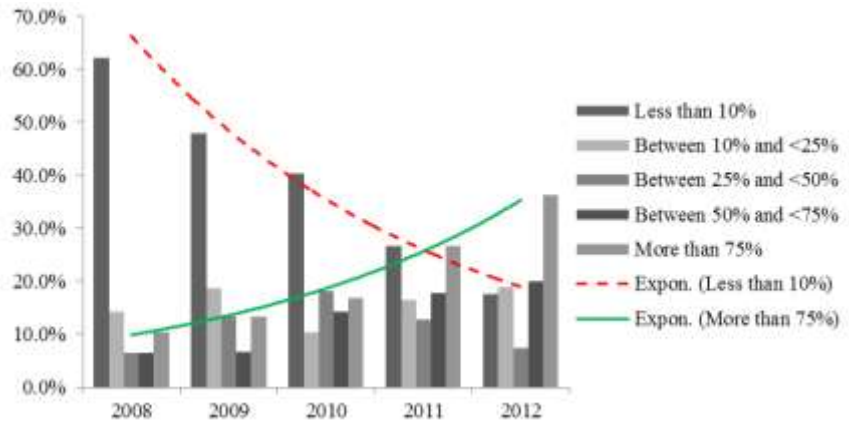

Figure 1. How often did your company participate in projects that mandated use of BIM?

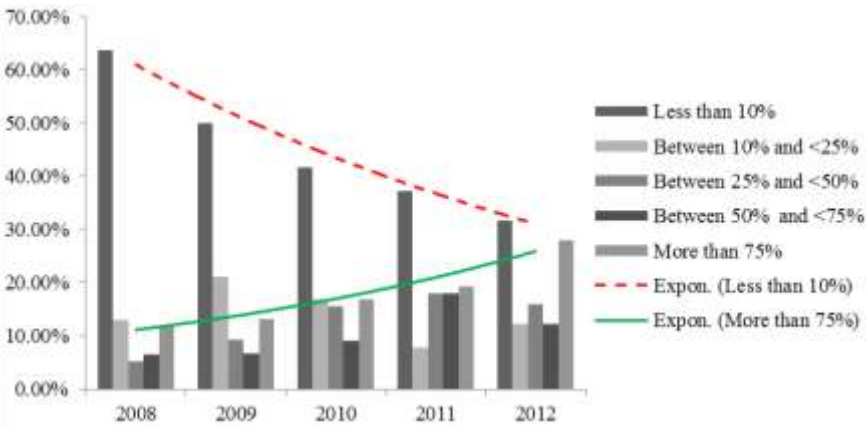

Figure 2. How much did BIM contribute to your company's annual revenue?

The demand for BIM talent has also been influenced by companies' workforce planning and the incentives that companies have perceived to adopt BIM. Most companies (53.6%) considered themselves "proactive" in workforce planning, driven by projected BIM business growth to acquire BIM talent. In contrast, about a third (28.6%) of the companies admitted to being "reactive", and only hiring when there is an immediate need for BIM talent (e.g. a project they were bidding on specified BIM as a desired qualification). In terms of incentives, companies felt most motivated by the perceived internal business benefits from BIM adoption (34.1%). They also felt encouraged to acquire BIM talent to more competently explore new business opportunities (20.9%). The third highest ranked incentive (16.5%) came from the owners' demand, as companies felt that owners might mandate BIM sooner or later.

Companies' historical hiring statistics offer reliable evidence for the rising BIM talent demand. Figure 3 provides a comprehensive summary of the participating companies' recruiting data over 2008 to 2012 in two major types: Type 1 - hiring that listed BIM as a qualification; and Type 2 - hiring that was dedicated to BIM. These exponential trendlines suggest that both types of hiring for BIM talent are increasing in terms of its percentage in total hiring, although at slightly different paces. The constituents of employee are shifting from BIM-marginal to highly BIM-relevant.

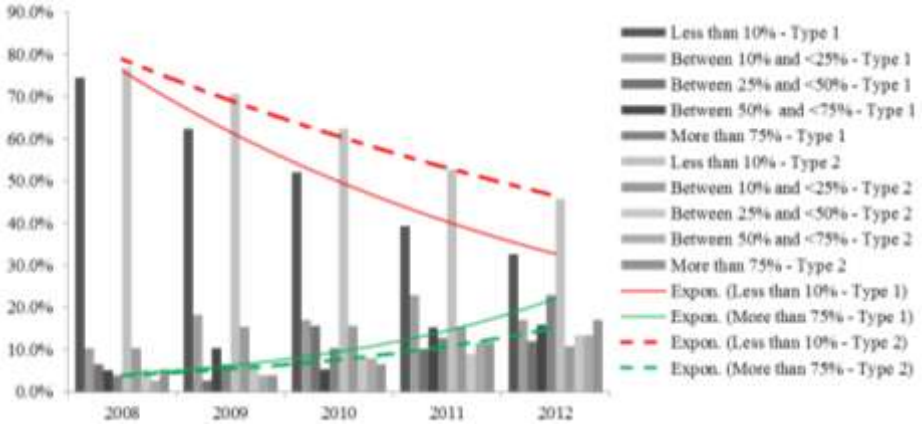

Figure 3. How many newly hired employees in your company were 1) listing BIM as a qualification or 2) dedicated to BIM?

BIM job profile and qualification description

Aligned with Research Objective 1 (RO1), the impacts of BIM on skillset requirements for future construction professionals were directly reflected in the description of BIM job profile and qualification. The emergence of BIM-prefixed job titles provides some insights. As found out in this survey, BIM Coordinator (47.1%), CAD/BIM/VDC Manager (42.4%), BIM modeller (31.8%) and BIM Director (29.4%) are the most popular BIM job titles among participants. But there were also a considerable number of people (28.2%) who chose not to use BIM in job titles. Very diverse opinions were observed on whether or not the company should define Job descriptions and qualifications when advertising BIM positions, with almost equivalent proponents (54.1%, 52.4%) and opponents (45.9%, 47.6%). To go in more depth, more than half of the participants in this survey found Technical/Functional Skills (74.1%), BIM Workflow/Strategic Plan and Execution Knowledge (61.2%), Multidisciplinary Model Management Knowledge (55.3%) and BIM Communication and Collaboration Skills (54.1%) most desirable qualifications. Companies relied predominantly (58.8%) on previous experience and reference checks to assess candidates' BIM competencies when hiring. Some companies also used Internal Metrics and Standards (27.1%), instead of Industry Certification/Credentials (e.g. AGC Certificate of Management - BIM or Autodesk Certified Professionals) (5.9%), which revealed that there is a lack of common metrics and widely accepted standards for BIM competency evaluation in talent acquisition.

Identify the source of BIM talent

Sources of BIM talent are also important to RO1 since it reflects the overall quality expectation of the talent acquired by the company. Training and educating employees was the top option (chosen by 17.8% of the respondents in recruiting 80% or more of their BIM talent) for companies at this moment, followed by free-agent BIM professionals in the job market. College students (non-doctoral students) were receiving more attention from companies, although still not a priority. This is probably

attributed to the perceived strength of college students in BIM technical/functional skills, which was identified as a most preferred qualification of BIM talent. CAD managers were in an awkward situation. They received second lowest votes, only better than college doctoral students who typically would not choose a career in the industry. This may suggest that more companies have realized the substantial difference between CAD and BIM competency in talent acquisition.

Recruiting BIM talent

As directly pertaining to RO2, BIM recruiting is an important investment for companies. More than half (52.4%) of the companies set aside budget and personnel for BIM recruiting, and 9.5% of them even had this as a routine. Most companies (59.5%) still rely on conventional web-based job posting for recruiting, followed by conventional job fairs (32.1%). New generation social media is also gaining recognition (27.4%). Special attention was given to college BIM recruiting. About a third of companies either hired students to fill permanent BIM positions (34.9%) or BIM internships (31.3%). Yet, there were still more than a third of companies (38.6%) that did not recruit college students at all.

Retaining and managing BIM talent

Recruiting is not the end of BIM talent acquisition, but a starting-point. To further address RO2, it is extremely important to investigate what talent retention and management strategies have been taken to sustain the success of companies' transformation to BIM. Most companies (76.2%) did not have an established BIM career path (like the traditional project managers and estimators, etc.). Major efforts made to retain BIM talent include encouraging organizational learning and knowledge management (55.4%), cultivating BIM culture and celebrating BIM champions and success (42.2%), encouraging BIM career development (39.8%) and creating a clear vision and goals for BIM business (38.6%). In terms of managing BIM talent, most companies (59.0%) assign them as part of the conventional workforce, performing both ordinary and BIM-specific tasks. About a quarter of companies (22.9%) would put their BIM talent in existing departments and assemble them for project-based BIM tasks. Only 13.3% of the companies had BIM departments to accommodate their BIM talent to handle only BIM business.

Outlook of market demand for BIM talent

To address RO3, the survey revealed some deficiencies in current BIM talent acquisition. Companies attributed such deficiencies majorly to lack of competent talent pool (46.7%). Other challenges they found in acquiring BIM talent include tight budget versus increased recruiting costs (37.0%), lack of opportunities to conduct BIM business and gain project experience (30.4%). Lack of top management commitment (28.3%) was still significant but no longer a dominant obstacle. To facilitate acquisition of BIM talent, more than half (55.6%) of the participants believed the key would be the continued growth of BIM business market, Enhanced College BIM Education and Professional BIM Training (53.3%), Enhanced Partnership and Collaboration between Industry and Academia (50%) and Development and Implementation of BIM Standards (50%). In forecasting hiring (dedicated BIM positions) over the subsequent 5 years, Figure 4 shows that respondents anticipated significant increase in both frequency (as the "0" hiring trendline drops while the "20+" hiring trendline rises) and magnitude (percentage of "20+" hiring), where "0" and "20+" denote numbers of dedicated BIM positions budgeted.

CONCLUSIONS

BIM is drastically reshaping the construction industry at large, and acquisition of the desired BIM talent becomes critical for companies to address the dual technology and process challenge in the BIM transformation. After reviewing the challenges and impacts of BIM on workforce planning, an online survey to identify the key features that characterized current practice of BIM talent acquisition in the industry was conducted. The results of the survey suggest that BIM as a trend is strengthening, with further expanded business opportunities. The impacts of BIM on talent acquisition were confirmed yet very few companies had established holistic strategies to address such impacts. More sophisticated strategic planning and financial investment are desirable to improve the status quo. Among the various efforts in meeting the rising demand for BIM talent, organizational learning, knowledge management and industry-academia partnership in BIM education are facilitators that deserve stronger commitment and further development.

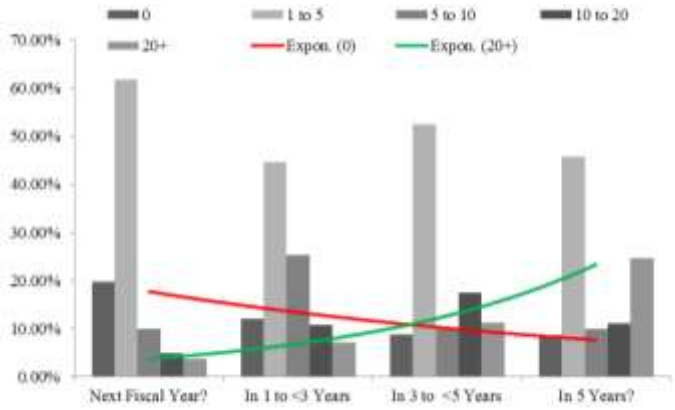

Figure 4. How many dedicated BIM positions do you company plan to recruit?

REFERENCES

Barison, M B, Santos, E T (2010) An overview of BIM specialists. In: Tizani, W (Ed), "The 13th International Conference on Computing in Civil and Building Engineering", 30 June - 2 July 2010, University of Nottingham.

Becerik-Gerber, B, Gerber, D J and Ku, K (2011) The pace of technological innovation in architecture, engineering, and construction education: integrating recent trends into the curricula. "Journal of Information Technology in Construction", 16, 411-32.

buildingSMART Australasia (2012) "National Building Information Modelling Initiative. Vol.1, Strategy". Sydney: buildingSMART Australasia.

Clevenger, C and Rush, M (2011) Collaborating with Industry and Facilities Management to teach BIM. "EcoBuild America 2011: BIM Academic Forum", 6-8 December, Washington D.C.

ConstructionSkills (2008) "2020 Vision - The Future of UK Construction". Norfolk: The Construction Industry Training Board.

Crumpton, A and Miller, B (2008) Building Information Modelling: State of the A&D Industry and BIM integration into Design Education. "Interior Design Educator's 2008 Annual Conference", 5-8 March, Montreal, Quebec, Canada.

Deutsch, R (2011) "BIM and Integrated Design: Strategies for Architectural Practice". Hoboken, New Jersey: John Wiley & Sons, Inc.

Eastman, C, Teicholz, P, Sacks, R and Liston, K (2008) "BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers, and Contractors". Hoboken, New Jersey: John Wiley & Sons, Inc.

Employment and Training Administration (ETA) (2004) "America's Construction Industry Identifying and Addressing Workforce Challenges". Washington, DC: ETA.

Hardin, B (2009) "BIM and Construction Management: Proven Tools, Methods, and Workflows". Indianapolis, Indiana: Wiley Publishing, Inc.

Jordani, D (2008) BIM: A healthy disruption to a fragmented and broken process. "Journal of Building Information Modelling", Fall 2008, 24-6.

Joseph, J (2011) BIM Titles and Job Descriptions: How Do They Fit in Your Organizational Structure? "Autodesk University 2011", 29 November - 1 December 2011, Autodesk, Inc.

Kiker, M W (2009) BIM Manager - The Newest Position. "Autodesk University 2009", 1-3 December, Autodesk, Inc.

LeFevre, M (2011) No BIM for You: The Case for Not Doing BIM - Leverage Points, Reframing and Key Decision Factors in BIM Transformation. "Journal of Building Information Modelling", Spring 2011, 14-7.

McGraw-Hill Construction (2008) "BIM: Transforming Design and Construction to Achieve Greater Industry Productivity". Bedford, MA: McGraw-Hill Construction.

McGraw-Hill Construction (2009) "The Business Value of BIM: Getting BIM to the Bottom Line". Bedford, MA: McGraw-Hill Construction.

McGraw-Hill Construction (2012a) "Business Value of BIM in North America Multi-Year Trend Analysis and User Ratings (2007-2012)". Bedford, MA: McGraw-Hill Construction.

McGraw-Hill Construction (2012b) "Construction Industry Workforce Shortages: Role of Certification, Training and Green Jobs in Filling the Gaps". Bedford, MA: McGraw-Hill Construction.

Mihindu, S and Arayici, Y (2008) Digital Construction through BIM Systems will drive Re-engineering of Construction Business Practices. In: Ceballos, S (Ed), "VIS 2008", 9-11 July 2008, IEEE.

National Building Specification (NBS) (2012) "National BIM Report 2012". London: RIBA Enterprises, Ltd.

Neeley, D (2010) "BIM 1.0, BIM 2.0, BIM 3.0: 2010 Update", "Convention 2010: Design for the New Decade", 10-12 June 2010, American Institute of Architects.

Nulty, D D (2008) The adequacy of response rates to online and paper surveys: what can be done? "Assessment & Evaluation in Higher Education", 33(3), 301-14.

Sacks, R and Barak, R (2010) Teaching Building Information Modeling as an Integral Part of Freshman Year Civil Engineering Education. "Journal of Professional Issues in Engineering Education and Practice", 136(1), 30-8.

Smith, D and Tardif, M (2009) "Building Information Modelling: A Strategic Implementation Guide for Architects, Engineers, Constructors, and Real Estate Asset Managers". Hoboken, New Jersey: John Wiley & Sons, Inc.

Watson, A (2010) BIM - a driver for change. In: Tizani, W (Ed), "The 13th International Conference on Computing in Civil and Building Engineering", 30 June - 2 July 2010, University of Nottingham.

Wu, W and Issa, R (2013) BIM Education for New Career Options: An Initial Investigation. "Building Innovation 2013: BIM Academic Education Symposium", 7-11 January 2013, Washington, D.C.

Yori, R (2011) The Cost of Not Doing BIM: Education and Professional Development. "Journal of Building Information", Spring 2011, 28-9.

BIM IN FACILITY MANAGEMENT AND MAINTENANCE: THE CASE OF KAISA LIBRARY OF HELSINKI UNIVERSITY

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One of the promises of building information modelling is that it will be used during the whole life cycle of a building. However, there are very few studies of the actual uses of BIM and other information systems by facility management and maintenance personnel. The purpose of this study is to clarify the daily tasks of the maintenance personnel, the types of software used in maintenance and how the information is handed on to maintenance. Key persons involved in the maintenance of Kaisa Library, main library of Helsinki University, were interviewed and a member of the maintenance personnel was observed in his work. Results show that an electrical maintenance manual is an essential part of maintenance personnel's work. University as an owner has been active in developing and interconnecting FM and maintenance tools it has implemented. However, building information models were not linked to these systems. The representatives of facility management found a partial, stepwise integration based on selective communication between the FM and maintenance systems already developed a way forward. They did not find the advantages of BIM implementation evident enough to legitimate the investments in the implementation.

Keywords: building information modelling, facility management, maintenance.

INTRODUCTION

The central goal for the development of a product model and later BIM in the 2000s was that all the information of the building created during the design and construction process would be available during the whole lifecycle of the building. For instance, a forerunner of building information modelling in Finland, the RATAS project, defined its goal in 1988 as follows (Enkovaara & al. 1988, 15) "The kernel of the RATAS systems is a product model for structuring all data on a specific building, for the use of design, production and maintenance." This goal has included the promise that the owners and facility managers can use BIM as a powerful tool for carrying out management operations more efficiently. On the other hand, it is recognized that thus far, the industry has mainly used BIM in design and construction and that its use in Facility Management (FM) and operation is still in its infancy (Eastman & a. 2011, 170)

In the 2000s, it has been pointed out that 85 % of the lifecycle costs of a facility occur after construction is completed. Moreover, approximately 20 billion dollars are annually lost in the US alone due to inadequate information access and

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Korpela J and Miettinen R (2013) BIM in facility management and maintenance: the case of Kaisa library of Helsinki University *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 47-56

interoperability issues during operation an maintenance phases (Newton 2004). It is argued that the use of BIM in FM will significantly help to prevent these losses (Azhar & al. 2012, 21).

Paradoxically, it seems that the owners and facility managers, however, have not thus far been motivated to implement BIM or invest in the creation of interoperability between design and construction models and maintenance software systems. An evident reason for this is that property owners and facility managers do not see sufficient benefits to be gained or positive return in investment of the BIM implementation (Kiviniemi 2013). The BIM literature has reacted to this situation in three ways. First, it has been underlined that positive examples of the implementation have to be reported to enhance the implementation in FM and maintenance. Eastman & al. (2011) present two cases in the BIM Handbook, Maryland General Hospital and Cost Guard Facility. In the Cost Guard facility Planning Case (Eastman & al. 2011, 168) "the project team realized a 98% time savings by using information models to populate and edit the facility management database." Also other authors find the savings in the data handover in the establishment maintenance information systems as an argument for the BIM implementation (Becerik-Gerber 2012). It can be doubted, however, whether the savings in the information handover are a sufficient reason to attract the interest of property owners in the implementation of BIM. Knowledge of more substantial and fundamental BIM-related benefits related to the operation during the building lifecycle may be needed for them to take the initiative.

The second approach dealing with the possible uses of BIM in FM and maintenance is to interview specialists and ask them to forecast what would be the forthcoming areas of BIM use in FM. This takes place by interviews, questionnaires and focus group discussions. This approach produces an expert view of possible or imagined uses of BIM. For example, Becerik-Gerber and her colleagues (2012, 434) found in their study ten areas of the application of BIM. The most frequently mentioned among them were: locating building components, maintaining real time data access, visualization and marketing, and checking maintainability.

The third approach comprises attempts of defining the data structures, conceptual diagrams and technologies that would allow the integration of design and construction models with maintenance software systems. The suggested solutions by which to achieve this include defining the necessary information needed in FM models, creating BIM servers, and outlining FM object repositories etc. These technologically oriented projects create technological conditions for the integration of the systems but do not as such provide motives for the implementation. Also the difficulties of integration, such as unclear responsibilities in the creation of as-built models, problems created by the variety of software used or insufficient supply of complementary tools in different phase of project are mentioned.

The approaches characterized above all assume the point of view of extending BIM from design and construction to FM and maintenance. However, the activities and needs of the owners and facility managers have not been extensively studied. Neither the uses nor challenges of the FM software systems currently in use have been duly reported. In this paper, we aim at contributing to the discussion of the implementation of BIM in FM by studying the relationship between design modelling and the uses of maintenance software in a Finnish project, the construction of Kaisa Library, the central library of Helsinki University. We will interview ten central stakeholders of the project and ask them to report the information tools used in FM and maintenance

as well as their opinions on the future uses of BIM and the problems of its implementation. We will also find out the daily tasks of a caretaker to see, whether there are possible uses for BIM in his work. Shadowing method is used to solve this. Before analysing the Kaisa Library case, we first characterize the state-of-the-art use of BIM in FM and maintenance in Finland.

HISTORY OF BIM IN FINLAND

First projects to create foundation for the use of product models in construction in Finland started already in the late 1980s. Subsequently, several national projects have been carried out. The so-called HUT600 project in 2002 was a pilot in which models were used in design (Hänninen et al., 2010). In 2002 the ProIT–project was launched, with the aim of create a common practice for modeling. As a result, common product modeling instructions were published. (Kiviniemi, 2006) At 2007 Senate Properties published their own BIM requirements, which served as a basis for the Common BIM requirements 2012.

The Common BIM requirements (Yleiset tietomallivaatimukset, YTV) present the requirements for modelling and using BIM in a construction process. Finnish real estate owners, developers, construction companies and software vendors created the requirements. One of the series concentrates on using BIM in facility management. It points out that building information modelling is a relatively new concept in facility management and practices are still under construction. Because of that, the Common BIM requirements for facility management mostly introduce opportunities and alternatives rather than requirements.

Our research group studied several life-cycle projects carried out in central Finland in 2011. In an interview, a property manager in charge of a life-cycle project strongly stated that a maintenance manual is an essential tool in facility management and maintenance.

"It is an unbeatable tool for a property owner today. It's an absolute precondition for being able to do my job properly… The maintenance manual is a tool for a maintenance company. It's a tool for the management of a maintenance company. It's a tool for a property manager. It's a supervisory tool for a property owner. He will be able to see what's going on all the time. For the users, in this regard it is a tool, because all service requests are made using it." (property manager)

Correspondingly, the property manager did not find good reasons for implementing BIM in maintenance. One reason for this was the risk of incorrect information related to using BIM in maintenance. An as-built model has to be done correctly and maintained through the life cycle of a building. The model has to be reliable and if it fails (even) once, its value is compromised. As far as we can evaluate, this statement reflects well the state of Finnish construction industry.

"The problem is that when the modeling is done; it must correspond to the real product. If it doesn't, the point of modeling goes down the drain right away. And that's the challenge, for example when in the construction site they have done some installations that deviate from the plans and models, so how to correct these deviations in the drawings and models. If, even once, somebody would like to use the models but he notices that it's not correct, the models will then be forgotten and they say that let's do it like we have done before. And that is, in my opinion, the biggest fear in modeling: who will maintain, and who is capable of maintaining the models

through the life cycle of a building. It has to be maintained all the time." (property manager)

KAISA LIBRARY: GOAL OF THE MODELLING AND DATA HANDOVER

Our research's site, Kaisa Library, is the central library of University of Helsinki now with room for 1 500 000 books, 5000 customer, and 150 employees. The design phase started in 2008, renovation and construction started at spring 2010. The building was completed two years later and opened in autumn 2012.

It was required in the design contract that the architect and designers use modelling in preliminary drawings. After that, modelling was optional. The goal of modelling was to get useful data for priced bill of quantities and to secure enough space for HVAC routings. The contractor also used IFC-models for crosschecking the architect and engineers' designs.

The architect made nearly 300 drawings and planning documents, of which most were 2D line drawings. However, the architect used the model for making floor plans, indoor wall drawings, and stair and elevator charts as well as a base of those 2D line drawings. Electrification engineers modelled the preliminary drawings. They modelled the cable routings, but all installation solutions are not in the model. HVAC engineers modelled the main routings in the right height. HVAC-engineers delivered 2D drawings that were from the model but all changes during the construction phase were made in those 2D drawings only (using drawing symbols and numeric information). The structural engineer used modelling. The main drawings for construction were from the model as such or with minor changes. Reinforcements were not modelled.

The data handover in the project was realized in two ways. First, all design documents and drawings, including the models were handed over. Models were handed over both in native and in a combined IFC format. These models can be used in future refurbishments. 2D drawings were saved as DWG-format and PDF-format in the University's electronic archive. In addition, all project documents were archived in paper form.

Second, information was collected by a separate procedure for the RYHTI maintenance manual. Ryhti is a product of a Finnish building services consulting firm, Granlund Oy. The main users of the maintenance manual are caretakers, technical building managers and in some cases, contracted service producers. The coordinator of the maintenance manual (an employee of Granlund Oy) sent a comprehensive list of required information to designers and contractors. There were 13 named sources of information in the list and additionally, 35 other smaller suppliers. The number of different types of information, the source of information and some examples are depicted in Table 1. Information in the maintenance manual is in PDF-format so it is easily opened and read. The maintenance manual does not include models.

Table 1: Sources and number of different information types gathered in the maintenance manual

Source of information	Number of items of data required	Examples of information
Architect	6	Basic information, location drawings, window schedules
Structural engineer	4	Types from structures, system description
HVAC engineer	9	Catchment area drawings, target values for indoor conditions
Electrical engineer	9	Catchment area drawings, target values for electricity consumption
Main contractor	2	Material information
Ventilation casing	2	Device card information
Pipe contractor	4	Device card information, repair and care instructions
Ventilation contractor	4	Device card information, repair and care instructions
Automation contractor	5	Device card information, repair and care instructions
Electrical contractor	6	Device card information, repair and care instructions
Sprinkler contractor	5	Sprinkler location drawings
Reserve power contractor	3	Device card information, repair and care instructions
Elevator contractor	2	Device card information, repair and care instructions
Other suppliers	35	Use, repair and maintenance information
TOTAL	**96**	

The information handed over to the electronic archive guarantees that all possible information is in use for future refurbishments. The data collected for the maintenance manual are the information most needed in the everyday maintenance work.

THE USE OF INFORMATIONAL TOOLS IN MAINTENANCE WORK

As part of the study, the work of the caretaker of Kaisa Library was shadowed for two days. Shadowing is a research technique, which involves a researcher closely following a member of an organization over an extended period of time. The researcher follows the person being shadowed everywhere he or she goes and takes field notes about what the shadowed person is doing, with whom is he or she discussing, and the times and contents of conversations. (McDonald, 2005, Czarniawska, 2007) The data consist of 9 hours of audio and 5 hours of video material, and the field notes. In the analysis, the recordings were watched and listened to and with help of them a data template was filled. The data collected included 61 events, the starting and finishing times of these events, conversations related these events, and the software used. The events were categorized into 10 main types of tasks. The tasks, the number of different events and the time spent in these tasks are listed in Table 2.

Table 2: The caretaker's tasks

Task	Explanation	Time spent (minutes)	Number of realized events
Following the work of subcontractors	Following the work of subcontractors, commenting, helping	135	11
Leading subcontractors to their posts	Opening doors, guiding routes	88	12
Regular inspections	Monthly inspections in ventilation plant rooms	75	5
Repair and maintenance tasks	Repairing things, changing fuses, putting warnings of falling snow	64	7
Using automation and maintenance software	Checking automation system, maintenance manual, e-mail	48	7
Checking smoke detector system	Regular test of smoke detector system	42	1
Looking for and delivering information	Looking for information from papers and software, delivering it to subcontractors	41	4
Investigating announced faults and problems	Investigating faults for further measures	36	6
Conversation with users, feedback	Getting and giving feedback, changing information	17	7
Ordering subcontractors	Ordering subcontractors for falling snow	9	1

The analysis shows that the caretaker spent most of his time following, guiding and helping subcontractors and other workers. The caretaker followed the subcontractors' work, listened to them and collected “silent information” about the repairs. The second biggest part of his time was spent leading subcontractors to their posts. Kaisa Library is a complex building and the most of the routes contain locked doors. The caretaker guided the routes and opened doors to subcontractors.

Third, the caretaker made regular inspections in ventilation plant rooms. He inspected every ventilation plant room monthly to secure that everything worked correctly. The fourth task consisted of small repair and maintenance tasks such as changing fuses and putting up signs and fences to warn about falling snow.

Fifth, the caretaker spent time on his computer checking the building automation system, checking and filling the maintenance manual and reading his e-mail for service requests.

In addition to these tasks, the caretaker also spent time checking the smoke detector systems, looking for and delivering information, investigating reported faults and problems, discussing with users and ordering subcontractors.

Table 3 presents the software used by the caretaker and the main uses.

Table 3: Software the caretaker used

Software	Use	Number of realized events
Trend – building automation and energy management system	Watching data sent from control panel switchgears	3
	Keeping track of room temperatures	1
	Keeping track of daily energy consumption	1
	Checking ventilation system diagrams	2
	Checking alarms	4
Atmostech – building automation system	Checking ventilation system diagrams	3
	Keeping track of daily energy consumption	1
	Checking a meter read-out	1
	Looking for information about devices for the maintenance manual	2
Ryhti – maintenance manual	Tagging tests and regular inspections done	2
	Keeping track of monthly energy consumption	2
	Checking, responding and commenting service requests	2
	Checking a use register	1
Tampuuri – maintenance manual	Keeping track of monthly energy consumption	1
	Looking for last year data for a new maintenance manual	2
E-mail	Getting service requests	4

The caretaker used two building automation software, two maintenance manual systems and e-mail. The caretaker used building automation software for keeping track of and observing the general condition of buildings. He checked alarms, read diagrams and meters to get an overall picture of the buildings.

The caretaker used Ryhti maintenance manual in tagging tests and the regular inspections made. He also checked and commented on service requests and kept track of energy consumption. The other maintenance manual was used only when he tried to find out information on another building he took care of besides Kaisa Library.

VIEWS OF THE STAKEHOLDERS ABOUT THE POSSIBILITIES AND CHALLENGES IN UTILIZING BIM IN MAINTENANCE AND FM

The coordinator of the maintenance manual, the caretaker and the contact person of the library had no views about either the possible uses of BIM in maintenance or the requirements for utilizing it. This was evidently because they mainly operated with RYHTI and other maintenance software and were not knowledgeable of BIM.

The architect had doubts whether there was anyone capable of maintaining the model and its information content in maintenance. The HVAC engineer and the BIM expert also thought that maintaining the model would require skills of the maintenance personnel. However, the HVAC engineer and the BIM expert found many possible

uses for model, such as space management and planning and scheduling maintenance tasks.

"If they don't maintain it [the model], it will lose its meaning. And I can't tell what will happen to it [the model] within the next 10 years, for example. Like, who is the person to maintain the model?" (architect)

"In my opinion, it [the model] would need to be useful. It is good just in the construction phase, but it seems senseless if its use ends there. It should be able to be used somehow for this sort of maintenance manual data, or that it would be directly obtainable to maintenance software." (BIM expert)

Persons in the real estate administration responded positively towards modelling. The property service manager combined BIM to environmental issues and simulations and meters in energy consumption. More generally, he found it potentially useful to have a model for calculation and simulation. The HVAC Coordinator thought that using models in maintenance would require simplification of the designers' models. The different maintenance models should be allocated to specific tasks so that they contain only the needed information.

"But if we want it [BIM] in use in maintenance, it should be able to be reduced so that all its elements are in a scale that is reasonable in maintenance. At this moment, these needs [between different maintenance and repair tasks] diverge so greatly that it would be possible to use the reduced model in different sectors such as fire safety, electro-technical repairs, and controlling different dangerous situations… The use of this building information model should be increased the right way, the use of this heavy model as reduced, controlled, and allocated to different actions." (HVAC coordinator)

The technical building manager was hesitant about the benefits of models and suspected it would be time consuming and expensive to build a useful model. He imagined that models could be useful in getting a better picture of a room or space for renovation and in helping with making contracts with service providers.

"…One can't always remember the shape of a space so then, if you could perceive it better with a picture, and then maybe if more people had to discuss one thing so there, in that situation, it perhaps (-) I don't know, were you looking for something like this?" (technical building manager)

CONCLUSIONS

Our expectation at the beginning of the study was that the central library project would elucidate the relationship between design and construction modelling and the FM information systems. It, however, turned out that the owner and the client wanted the project modelled only in the early stages of design. The client announced that it would not pay for modelling after the early design phase and the decision of the use of models was left to the designers. For this reason, an as-built model never emerged and the possibility of interaction between design modelling and maintenance software disappeared.

The case, however, showed that the Facility Management had been active for years in developing and interconnecting FM and maintenance tools it had implemented. These tools included Optimaze space management system, RYHTI maintenance manual, ATOP cleaning systems, and an electronic archive of drawings of all buildings as well as the newest system, a system for planning the care of the outdoor area. The owner

underlined that information can be exchanged between the systems. For this, the property owner has asked the vendors of Optimaze and RYHTI systems to develop a function that makes the communication between the two systems possible. For the Facility Management it was a challenge to get these information tools into efficient use. They thought that the uses of BIM models would not provide an essential added value in relation to the informational systems already in use. In addition, they thought that the use of the design of BIM models would be too demanding both for the facility management and even more for the maintenance personnel. The challenge for the FM is to get the RYHTI maintenance manual into efficient use.

The representatives of facility management did not see concrete uses that would exceed the possibilities of the present uses to be valuable enough for the investment in maintaining the BIM models. The management, however, believed that the utilization of the models would proceed. They thought that the possible progress would realize by requiring the designers to provide models from which the key information could be directly transferred to Optimaze and RYHTI. This solution would, however, require that the parts and sets of information needed for these two systems should be defined in a way that specifies the requirement for the designers.

The case shows that instead of defining possible or imaginary uses for BIM model, the starting point should be shifted to the needs of the owners, who will be in a key position in enhancing the utilization of BIM in FM and maintenance. Maybe a rethinking of the concept of BIM is also needed. It has strongly been emphasized that the stakeholders should share all information during the lifecycle. It might be more realistic to recognize that the FM and maintenance information systems are an essential part of building information management with their own functionalities and contents that differ from the models developed to be used in design and construction. A partial, stepwise integration based on selective communication between systems may be the way forward. Such steps of integration between multiple information tools will partly take place locally according to the needs of the owners.

REFERENCES

Azhar, S, Khalfan, M and Maqsood, T (2012) Building information modeling (BIM): now and beyond. “Australasian Journal of Construction Economics and Building”, 12(4), 15-28.

Becerik-Gerber, B, Jazizadeh, F, Li, N, & Calis, G. (2012) Application areas and data requirements for BIM-enabled facilities management. ”Journal of Construction Engineering and Management”, 138(2), 431-442.

COBIM (2012) Yleiset tietomallivaatimukset 2012. Osa 12. Tietomallien hyödyntäminen rakennuksen käytön ja ylläpidon aikana (in Finnish)

Czarniawska, B. (2007) Shadowing and Other Techniques for Doing Fieldwork in Modern Societies. Malmö/Copenhagen: Liber/CBS Press.

Eastman, C. Teicholz, P. Sacks, R. & Liston, K. (2011). BIM Handbook. A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors. New Jersey: John Wiley and Sons, Inc.

Enkovaara,E, Salmi, M, Sarja, A (1988) RATAS project. Computer aided design for construction. Hämeenlinna: Karisto Oy.

Hänninen, R, Jokela, M, Aavaharju, H, Reinikainen, E (2010) “Insinööritoimisto Olof Granlund Oy. Suomalaista talotekniikan suunnittelua ja konsultointia vuodesta 1960” Keuruu: Otavan Kirjapaino Oy. in Finnish

Kiviniemi, A. (2013), Value of BIM in FM/OM – why have we failed in attracting owners and operators? Presentation in "BIM and Facility Management" seminar, April 4th, in Aalto University, Espoo.

Kiviniemi, M (2006) General introduction. Pro IT. http://virtual.vtt.fi/virtual/proj6/proit_eng/indexe.htm

McDonald, S (2005) Studying actions in context: a qualitative shadowing method for organizational research. "Qualitative Research", 5(4), 455-473. SAGE Publications (London, Thousand Oaks, CA and New Delhi)

Newton, R. S. (2004) 'Inadequate Interoperability in Construction Wastes 415.8 Billion', *AECNews.com*, 13, Article 342.

CONSTRUCTION DESIGN AND TECHNOLOGY

A DECISION EVALUATION MODEL TO CHOOSE BETWEEN MANUFACTURING OFF-SITE OR ON-SITE METHODS FOR CONSTRUCTION OF HOUSE BUILDING PROJECTS

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Despite the wealth of knowledge and information on off-site manufacturing systems, current decision making models do not adequately provide a clear cut choice between using offsite manufacture of building elements and onsite in-situ construction, especially at the pre-construction stage. This paper describes the development of a Decision Evaluation Model (DEM) that provides this opportunity particularly for house building projects. The primary objective of the model is to improve the quality of information on which the decision is based. Having carried out an extensive literature review, primary research data and information was collected from 30 structured interviews, questionnaires completed by 30 selected respondents, and 30 case studies made up of 15 manufacturing 'offsite' projects and 15 projects using 'onsite' construction methods. A robust set of factors have been identified, measured and ranked according to their significance in the decision. Using these factors, a methodology has been developed to measure and evaluate the characteristics of a project, which forms the core of the DEM. The developed model enables decision makers to clearly establish whether to use offsite or onsite construction as a construction strategy. The DEM model provides the opportunity to assist the construction practitioners and clients in making decisions based on adequate data and predictable outcomes against any given project within its environment.

Keywords: decision making, decision evaluation, construction strategy, off-site manufacturing

INTRODUCTION

Since 1998 when Egan recommends the use of offsite innovations in construction (Egan Report, 1998), the UK house building industry has faced additional demands such as: the call for a reduction in CO2 emission and the environmental impacts of buildings, shorter project duration and costs savings, reduction in defects, elimination of accidents and ill health, and improvement in house building supply rate (NHBC

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Elnaas H, Ashton P and Gidado K (2013) A decision evaluation model to choose between manufacturing off-site or on-site methods for construction of house building projects *In*: Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 59-67.

House, 2009; Ross et al., 2006 and Housing Forum, 2004). Experts have suggested that traditional form of construction is failing to meet these and future demands. Blismas and Wakefild (2007) stated that Off-Site Manufacturing (OSM) can contribute to meeting some these demands facing the construction industry. Housing Corporation (2007) suggests that the potential of using OSM may be a key vehicle for driving the process and efficiency improvements within the house building sector. However, despite this opportunity, Goulding et al (2012) stated that the uptake of OSM is much lower than expected in the UK construction industry. The reason for this has been identified to hinge on the many issues and questions that need to be addressed within the client's or the practitioners' decision making process that leads to the use of OSM for building projects. This work provides the evidence to support the need for the development of a new model to assist the construction professional to make decisions on whether to use offsite systems or onsite methods of the construction particularly for house building projects.

THE NEED TO ESTABLISH THE CONTEXT OF THE DECISION MAKING PROCESS

Whilst there exists decision support systems and evaluation techniques, Pasquire and Gibb (1999) argued that decisions to use offsite techniques in construction are still largely based on unreliable/subjective evidence rather than accurate data, as no formal measurement procedures or strategies are available. Further, Blismas et al. (2006) stated that the decision making process that is used to evaluate to what extent a component or a building system should be produced offsite is inadequate. Elnaas el al. (2012) argued that despite the wealth of knowledge and information available in the UK, the house building industry seems to be failing to use existing models and systems designed to improve decision making.

Industry professionals have expressed their interest in the process of Off-Site Manufacturing (OSM) systems in construction, however due to the lake of expertise in the area of OSM decision making, some professionals have simply avoided the use these technologies (Ogden, 2010). A major reason, established by Pasquire and Gibb, (2002) is that contractors are unwilling to adopt OSM because they have difficulty ascertaining the benefits that would add to their individual project.

CIRIA (2000) reported that the decision making process used to evaluate the application of OSM in the construction process is poorly understood. Pasquire et al (2004) have re-emphasised the inadequacy of the decision making process, while Blismas et al. (2006) said that decisions regarding the use of OSM are often unclear and complex. Pasquire and Gibb (2002) added that the decisions used in the construction industry seem to be based on anecdotal evidence rather than reliable data, as no formal measurement procedures or strategies are available. Pan et al (2008) reminded practitioners that with increasing pressure on construction professionals to improve efficiency and to make decisions quickly, there is a lack of rational, robust and balanced decision criteria for building system selection in house building.

The literature review clearly indicates that there has been very little evidence to suggest that the existing decision making systems designed in the context of OSM are meeting the current needs of the construction practitioners. Therefore, there is a need for a mechanism to be designed based on robust knowledge of decision making methodology in the house building industry.

Elnaas et al., (2012) defined that decision making is an on-going task, carried out throughout the project life cycle and it is the process of problem solving activity, through making a conscious choice or selecting to achieve an objective or desirable outcome. Further, Lucey (1997) stated that making decisions must decide by some means to choose the outcome or outcomes which are desirable to decision maker(s) and to do so after some form of appraisal of the situation. While, Choo (2006) declared that an alternative decision is considered most favourable if it is greater to all other alternatives when a single, consistent set of criteria is used to compare all the available alternatives. Abdullah and Egbu (2010) argue that the best decision should be supported with sufficient information and knowledgebase of the decision making context.

In this research, the context of making the decision is to determine and choose between manufacturing OSM systems or onsite methods as a construction strategy for house building projects. This will require an optimum decision strategy which involves careful understanding, measurement and evaluation of a number of drivers, constraints and factors that can have the most influence on successful decision making process.

THE RESEARCH METHODOLOGY

Mixed methods were employed throughout this research using both qualitative and quantitative approaches for data gathering including literature search and review, semi-structured interview, questionnaire survey and case studies. A total of 30 interviews were carried out using semi-structured form with leading construction professionals and members of BuildofSite (BoS) organisation. All the interviewees were senior managers and directors with responsibility for making company policy decisions including clients, contractors, consultants, project managers, design managers and construction managers. This mixed range of views and opinions explored how decisions to use OSM systems were currently being made in the house building industry.

A further 30 case studies, which included 15 projects using OSM systems and 15 projects using on-site construction methods, were conducted. This provided a comprehensive set of factors and the impact of each factor on the outcome of the decision made when considering to use or not to use OSM systems for house building projects. This research has focused on typical domestic housing developments consisting of one to four bedrooms homes, flats, apartments or accommodations units.

A questionnaire survey targeted house builders using the data obtained from construction professionals on decision making to use of OSM systems; and further explored how decisions to use onsite construction methods were currently made within the industry. The survey was sent out to the top 100 UK construction contractors involved in house building projects. The questionnaire has been designed in a manner to enable respondent to answer either from past experience or from current on-going projects. There were 36 responses collected but only 30 were included in the data analysis simply to equal the number of interviews that have been conducted.

The outcomes of which were used to establish 16 themes of decision factors and a selection criteria. The data obtained from both offsite and onsite studies were analysed using a five point likert scale. In order to derive frequency index, importance index

and significance index for each factor. The frequency index (Fi) was derived and established using the following function:

$$Fi = 100 * \sum (f / F)$$

Where:

f = frequency of possible weighting
F = total number of respondents

Whilst, the importance index (Ip) was derived and established using the following function:

$$Ip = 100 \sum (a * f)/AF$$

Where:

a = the weighting
A = maximum possible weighing
f = frequency of possible weighting
F = total number of respondents

Moreover, the importance indices were used to calculate a significance index (SI) for each factor on both offsite and onsite data using the following equation:

SI = Importance index (Ip) * Frequency index (Fi)

Having established the importance and significance indices of the sixteen themes factors, the severity indices (SvI) are calculated as the difference between significance indices of 'offsite' and that of 'onsite' for each theme in the matrix. If the value of severity index of a factor is positive (≥ 0), then the decision favours using offsite. However, if the value is negative (<0), it means that the decision is in favour of using onsite construction methods for a given project.

The decision maker may need to come back and check the impact and interrelationship of the importance indices of some factors if the value of severity index of a factor is equal zero (= 0). The severity index matrix could be presented using a simple Microsoft Excel spread sheet, which should give a summary of all information of the theme decision factors.

THE DEVELOPMENT OF DECISION EVALUATION MODEL (DEM)

A critical success factor for any model that is expected to be used by practitioners is its user friendliness and simplicity. The proposed new model has been designed in four phases, identified in Figure 1. The four phases were identified by this research whilst analysing the data and information collected from the interviews, questionnaires and case studies as part of the model development stage of the research.

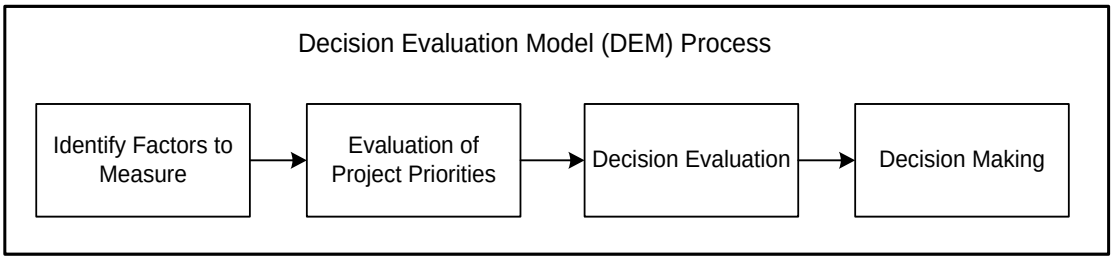

Figure 1: Illustrates decision evaluation model process

The first phase of the model deals with strategic planning of the project from the client's statement of need, brief development to project scheme development. It involved basically the identification of project priorities. Phase two involved the establishment of a means of measuring the impact of the 16 theme factors based upon the project in question. As part of the third phase, the severity index was developed using the importance and significance indexes of the factors to be used as database for the evaluation of decision. Phase four involved the development of mechanism for evaluating project characteristics in order to make a decision on whether to use offsite or onsite construction methods based on adequate data and predictable outcomes.

Blismas et al (2006) argued that the evaluation method used within conventional decision making process is often by considering cost of materials, labour and transport and its associated costs into account when comparing various construction methods. While other sources of value, such as quality, health and safety, process, procurement benefits are not often evaluated in monetary context, either implicit or overlooked within the selection. Further, Laing et al (2008) stated that the large majority of cost modelling work focused onsite work, but a detailed appraisal of offsite procedures would in itself be a useful outcome. They also argued that accuracy in estimating must be drawn from an understanding of the factors in a given situation, rather than relying on a general mathematical technique. Thus, the new model was developed to address this significant challenge rather than to make decision based on subjective evidence. The DEM model has been developed to be used in practice to structure the decision making process, improve the quality of information on which the decision is based; providing the end user with a user friendly interface to assist in making decision against any given project within its environment.

PRESENTATION OF DECISION EVALUATION MODEL (DEM)

The Decision Evaluation Model (DEM) has been developed and presented as shown in Figure 2. The DEM follows the four basic phases described earlier:

- Decision Selection Matrix
- Evaluation Priorities Matrix
- Decision Evaluation Matrix
- Decision Making Outcomes

The four phases involved in the development and evaluation process of making decision will drive the process of identifying an optimum decision strategy involving careful measurement and evaluation of number of factors that can have the most influence on successful decision of choosing either manufacturing 'offsite' or using 'onsite' methods as a construction strategy of any given project. These phases are detailed as following:

Phase 1 - Decision Selection Matrix

The DEM model begins with the evaluation of client's statement of need and the outcome of brief development into its first phase, in order to identify project priorities and desirable outcomes of project. The project priorities need to be set and named according to the established16 themes of decision factors that need to be considered based upon their significance on the project.

Having identified priority factors of the project, the model functions by using codes for each of the 16 factors as shown in the figure (i.e. A: Time, B: Quality, C: Cost, D: Predictability, etc.), which is the only input data is required into the model. The user will evaluate those factors using the Decision Selection Matrix of the DEM depending upon their priorities and significance for given project. Each single factor will be evaluated versus the other 15 factors in the matrix, by putting the code of the right factor that can add value to the project depended upon its set up priorities in the suitable cell in the matrix. The value here can be referred to how desirable a particular evaluation outcome is, the value of alternative between each two factors versus each other, whether in money, satisfaction or other benefits, for willing project outcomes.

DECISION EVALUATION MODEL (DEM)

CLIENT	
PROJECT REF.	
PROJECT NAME	
PROJECT LOCATION	

DECISION FACTORS SELECTION MATRIX

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
A. Time																
B. Quality	B															
C. Cost	C	B														
D. Predictability	D	B	C													
E. Interface Issues	E	B	E	D												
F. Environmental Issues	A	B	C	F	F											
G. Performance	A	B	C	D	E	G										
H. Labour	A	B	C	D	H	F	G									
I. Productivity	A	B	C	I	I	I	G	I								
J. Lack of Space	A	B	C	D	E	F	G	J	I							
K. Safety	K	B	K	K	K	K	G	K	K	K						
L. Project Complexity	A	B	C	D	E	F	G	L	I	L	K					
M. Logistics Issues	A	B	C	D	E	M	G	M	I	M	K	L				
N. Availability of Resources	A	B	C	D	E	N	G	N	I	N	K	L	M			
O. Planning Issues	A	B	O	O	O	O	G	O	I	O	O	O	O	O		
P. Market Demand	P	P	P	P	E	P	P	P	I	P	P	L	P	P	P	

DECISION EVALUATION MATRIX

		TOP 10 RATED FACTORS FOR PROJECT	Severity Svl	± QUANT	DECISION	
Highly Important	F1	B. Quality	48.75	48.75	+ve (off-site) -ve (on-site)	
	F2	P. Market Demand	1.74	50.49		
	F3	K. Safety	-14.85	35.63		
	F4	C. Cost	-41.16	-5.52		
	F5	I. Productivity	3.28	-2.24	ON-SITE	Decision based on the ***Top 5*** factors
Moderately Important	F6	O. Planning Issues	-3.06	-5.30	ON-SITE	Decision based on the ***Top 6*** factors
	F7	A. Time	35.47	30.16	OFF-SITE	Decision based on the ***Top 7*** factors
	F8	G. Performance	11.30	41.46	OFF-SITE	Decision based on the ***Top 8*** factors
	F9	D. Predictability	15.49	56.95	OFF-SITE	Decision based on the ***Top 9*** factors
	F10	E. Interface Issues	8.66	65.61	OFF-SITE	Decision based on the ***Top 10*** factors

FINAL DECISION SUMMARY

NUMBER OF FACTORS CONSIDERED	7
RECOMMENDED CONSTRUCTION METHOD	**Off-Site** Construction Methods
DATE	15/05/2013
DECISION MAKER / USER	GK

EVALUATION PRIORITIES MATRIX

Factor Code	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
Occurrence (Oi)	9	14	10	8	8	5	9	1	10	1	11	5	4	3	10	12	(Occurrence of Each Factor Code in the Matrix)
Frequency (Fi)	56.3	87.5	62.5	50.0	50.0	31.3	56.3	6.3	62.5	6.3	68.8	31.3	25.0	18.8	62.5	75.0	(Frequency (%) of Each Factor)
Rating (Ri)	F7	F1	F4	F9	F10	F11	F8	F15	F5	F16	F3	F12	F13	F14	F6	F2	(F1 to F16, Where F1 being the Highest Rate & F16 the Lowest Rate)

Figure 2: Illustrates the design of the Decision Evaluation Model (DEM)

Phase 2 – Evaluation Priorities Matrix

The focus in the second phase is to evaluate the project priorities into three sub-stages. Firstly, the factors codes entered in Decision Factors Selection Matrix (stage one), will be used to generate number of occurrence automatically for each factor. The function used to derive the Occurrence Indexes (Oi) as follows:

$$Oi = \sum (a * f)$$

Where:

a = weighting
F = frequency of possible weighting

Secondly, the number of occurrence will be used to calculate frequency indexes of each factor. The equation used to derive the frequency Indices (Fi) is as follows:

$$Fi = 100 * \sum \left({}^{Oi}/_{F} \right)$$

Where:

Oi = Occurrence index of each factor
F = total number of possible factors

Thirdly, ranking those factors based upon their significance, which will be automatically generated using the frequency indexes. This ranking system will rank and put in order the factors that can have the most influence on decision for project from F1 to F16, where F1 the highest and F16 the lowest ranked factor in the evaluation of project prioritisation stage. The characteristics of each factor will possess to a greater or lesser extent of value on decision and outcomes. In this stage, each single factor can be ranked from F1 to F16. Thus, multi-equations of probability used to derive the rating Indices (Ri). This means that there is a 16 probability of a chance for example to be F1.

Phase 3 – Decision Evaluation Matrix

The function of Decision Evaluation Matrix is quantified by taking the top ten ranked factors from the outcomes of previous stage to be considered at this stage in order to evaluate them in favour of project. The model will record those factors automatically based on their significance ranking F1, F2, F3 – F10, respectively in column three of the matrix. A severity index will also be recorded for each factor in column four of the matrix using Severity Index Matrix (database), in order to calculate and generate quant indices (Qi) and recorded in the fifth column of the matrix. This will indicate and make a decision on whether the project is in favour of using offsite or onsite construction methods at F5, F6, F7, F8, F9 and F10. The DEM will automatically indicate based on Quant indices (Qi) that the decision is to use offsite at any factor, F5, F6, F7, F8, F9 and F10 if its value to use offsite is greater than or equal zero (≥ 0) or if the value indicated positive (+) value. In contrast to this, the decision is to use onsite at any factor, F5, F6, F7, F8, F9 and F10 if its value to use offsite is less than zero (<0) or if the value indicated negative (-) value.

Phase 4 – Decision Making Outcomes

Having the mode deliberation and the inclusion of factors 5, 6, 7, 8, 9 and 10 all indicated to use either offsite or onsite construction methods should be used. The user or decision maker has essential role in this final phase of the model to decide how many factors should be considered among the top ranked factors if not all ten factors, which have the most potential for achieving predictable of project outcomes. Because, there can be different decision outcomes on whether to use offsite or onsite methods at each factor F5 to F10. Among the development of the model, the authors established that the decision should be based on minimum of 5 factors and maximum 10 factors. This was taken into account because all the 30 case studies were conducted on both

offsite and onsite projects for data collection throughout the research process were considered between 5 and 10 factors for evaluating their decisions.

The final decision of recommended construction method, therefore, will be the indicated methods at the end of decided number of factors to be considered at the Decision Evaluation Matrix as construction strategy for a given project. If factors that have been identified as the priorities of project did not appear among top 10 then the user/decision maker may need to go back to the first stage of the model to review his/her input data, in order to make the right decision based on project priorities and willing outcomes.

CONCLUSION

The house building industry has the potential to address some of the challenges facing the UK construction industry. The study highlighted that traditional construction methods have struggled to meet these demands. This research concurs with others that suggest the use of OSM systems could contribute to achieving government and industry targets. In order to achieve these improvements, decision making to choose 'offsite' or 'onsite' needs to be better understood. This developed a Decision Evaluation Model (DEM) to enable this to be realised.

This paper makes a contribution to knowledge in two aspects. Firstly, it has established a robust set of decision factors that need to be considered and the establishment of severity indices matrix that maps the impact, the importance and the significance of these factors particularly for house building projects. Secondly, since there is currently no formal method or decision support systems used within the industry designed in the context of decision making, the paper presents the development of new decision support system, DEM. The DEM functions by taking factors that have most influence on the project, and then measure and rank each of these factors by regarding their significance on the decision whether to use offsite against onsite construction methods. The project decision is quantified based upon the evaluation and priorities for project, using the database of the severity indices of those factors.

The DEM model has been developed in collaboration with construction professionals, to be used in practice to structure the decision making process, improve the quality of information on which the decision is based, providing the opportunity to assist the construction practitioners in making decisions based on adequate data and predictable outcomes against any given project within its environment. Obtaining the right construction strategy has to be the highest probability of project success and best fits with the project goals, as well as overall company outcomes. The model has been designed to be user friendly interface and to minimise the time and the quantity of data required by the user to complete the exercise of the evaluation.

REFERENCES

Abdullah, M. And Egbu, C. (2010) Selection Criteria Framework for Choosing Industrialized Building Systems for Housing Projects. Procs 26th Annual ARCOM Conference, Leeds, UK, 1131-1139.

Blismas, N. and Wakefield (2007) Drivers, Constraints and the Future of Offsite Manufacture in Australia. Produced by CRC for Construction Innovation Special Edition 2008. QUT, 27575

Blismas, N., Gibb, A. and Pasquire, C. (2006) Benefit evaluation for offsite production in construction, Construction Management and Economics, 24 (2), February 2006, pp. 121-130, ISSN 0144 6193.

Choo, C. (2006) The Knowing Organization: How organizations use information to construct meaning, create knowledge and make decisions, 2nd ed. Oxford University Press, Oxford.

CIRIA, and principal author Gibb, A. (2000) Client's Guide and Tool Kit for Standardisation and pre-assembly, Construction Industry Research and Information Association (CIRIA), 2000, Report CP/75, 70 pp. ISBN 0860 175448.

Egan, J. (1998) Rethinking Construction: Accelerating Change. Department of the Environment, Transport and the Regions, London.

Elnaas, H., Ashton, P. and Gidado, K. (2012) Factors and Drivers Effecting the Decision of Using Off-Site Manufacturing (OSM) Systems in House Building Industry. 3rd EPPM international Conference, September 2012, Brighton, UK.

Housing Corporation (2007) Modern Talking: Building better value homes using modern approaches. February 2007, London.

Housing Forum (2004) Manufacturing Excellence: UK capacity in off-site manufacturing. London: The Housing Forum.

Goulding, J., Rahimian, F., Arif, M. and Sharp, M. (2012) Offsite Construction: Strategic Priorities for Shaping the Future Research Agenda. Architectoni.ca 2012, 1, 62-73.

Lucey Terrt (1997) Management Information Systems, 8th ed. DP Publications, London.

Laing, R., Craig, A. and Edge, H. (2008) Prefabrication Housing: An Assessment of Cost, Value and Quality. The Robert Gordon University, Adrdeen.

NHBC House (2009) Defining a Fabric Energy Efficiency Standard for Zero Carbon Homes: Executive Summary of Task Group Recommendations, November 2009, London.

Ogden, R. (2010) Year Book: the Build offsite vision. July, 2010, Build offsite, London.

Pan, W., Gibb, A. and Dainty, A. (2007) Perspectives of UK House-builders on the use of Off-Site Modern Methods of Construction, Construction Management and Economics, Vol 25, No 2, 2007, pp. 183-194, ISSN 0144-6193.

Pan, W., Gibb, A. and Dainty, A. (2008) Leading UK housebuilder's Utilisation of offsite modern methods of construction, Building Research and Information, 36(1), 56-67.

Pasquire, C. and Gibb, A. (1999) Considerations for Assessing the Benefits of Standardisation and Pre-assembly in Construction. Report to CIBSE Seminar on standardisation in design and construction of building services installations, 26 October 1999.

Pasquire, C. and Gibb, A. (2002) Considerations for Assessing the Benefits of Standardisation and Pre-assembly. Journal of Financial Management of Property and Construction, 7(3), 151-61.

Pasquire, C., Gibb, A. and Blismas, N. (2004) Off-Site Production: Evaluating the Drivers and Constraints Proceedings of the 12th Annual Conference on Lean Construction, Copenhagen, Denmark, 3-4 August.

Ross, K., Cartwright, p. and Novakovic, O. (2006) A Guide to Modern Methods of Construction. The BRE Housing Innovation Centre Published by IHS BRE Press on behalf of NHBC Foundation.

AN EXPLORATORY STUDY OF INFORMATION MATURITY IN CONSTRUCTION AND DEVELOPING A DECISION-MAKING MODEL

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The efficiency of a design process has a close relationship with effective information management. However, the increasing volume of digital information makes effective information management in design and construction organisations more difficult, in particular in retrieving high value, high quality and, more importantly, "mature" design information when it is needed. There is a need to develop a tool that can assess, or indeed increase, the maturity of any design information for ease of storage, retrieval and reuse with suitable information management tools. The engineering industry has been striving for this for many years, and has been successful in capturing design rationale .Based on a literature review, the aim of this paper is to describe how the concept of capturing design rationale from the engineering industry and its tool called the Design Rationale Editor (DRed) can be incorporated as a new conceptual tool called the DRed-based decision-making model for use in the design stage of construction. It can capture and evaluate design rationale and hence help designers to make better and more effective design decisions through assessing and perhaps increasing the design information maturity. The definition or concept of information maturity in construction has yet to be explored and will form a major part of future work. Future work will be to demonstrate how design information rationale can be captured and edited along the life cycle in the digital environment through the use of real case studies, and to address any issues and limitations on its applications in the industry.

Keywords: design, decision-making, information assessment, maturity, modelling.

INTRODUCTION

The design process for a construction project is not linear, it is iterative; it involves many different stakeholders and is reliant upon having the right information available at the right time. A major challenge in a construction project derives from different organisations relying on a large number of various data sources that are interconnected and interrelated, yet with no proper way or tool to manage these sources in a convenient, integrated and principled way (Franklin et al., 2005). Such an information management issue can be attributed to a lack of a clear and concise understanding of

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Zou RR, Flanagan R, Jewell C, Tang LCM (2013) An exploratory study of information maturity in construction and developing a decision-making model *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 69-80.

the data or information generated and received between different stakeholders, such as designers and engineers and other construction professionals, at the conceptual design stage. This is critical to a successful project to ensure good design decisions are made at the early design stage of a project (Raisbeck and Tang, 2009), such as at the Concept Design stage (RIBA Plan of Work, 2013). These good conceptual design decisions "can demonstrate a constructive approach to planning requirements and greatly reduce the risk of costly later revisions" (RIBA 2011). In order to achieve this, it was suggested that a small increase in upfront costs of just 2% to support sustainable design can, on average, lead to a building life cycle saving in total whole life construction costs of approximately 20% (Kats, 2003). It can been seen that key decisions made at the concept design stage can generate a significant impact on the product in terms of the way it is produced and the strategy to be marketed throughout the life cycle of a construction project.

Research over the last twenty years has shown that the early development of design support systems is imperative to construction projects (Franklin et al., 2005; Kolodner, 1991; Senthilkumar et al., 2010). The systems can assist designers dealing with this massive and complex information, and can provide automated problem-solving abilities at early design stages. At the other end of the value chain, an emphasis has been placed on the provision of more accurate and high value information for building performance analysis and evaluation (Klashner and Sabet, 2006).

This paper aims to demonstrate the importance of capturing and evaluating design rationale, and how the principles of Design Rationale Editor (DRed) tool could be used to develop a DRed-based Decision-making model. This conceptual model would assess the design information maturity at the concept design stage of a construction project, and so help designers and other construction stakeholders to make optimized decisions by assessing design information's context-sensitive characteristics and attributes. The three major research questions this paper will address are: 1)What is information maturity in a design process? 2) How possibly can it be increased through the evaluation and capture of design information rationale? 3) Why is it important to adopt this developing model in collaborative design in construction?

Research rationale

This paper is based on a literature review, where a gap was identified and developed. The literature review revealed that the deficiency of capturing design information with the characteristics of high value, high quality and, most importantly, "maturity", results in information overload and impacts the efficiency of information management in construction. It is therefore important to assess the maturity of information used in construction. Moreover, there is a great potential for the introduction of DRed tool methodology to assist with the capture of design information rationale in construction. There is a potential for integration of this method with a decision-making ,model, which could assess design information maturity, and demonstrate the probability of success of each design option of design packages. It is upon this probability that optimized design decisions can be made.

In recent years, the rapidly increasing pressures of "data everywhere" creating information overload, have resulted in practitioners needing to take more interest in and put more effort into monitoring the effectiveness of their data and information management. The application of digital design tools, such as Building Information Modelling (BIM), breaks down certain information flow barriers and at the same time bridges communication between extended design and construction teams. In practice, commercial data from the UK construction sector also showed that BIM could achieve a

consistent reduction of 8-18% in the cost associated with the design stages of the RIBA Plan of Work 2013, while the upside potential of savings could be as high as 40% (BIS 2011). Moreover, there is a deficiency in generating reliable information within and across project teams, against which a mechanism for the justification (e.g. costs and benefits) of using BIM has to be provided (BuildingSMART, 2010). Unless the issues of capturing reliable information at the concept design stage are otherwise addressed, the benefits of BIM application cannot be achieved (Bernstein and Pittman, 2005).

The difficulties of retrieving high value, high quality and mature (i.e. reliable, stable, precise and complete) design information at the concept design stage are sometimes considered as a major shortcoming of existing digital design support tools. This has led to a disparity between the reality and the simulation of conceptual digital building models (Moffatt and Kohler, 2008). This deficiency is identified as one of technical reasons that hinder the adoption of digital design support tools (Bernstein and Pittman, 2005). In fact, during the design process of a construction project, the stakeholders become more subjective owing to the increasing complexity of design problems and project objectives (Nemati et al., 2002). Consequently, the ability of designers to retrieve and utilise information is critical to the project outcome in its life cycle. There is an increasing volume of design information, and if this is immature (i.e. unstable, imprecise or incorrect) (Hanssen, 1997; Helms, 2000), this can lead designers to make inappropriate design decisions, which will result in the high possibility of reworking the design, and even be fatal to a construction project. On the other hand, the provision of mature information can help designers make effective decisions with avoidance of immature information being used, increase effectiveness of information management. Therefore, it shows the need for a well-developed practical strategy for the purposeful exchange of and integration of meaning, high value, quality and mature information within the digital design environment.

DRed supports the function of mapping and modelling design as an information processing activity, which has been found to help designers view, clarify and structure their design thinking and assist with managing design tasks. The capture and evaluation of design rationale in the engineering industry using DRed has proved to be efficient in assessing design options (Bracewell et al., 2009). This technique can uncover the reasons behind selecting one option over another and allows fully-evaluated decisions. It also provides visualisation and justification of any arguments among immature design decisions, and can possibly make a significant impact on a collaborative design process..

The framework of information evaluation provides the foundation for context-sensitive information assessment (Darlington et al., 2008). This framework has identified the dimensions influencing the evaluation process and defined the elements (information object, design package); characteristics (value, quality, and in this paper, maturity); and attributes (accuracy, reliability, credibility, relevance, accessibility and so on) of information. It facilitates decisions to be made during the life cycle of information about its management, such as acquisition, storage, creation, maintenance and disposal. Moreover, it is a strategy that supports good decisions to be made concerning information in respect of its capability to satisfy the current and short-to-medium-term problem solving or need for decision-making. This strategy promises a basis for the development of an automatic and semi-automatic information maturity evaluation methods

It is a potential of the Bayesian network that it could be used to assess the information maturity of primitive tasks of the defined packages, its probability, and evaluate information maturity attributes (such as accuracy, usability, trustworthiness and so on). The network links various interrelated sub-components together, with each sub-component regarded as a node. In information management and automated design, the network can act as a probability support structure for combining the various

characteristics and metrics into an overall assessment of quality (Tang et al., 2007), and as a design support tool (Matthew, 2007).

NATURE OF INFORMATION IN CONSTRUCTION

Knowledge can be classified in various ways, Quintas' (2000) "Iceberg model" classifies knowledge as explicit, implicit and tacit. This is further explained by Tang et al. (2007), who state "knowledge can be explicit (recorded or codified in some way), implicit (in the mind) or even tacit (cannot be recorded and codified in any format). Explicit knowledge can be stored as information". This design information is uniquely designed, structured and applied to complete a task in a project by decisions made on it. Communication between designers and among stakeholders is a multidimensional flow of information, and is highly dynamic and interactive.

The stakeholders in a construction project have to retrieve relevant information from other data subjects such as colleagues, documents, drawings, models and databases. Therefore, the ability of designers to retrieve and utilise information is critical to the outcome of the project.

DESIGN PROCESS IN CONSTRUCTION

The execution of the design process aims to satisfy the design requirements, in order to achieve design quality of a building, which is a combination of functionality (how useful the facility is in achieving its purpose); impact (how well the facility creates a sense of place); and building quality (performance of the completed facility) (OGC, 2004). Given this, proactive thinking and planning of the design at concept design, in terms of how to achieve design quality, is critical to the success of any construction (OGC, 2004; Emmitt, 2007). Although the introduction of digital design tools, such as BIM, help to address the iterations of redesign in order to refine or amend the functional requirements, design concepts and financial constraints of a project, its use for information management in facilitating effective information management in the construction design process still needs some improvement.

Darlington et al. (2008) discussed the foundations of a framework for information evaluation. They also identified and defined a number of important variables, e.g. the objects of evaluation, the high-level operational contexts in which evaluation takes place, the motivations and post-evaluation actions associated with these contexts and how they and information entity attributes can be mapped on to the information life cycle. This leads to the questions about the value and quality of the design information (Tang et al., 2010) and, more importantly, the maturity of the information in order to avoid unnecessary design reiterations.

THE CONCEPT OF INFORMATION MATURITY

"Right information needs to be available at the right time in the right format to the right person" (Winch, 2002). The term 'right' strongly relates to how 'mature' the information is. There is little literature defining the maturity of information but immature information is defined as tentative, untested and possibly incorrect information (Hanssen, 1997; Helms, 2000; Grebici et al., 2006). In construction, the Lean Management Model proposed by Sacks and Goldin (2007) demonstrated that this method facilitates the replacement of a fixed activities network to be scheduled for the purpose of works' completion in a highly dynamic environment. In order to achieve this goal, the construction schedule should be carried out according to the maturity level of the client's and designer's changes to design. In the construction production phase, maturity is measured according to the state of readiness of a work package or a task (Sacks et al., 2010). Watson (1998) stated that in construction the accumulated data becomes information when it is mature enough and

ready to be passed on from one discipline to another. This information needs to be interpreted and applied by users (information creators and receivers) within the construction contexts (Darlington et al., 2008). Otherwise, immature information will flow from one stakeholder or knowledge broker to another. In this paper, mature information is simply defined as high certainty information (e.g. stable, precise and complete) that can be passed on to the next stage of the design process with the least likelihood of re-iterations and/or other associated uncertainties, which can cause significant impacts on the collaborative design process among stakeholders.

The concept of information maturity assessment for decision-making can refer to the development of a number of approaches to automatic information evaluation (Tang et al., 2007; Zhou et al., 2008). This concept includes the principled characteristics identified by the above researchers as being central to information maturity assessment, including accuracy, usability, trustworthiness (which together consist of quality), currency, benefit, impact and relevance. Such a concept takes the manifestation of "information as thing" rather than merely considering "information as knowledge", since the identification of "information as thing" provides the foundation for considering information as practical objects for evaluation (Darlington et al., 2008). Additionally, information maturity assessment cannot be undertaken in a vacuum, which is characterized by the set of circumstances and facts around the event, for example, context. Therefore, information maturity assessment has to consider the influential and common characterized dimensions. These are the organizational, motivational and information life-cycle dimensions. The consideration of dimensional influence supports information assessment that can have the necessary context-sensitivity.

After taking into account the above, information maturity assessment for decision-making could be explained by an analogy of the "tube map". The tube map was designed to provide the clearest information for passengers, to allow them to discover the shortest and fastest route from one stop to any other. The design process needs to be mapped in the same way, breaking down the process into a number of design packages, with the design options generated within each package assessed on the basis of their information maturity level. An optimised design decision will be made and combined with the consideration of stakeholders' preferences, project goals and expenditure. The "tube map" concept is represented in Figure 1 which illustrates what information has been assessed in relation to its maturity level.

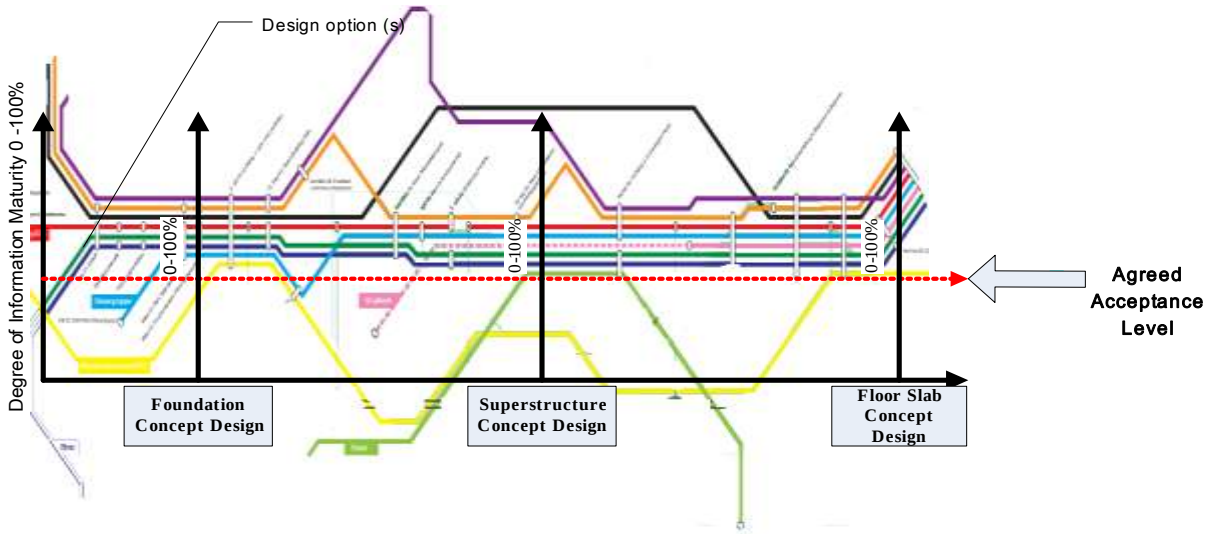

Figure 1 Presentation of "Tube map" concept for assessing information maturity in structure concept design

The x-axis in Figure 1 shows the design packages of the structure concept design, which include the foundation, superstructure and floor slab concept design decisions, while the y-axis represents the level of information maturity for each package (from 0% to100% probability). Each coloured line represents a design option. The lines above the red dotted line (agreed acceptance level) represent the design options (orange, black and purple) with more mature information being represented towards to the right hand side of the maturity map. The travel routes, representing design options, take account of all decision-making criteria that reflect probability, certainty, uncertainty, risky and possibility issues when assessing the information maturity of multiple design options. The point where each line intersects a vertical axis represents the level of the corresponding information maturity variable of a particular design package. As defined, visualising results in this form allows the designers to identify quickly the range of the level of information maturity, the probability of the design options. For example, it can be seen that the best designs for the beam section (which include the design options: purple, orange, dark green, red and light green) have a higher volume of information maturity above the red dotted line (the agreed acceptance level). This means that the five design options meet a project's design requirement better than those with a maturity below the acceptance level. This way of visualizing information allows a quick assessment of information maturity levels. For instance, the purple best design option changes after passing through the entire Girder section, with its maturity probability decreasing. This indicates that the purple design option for the Girder has a strong influence on the design performance, due to its deficiency in meeting the design requirements. The optimised design decision option for each design package can be generated in accordance with a high level of information maturity; the final optimised design will be produced as a combination of all the best options for each package.

The benefits of assessing information maturity are 1) the expected and targeted certainty among designers and other stakeholders on different design options (uncertainties) are lined up so that mature information is provided as an input certainty for the stakeholders in the next stage of the project life cycle; and 2) a unified language for communication, for instance, the optimised design option is the one with the highest level of maturity, is interpreted by a singular language, corresponding to the highest probability. The higher the probability of information maturity, the better is the design option. An agreed acceptance level for information maturity, in others words, an acceptable probability of information maturity, is generated among the decision makers for a specific design package, for example, between the architect and the structural engineer when determining conceptual superstructure structure design. The consensus reached enables the mitigation of the probability of occurrence of arguments or conflicts that may result in design changes. Visualizing information during the design process enables the stakeholders to monitor the variation in maturity levels of the design options.

DESIGN RATIONALE EDITOR (DRED)

An advantage of accurate design maturity assessment is less re-design because the organisations can measure their designs' maturity in the process (O'Brien and Smith, 1995). A better understanding of designers' interactive processes and thinking should help to establish methods for maturity assessment which allow decision-makers and stakeholders to forecast the level of risk on releasing a design option (O'Brien and Smith, 1995). The Cambridge Engineering Design Centre carried out research into information capture, storage and retrieval for 20 years. Lee (1997) undertook a review of the advantages of the available design rationale capture tools while pioneering work can be traced back 43 years to Kunz and Rittel's research at 1970, who developed the Issue-Based Information System (IBIS). A tool called the Design Rationale Editor (DRed) has been developed to assist engineering designers to structure their design thinking, to

capture their rationale, and to reduce the need for paper work (Bracewell et al., 2009). DRed has been popularly adopted by Rolls-Royce in the design stage of production. This paper considers the use (and development) of this tool in relation to the definition of information maturity in construction. This would not only allow the capture of design rationale but could also increase the maturity of design information. The inclusion of the design rationale in the design process makes an important contribution to decision-making in respect of which design options work and which do not. The major contribution made by DRed in the engineering sector is to understand design rationale for taking design decisions by weighting multiple aspects together in the three stages of the traditional design process. It is a linear process that consists of the design task, the creation, the evaluation, and determination of design options.

DRed as a design rationale capture tool has been shown to improve the design process. the listed advantages of using DRed, include the provision of better support for re-design, learning, reuse, maintenance, documentation, project management and collaborative work (Lee, 1997). It also allows "designers to record their design rationale at the time of its generation and deliberation". Functionally, DRed can be complemented with the analysis of BIM, CAD tools, Office, web and communication applications, which designers use to support their day-to-day activities. DRed facilitates the creation of an optimised design portfolio which is structured according to the dependencies in the design rationale, through the capture and evaluation of design rationales. Such a tool with its theory/methodology can assess and then increase the final design information maturity in its routine use, which is potential to improve the design process in construction.

DEVELOPING A DRED-BASED DECISION-MAKING MODEL

The design of a new facility often begins with the search for the most relevant information for a design. In order to support collaborative design between designers, this section of the paper shows how DRed can potentially be developed as a conceptual DRed-based decision-making model to capture the design rationale of designers and hence to assess and then increase the maturity of design information in the concept design stage. Stakeholders in this stage, such as architect and engineer who will make design decisions, are both information providers and information receivers. Therefore, design decisions should be made depending on the level of information maturity (agreed acceptance level), as agreed by the stakeholders concerned (such as architect and structure engineer, in structure concept design process), which is agreed by design team and other stakeholders. By establishing a platform for communication, the developing decision-making model encourages collaborative design between actors from multiple disciplines to share their knowledge and experience about both the design process and the design content. Figure 2 shows the conceptual DRed-based decision-making model in this research and how it can be applied to construction. In this model, the design rationale is displayed in a document as a graph of nodes linked with directed arcs. The user creates the nodes by choosing from a predefined set of element types. More than just to capture design rationale, it is a model to assess design information maturity. Therefore, the key element types include design issue, answer, argument (Bracewell et al., 2009), as well as criteria, attribute, and attribute option. Questions to ask include: 1) What design rationale is worthy of capture? 2) In what form is it post capture? And 3) Once the design rationale has been identified, captured, evaluated and stored, how can it be shared with others for reuse?

As for the application of DRed, designers start on the basis of forming theories concerning the causes of the potential problems, and are keen to find out the evidence to support or refute them. DRed can be used to capture the track of this diagnostic activity during its process, and Figure 2 shows the resulting chart with the diagnosis of evaluating superstructure options by the use of a ‘traffic-light coloured’ system. All the elements in

the DRed chart are given a colour, which represent various statuses of the elements. For example, each superstructure design option will be judged by decision makers' knowledge and experience by manually assigning a colour in a range from red to green. An element with green colour means the designers are satisfied with the diagnosis result, which is precise, complete and correct (i.e. mature), such as in "structure system option 1 " the issue "REQ for typical penetrations" as shown in Figure 2. Conversely, if an element is not satisfied by the designers, it is marked as insolvable and displayed in red, e.g. the issue of "structure cost" in Figure 2. Different design elements are interactive, but not isolated from each other. The linkage among the various design elements is established based on a Bayesian Network (BN) in order to assess their context-sensitive information attributes (such as currency, relevance and so on) within each characteristics (for example quality, value and maturity), in which each design element is regarded as a node. BN is a probability support network structure. Finally, the information maturity of design option 1 is assessed as having an A% probability.

A designer's diverse assumptions are captured and evaluated as answered elements, which will pass along the upstream routine until the issue is resolved. A successful resolution to a design issue relies on the number of answers being accepted. The higher the number, the higher is the percentage of the issues that are resolved. Hence, the maturity of that piece of design information increases until it reaches its optimised level. In the example of design option 1, if one more issue, such as "structure cost" is resolved, the information maturity of design option 1 increases to B%. This is a higher probability which shows an improvement to design option 1. The final optimized design decision needs to be determined after overall consideration of all the potential design options, relying on the assessed level of information maturity.

By visualising the design rationale, the conceptual model can: 1) monitor the design behaviour through assessment and capture immediate design thinking ; and 2) improve the 'richness and clarity' (Bracewell et al., 2009) of recorded rather than personal information, as shown in Figure 2, and hence increase the design information maturity. It helps to line up the targeted and expected certainty between designers and other stakeholders .

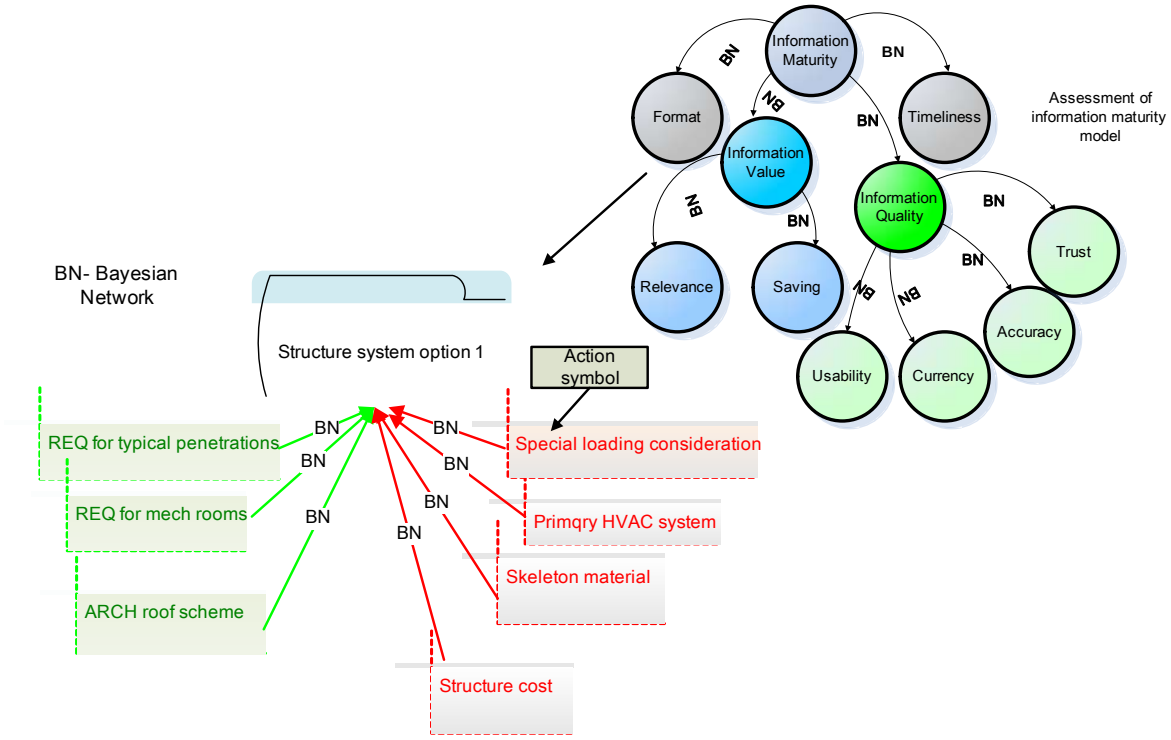

Figure 2 A demonstration of the conceptual DRed-based decision-making model for changing curtain walling system in the conceptual design stage

FUTURE WORK

The definition of design information maturity in construction has yet to be explored and will form a major part of future work. Further research is needed to demonstrate how design rationale can be captured and edited along the life cycle in digital design environment, such as a BIM environment (e.g. through the pre-construction, construction, post-construction and facility management stages), by the use of real case studies. There is a need to address any issues and limitations on its applications in the industry, in particular:

1. Which attributes of mature information in each description should be included in the model?
2. How can the measurement of future value of information maturity be carried out in construction at the conceptual design stage associated with RIBA Plan of Work Stage C?
3. How should the design rationale evaluation be carried out with multiple designers at the conceptual design stage?

Acting too early or too late can turn a good decision into a mistake. Untimely information flow has been proved to affect the quality of decision-making in a design process (Whelton and Ballard, 2002). The time scale for capturing design rationale needs to be explored further. McKenna (1994) treated this kind of decision-making model as being based on bounded rationality and suggested that it should include three investigation processes: the sequential consideration of alternatives; using heuristics to identify the most appropriate alternatives; and choosing on the basis of identifying the first acceptable solution.

CONCLUSIONS

The volume of digitised information is increasing but some of the intrinsic characteristics in the design process, e.g. value, quality and its overall maturity need further exploration. This paper shows that it is feasible to develop a collaborative DRed-based decision-making model to facilitate designers to make effective decisions in the design stage of a construction project. Such decisions will increase the productivity of a construction project design, in terms of cost, time, innovation, and sustainability, and will help to strengthen a company's competitiveness. The process of understanding the nature of information in construction will reveal that the identification of mature information (i.e. high value, high quality information, thereby minimizing the design re-iterations or other associated uncertainties) should be beneficial in bringing about optimized decisions in the design stage of a project. However, the concept of information maturity in construction has yet to be explored. In particular, when dealing with uncertainty and design changes among designers and various stakeholders, the conceptual DRed-based decision-making model could provide a systematic and informative way to show the optimised design decision through capturing and evaluating the design rationale of designers, a concept adopted from the engineering industry. In conclusion, there is a need to apply the conceptual model to construction, to be embedded in the digital working environment, and hence increase the information maturity level of design information among designers in order to facilitate effective information management.

REFERENCES

Bernstein, P.G., and Pittman, J.H. (2005). Barriers to the Adoption of Building Information Modeling in the Building Industry. Autodesk Building Solutions Whitepaper, Autodesk Inc., CA.

BIS (2011). A Report for the Government Construction Client Group: Building Information Modelling (BIM) Working Party Strategy Paper. UK: Department for Business Innovation and Skills.

Bracewell, R., Wallace, K., Moss, M. and Knott, D. (2009). Capturing design rationale. *Computer-Aided Design*, 41, 173-186.

BuildingSMART (2010). Investing in BIM Competence BuildingSMART: A guide to collaborative working for project owners and building professionals. U.K BuildingSMART.

Darlington, M.J., Culley, S.J., Zhao, Y., Austin, S.A. and Tang, L.C.M. (2008). Defining a framework for the evaluation of information. *International Journal of Information Quality*, 2 (2), 115-132.

Emmitt, S. (2007) Design Management for Architects. Blackwell Publishing Ltd.

Franklin, M., Halevy, A. and Maier, D. (2005). From databases to dataspaces: A new abstraction for information management. Appeared in ACM SIGMOD record December 2005.

Grebici, K., Blance, E., and Rieu, D. (2006). Toward PDM systems to support the exchange of preliminary information in design. *International Journal of Product Lifecycle Management*, 1(4), 352-366.

Hanssen, R.W. (1997). Reducing delivery times in engineer-to-order firms by using the concepts of concurrent engineering, *Proceedings of the 4th International Conference on Concurrent Enterprising (ICE'97)*, The University of Nottingham, 8-10, October, 495-508.

Helms, R.W. (2000). Product data management as enabler for concurrent engineering. PhD dissertation Eindhoven University of Technology, BETA Research institute.

Kats, G., Alevantis, L., Berman, A., Mills, E. and Perlman, J. (2003). The costs and financial benefits of green buildings: A report for California's sustainable building task force. CA: Capital E, Future Resources Associates, Task Force members, and the United States Green Building Council.

Klashner, R. and Sabet, S. (2006). A DSS design model for complex problem: lessons from mission critical infrastructure. *Design Support System*, 43(3), 990-1013.

Kolodner, J. (1991). Improving human decision making through case-based decision aiding. *AI Magazine*, 12(2), 52-68.

Lee, J. (1997). Design rationale systems: Understanding the issues. *IEEE Expert*, (May/June), 78-85.

Matthew, P.C. (2007). A Bayesian support tool for morphological design. *Advanced Engineering Informatics*, 22(2008), 236-253.

Moffatt, S. and Kohler, N. (2008). Conceptualizing the built environment as a social-ecological system. *Building Research & Information*, 36 (3) 248- 268.

Nemati, H.R., Steiger, D.M., Iyer, L.S., and Herschel, R.T. (2002). Knowledge warehouse: an architectural integration of knowledge management, decision support, artificial intelligence and data warehousing. *Decision Support Systems*, 33(2), 143-161.

O' Brien, C. and Smith S.J.E. (1995). Design maturity assessment for concurrent engineering co-ordination. Int. J. Production Economics, 41 (1995), 311-320.

OGC (2004). Achieving Excellence in Construction: Procurement guide: Design quality. Office of Government Commerce, London.

Quintas, P (2000). Managing knowledge: A big picture, presented at Routes into knowledge management. City Information Group, Baltic Exchange, London, 11 October.

Raisbeck, P. and Tang, L.C.M. (2009). Humanistic and scientific knowledge management: a comparison of design practice between architects and engineers. The *25th ARCOM Annual Conference 2009*, 7-9 September 2009, Albert Hall, Nottingham, UK. (Awarded research paper - The 'Rod Howes' Commemorative Award)

RIBA (2011) Retrieved at http://www.architecture.com

RIBA (2013) Retrieved at http://www.architecture.com

Sacks, R. and Goldin, M. (2007). Lean management model for construction of high-rise apartment buildings. *Journal of Construction Engineering and Management*, 133(5), 374-384.

Sacks, R., Radosavljevic, M. and Barak, R. (2010). Requirement for building information modelling based lean production management system for construction. *Automation in Construction*, 19, 641-655.

Senthilkumar, V., Varghese, K., and Chandran, A. (2010) A web-based system for design interface management of construction projects. *Automation in Construction*, 19(2), 197-212

Tang, L.C.M., Zhao, Y., Austin, S.A., Darlington, M.J. and Culley, S.J. (2007). Knowledge and information evaluation practice: An exploratory study in a construction firm. CIB W102 3rd International Conference - Information and Knowledge management - Helping the practitioner in planning and building, 25-27 October 2007, Stuttgart, Germany.

Tang, L.C.M, Zhao, Y., Austin, S.A., Darlington, M.J. and Culley, S.J. (2010). Codification vs personalisation: A study of the information evaluation practice between aerospace and construction industries. *International Journal of Information Management*, 30(4). 315-325.

Watson, W. (1998). Project Documentation and Information Flow. ICIS Issues Paper pp. 11

Winch, G. (2002). Managing construction projects: an information processing approach. Oxford: Blackwell Science Ltd.

Zhao, Y., Tang, L.C.M., Darlington, M.J., Austin, S.A. and Culley, S.J. (2008) High value information in engineering organisations. *International Journal of Information Management*, 28 (4), 246-258.

MULTI-STOREY BUILDING RETROFIT WITH A FOCUS ON THE FAÇADE SELECTION PROCESS: A UK COMMERCIAL OFFICE CASE STUDY

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Poorly-insulated existing buildings contribute significantly to the energy use of the built environment. In the UK, the existing building stock is replaced at a rate of less than 2% a year; thus, many of today's buildings will still be in use in 2060. Retrofitting aged buildings can significantly reduce their energy use. This paper analyses the selection process and success factors in retrofit façade decision-making. Literature relating to building retrofit and façade selection is reviewed. A case study is conducted on a five-storey 1970s UK commercial office building, retrofitted in 2011. Data is collected via in-depth interviews with key project decision-makers, a documentary evidence review, and thermography of the completed retrofitted façade. The façade evolution is mapped according to seven identified project stages and the RIBA Plan of Work 2007. The retrofit satisfied the client's aesthetic needs, while delivering an 85% reduction in the 'wall' U-value and a 'B' rated Energy Performance Certificate. Value engineering (VE) greatly influenced the façade selection, with less expensive alternatives replacing original elements of the façade design. The façade's thermal success is linked to the VE focusing on façade elements covering only a small extent of the building. Façade success factors key to attracting tenants (lower running costs and aesthetics) may apply to commercial buildings in general. Thermography aided in assessing the retrofitted thermal envelope, but to act as a tool to aid retrofit façade selection, it should ideally involve a 'before' and 'after' survey.

Keywords: decision-making, façade selection, multi-storey, retrofit.

INTRODUCTION

Retrofitting aged buildings can significantly reduce their energy use (Ma et al. 2012) and "work to the outside of the envelope is likely to be sufficient for most existing buildings" (Mara 2010: 37). Retrofit façade decision-making is a complex area, with strategic decisions being made under conditions of uncertainty. The literature gives examples of methods used to aid retrofit façade selection, but also states that decisions are often not based on well-deliberated calculations and instead, can tend to be based on past experience and built-in norms. This paper provides an insight into the process of multi-storey building retrofit façade selection and explores success in retrofit façade decision-making. The multi-storey focus is driven by the tendency for such buildings erected prior to the introduction of energy efficiency regulations to exhibit poor thermal performance (Zavadskas et al. 2008a; Rey 2004); and is defined in this paper as any building with more than one storey above ground level. This paper draws

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Garmston H, Fox M, Pan W and de Wilde P (2013) Multi-storey building retrofit with a focus on the façade selection process *In*: Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 81-90.

on the findings from a critical literature review and a real-life retrofit case study. The case study has two distinct parts: to aid façade selection analysis, data is collected via in-depth interviews and documentary evidence; while to aid façade success analysis, internal and external thermography is conducted. The objectives of this paper are to:

1. Identify what façade decisions are made, when and by whom;
2. Describe and analyse how the façade decisions are made;
3. Assess the thermal performance and success of the completed retrofit façade.

LITERATURE REVIEW

Building retrofit

Two common building energy retrofit classifications are conventional (e.g. replacing inefficient glazing) and 'deep-energy' (e.g. total envelope treatment) (Rysanek and Choudhary 2013). Retrofit strategies are also considered from an architectural view point by Rey (2004): stabilization (not fundamentally modifying the building's appearance); substitution (elements completely changed, transforming appearance); and double-skin façade (glass skin added, metamorphosing appearance). Retrofit is defined in this paper as the addition of a building "component or accessory" not existing when the building was originally constructed (Soanes and Stevenson 2003: 1505). In the UK, buildings are replaced at a rate of less than 2% a year, thus many of today's buildings will still be in use in 2060 (Femenías and Fudge 2010). Retrofitting aged buildings can significantly reduce their energy use (Ma et al. 2012). Moreover, some buildings may exhibit factors such as poor technical quality or a dull external image that trigger the need for retrofit. The retrofit can be a vital spark of life, not only for the building, but for its surroundings too. Disinterest in a building can lead to reduced occupancy, which can create a vicious circle whereby a neighbourhood deteriorates, causing occupancy to fall further still (Bragança et al. 2007). The office building retrofit cycle is around 30-years (Ebbert and Knaack 2007). Two thirds of European office buildings are considered outdated (being 30-years old or more) (Ebbert and Knaack 2007) and most "existing office spaces in the UK are older buildings with lower standards of specification" (Chow and Levermore 2010: 307). In 2010, Chow and Levermore stated that retrofitting existing older offices to Part L 2002 standards enables them to cope with predicted changes in climatic heating and cooling demands up to 2080. Commercial offices account for 8% of energy consumed by the service sector, which itself accounts for 12% of total final energy consumption in the UK (DECC 2012a: 1). These figures may seem low compared to other UK sectors' total final energy consumption: transport (38%), domestic (26%) and industry (18%) (DECC 2012b: 4); however, to reduce carbon emissions by 80% by 2050 "energy efficiency will have to increase across all sectors" (GOV.UK 2012).

Building retrofit façade decision-making

"The need for a decision arises when anomalous events occur" (Beach 1997: 2); which, considering the construction industry's prototypical nature supports research in this context (Sommerville and Dalziel 1998). Human decision-making has three main aspects (Bohanec 2001): normative decision-making (imposes order through the use of structured methods); descriptive decision-making (linked to cognitive psychology); and decision support. This research focuses on the methods it considers to aid façade selection, categorised as follows: decision-making, i.e. normative methods used to generate a decision; and decision-support, i.e. methods used to generate an output to aid decision-making. Descriptive decision-making is omitted from the research, since AEC industry decisions are complex, and in such situations "confusion can arise if a

logical, well-structured decision-making process is not followed" (Šaparauskas et al. 2011: 193). It is known though that "few people make decisions on the basis of well-deliberated calculations", instead making decisions "by following well established and built in norms" (Riabacke 2006: 453). Due to the cost and the long-term nature of their investment, retrofit façade decisions are considered strategic (Arup 2012; Sanguinetti 2012). As such, they are likely to have long-term timescales, a high degree of risk, an ill-defined structure, and to be heuristic in nature (Jennings and Wattam 1998). Heuristics is defined as "enabling a person to discover or learn something for themselves" (Soanes and Stevenson 2003: 815). The fact that retrofit façade decisions are considered heuristic is logical, given that this area occurs under the condition of uncertainty (Sanguinetti 2012). Examples of retrofit façade decision-making are rare in the literature; more so are examples that focus on office buildings. Rey (2004) describes the use of multi-criteria assessment in retrofit façade selection for a 1950s office building; other uses of normative decision-making are in a residential context: decision-making software, with multiple criteria decision-making (Zavadskas et al. 2008b); multi-objective optimization (Asadi et al. 2012); and integrated risk analysis framework (Sanguinetti 2012). Decision support in retrofit façade selection is used in various building contexts: life-cycle analysis (public) (Ardente et al. 2011); weather/ building knowledge (theatre) (Pérez et al. 2011); simulation (residential) (Clarke et al. 2004); and image survey (3D laser/photogrammetry) (educational) (Klein et al. 2012).

Thermography in building façade retrofit

Thermography is a relatively new and powerful tool for building investigations, which helps to identify defects such as missing insulation, moisture in walls, ventilation losses, and thermal bridges (Sadineni et al. 2011). The use of thermography for buildings can be split into two specific areas: existing building assessments, and new-build/retrofit quality control inspections (Holst 2000). Using thermography pre-retrofit allows structural details and defects to be identified, sometimes without needing as-built information or destructive investigations (Stockton 2007). It also enables a more accurate and cost effective retrofit solution, with a clearer idea on time scales and efficiencies; and can help verify and record the success of retrofit intervention (Snell 2008). Hart (1991) suggests using thermography as a quality control tool over contractor workmanship, especially for difficult to inspect details. Work in the field of façade retrofit aided by thermography has been undertaken, e.g. Johansson (2012), and Haralambopoulos and Paparsenos (1998). Hopper et al. (2012) study the use of thermography before and after external wall insulation retrofit; suggesting benefits in this technique that targeted key problem areas, and help to show contractors and designers where mistakes had been made, so that similar future retrofit projects can be improved upon. Retrofit work with thermography also identified poorly installed doors and windows (Hayter et al. 2000), masonry cavity wall tie defects (Doran et al. 2009), and evaluated component mock-ups prior to installation (Colantonio 2001).

METHODOLOGY

In order to develop robust guidance in retrofit façade selection for the AEC industry, a real-life case study was conducted. A case study protocol, pre-approved by the case study company prior to commencement, served to guide the investigators (Yin 2009). The case study gathered data from in-depth interviews, documentary evidence, and internal and external thermography. The in-depth interviews were conducted with key members of the case study retrofit project team. The interviewees were selected on the grounds of having knowledge on aspects of the retrofit, to include, but not be limited to: cost, technical function, and aesthetics; and were asked to talk freely about the

project, with the aim of capturing the interviewees' opinion of events (Robson 2011). The interviews lasted approx. one-hour and were recorded and transcribed. The interviewees are employees of the case study company and played key roles in the retrofit project: the Managing Director (MD) acted as Developer; and the Group Director acted as Lead Architect from the Technical Design (Stage E in the RIBA Plan of Work 2007 (RIBA 2009)). Two further recorded and transcribed interviews with the MD (one-hour face-to-face and 30-minutes by phone) aided in mapping the façade evolution to the main project points and the RIBA Work Stages. Documentary evidence was obtained from project-related documents, e.g. employer's requirements and tender reports. Internal and external thermography was conducted once on the completed building. A single image walkthrough style thermographic survey was carried out in accordance with BS EN 13187:1999 (BSI 1999). External thermography encompassed the total building façade, with internal thermography on the top floor only. The survey was conducted on 07.12.12, from 6.45-8.45am. Key thermography conditions were met: a 10 degree Kelvin difference between Temperature In and Temperature Out (UKTA 2007); overcast conditions (Hart 1991); and pre-sunrise (Walker 2004). Performing thermography post-retrofit only is a limitation of this study and is due to the case study building having been obtained via convenience sampling. To assess the multiple data sources, qualitative and quantitative methods were adopted. Thematic analysis using the repetition technique (Robson 2011: 482) was used to evaluate the in-depth interviews and documentary evidence, and the thermography findings; while simple spot temperature (quantitative) analysis was used to analyse thermography findings in greater detail where deemed necessary.

CASE STUDY

The case study investigated the retrofit of a real-life five-storey commercial office building, with a focus on the façade selection. The building is located in a waterfront conservation area in the UK, and comprises a central body (3210m2 total lettable floor space), plus two end towers for access to each floor (186m2 total floor space). The building is part-owned by the case study company (an architects practice), who also occupy the top floor. The building was constructed in 1971, from a concrete in-situ frame, with calcium silicate brick infill panels, single-glazed Crittall windows, and no insulation. Prior to retrofitting, the building achieved a 'wall' U-value of 1.49 W/m2K and a 'G' energy performance certificate (EPC) rating. The building was retrofitted in 2011, in line with Approved Document L2B 2006, and using a JCT Design and Build (D&B) Contract - 2005 edition. The work was funded by money borrowed against a group of eight stakeholders' (including the case study interviewees) Self Invested Personal Pension (SIPP). The retrofit aimed to achieve an energy efficient building; and to create a landmark building, thus demonstrating skill as architects.

The completed retrofitted building façade

The upper four floors remained as office use, while the ground floor was converted to retail use. The central body of the building was over-clad with a class '0' insulated render system (comprising 50mm phenolic boards at 0.037 W/m K), with stone tiling to ground floor height adjacent to the main entrances. The south façade was fitted with stainless steel brise soleil brackets (the aluminium louvres are not yet fitted). The two towers are clad with uninsulated two-tone metallic-effect aluminium faced rainscreen cladding. The cavity walls are filled with blown mineral fibre insulation. The window sills have been reduced in height, by removing three courses of brickwork. Thermally broken polyester-coated aluminium double-glazed ribbon windows alternated with coloured insulated spandrel panels have been installed on the upper four floors. The

ground floor is single-glazed, with thermal dry-lining to the rear. Other cost-effective building work was conducted internally and to the roof. The four upper floors have a 'wall' U-value of 0.22 W/m2K and a 'B' EPC rating. The ground floor is EPC rated 'C'.

Table 1: Overview of the evolution of the façade elements as the project progressed

Building element	Façade element	1	2	3	4	5	6	7
Cavity walls	Blown mineral fibre insulation	✓	✓	✓	✓	✓	✓	✓
End towers	Zinc sheet cladding (insulated) (VE)	✓	✓	✓				
	Metallic-effect rainscreen cladding		✓	✓	✓	✓	✓	✓
Main central part of the building	Insulated render system (phenolic board, mesh, render)	✓	✓	✓	✓	✓	✓	✓
Main central front façade to ground floor	Ceramic stone-effect tile cladding	✓	✓					
	Real-stone tile cladding			✓	✓	✓	✓	✓
Main central rear façade	Brise soleil brackets	✓	✓	✓	✓	✓	✓	✓
	Brise soleil louvres (VE)	✓	✓	✓	✓			
Ribbon windows to main central front and rear façade	Double-glazed, aluminium	✓	✓	✓	✓	✓	✓	✓
	Coloured clear spandrel glass (VE)	✓	✓					
	Coloured opaque spandrel panels			✓	✓	✓	✓	✓

Notes: The numbered columns indicate the main project points identified by the case study, to which the eleven RIBA (2009) Work Stages (A-H and J-L) are mapped: [1] Initial concept design (A, B, C); [2] Initial tenders received (end of C); [3] Planning application and consent received (D); [4] Technical design and product information (E, F); [5] 2nd tenders received (G, H); [6] Post-tender (J, K); and [7] As-built (L). A tick indicates façade element presence in that evolutionary stage. A 'VE' suffix indicates element removal due to value engineering.

The façade selection process

The façade decisions were made chiefly by the Developer, with Lead Architect input from Technical Design (RIBA Stage E) onwards. The façade decisions did not occur as per the RIBA Plan of Work; instead, seven main project points were identified and labelled, to which the RIBA Stages were then mapped (see Table 1). The final façade changes arose after the 2nd tenders were received (mapped against the RIBA Stages G and H). Façade decisions were observed at all RIBA Stages except J, K and L (this builds on the findings in Garmston et al. (2012) by providing a higher resolution of the process in practice). Due to the UK Government's strict financial restrictions on SIPP borrowing, this project was extremely cost aware. The decisions that guided the total envelope were driven (in order) by cost, aesthetics, planning, building regulations, and technical issues. The D&B Contractor did not make any post-tender façade decisions, which contradicts Garmston et al. (2012). However, this case study is a potentially unusual example of D&B contracting, in that the MD, acting as the Developer, was also the Client and one of the SIPP stakeholders, and being thus extremely conscious of cost, revisited each element after the initial and 2nd tender stages to identify cost reductions. This behaviour removed any opportunities for the D&B Contractor to make façade cost-saving decisions. A key example is the Developer's decision to use metallic-effect cladding instead of Zinc sheeting: a VE decision that halved the component cost. This decision arose after planning consent had been received for zinc sheeting, but fortunately, Planning accepted the change on the proviso that two-tone metallic-effect cladding was used. VE is a team-led, structured "evaluation of alternative construction materials and systems to save money without major effect on

program, maintenance, or appearance, chosen on a priority basis" (Kelly and Male, in El-Alfry 2010: 72); where the essence of 'value', as delivered to the owner, "expresses three main forms: Cost, Function and Aesthetic" (El-Alfry 2010: 72). In a multi-faceted role combining Developer, Client, and SIPP stakeholder, the MD made this, and other VE decisions (see Table 1), by discussing alternatives with the suppliers, and the Lead Architect. Cost effective insulated render was used to wrap the central part of the building. It was not deemed aesthetically acceptable to render the whole building, thus metallic-effect cladding was used on the towers. A robust material (stone) was used to ground floor level, as the render is not impact resistant. In attaching the brise soleil brackets, a small amount of cold bridging was anticipated by the Architect and Developer. However, from a practical point of view, attaching the brackets to the concrete boot lintels was considered to be the best option and unlikely to significantly affect the envelope's performance (as supported by the 'B' energy rating). The façade selection process did not use normative decision-making methods. The decision-makers instead used expert knowledge, in-house, and from suppliers and sub-contractors, to guide their decision-making. Decision support was used in the form of computer analysis (to check dew-point locations) and U-value calculations, both by the insulated render system supplier, to assess the render system's suitability.

The thermographic survey

The external thermographic survey visually reported largely cool temperatures across the main body of the façade. It also showed a few heat loss sources. As expected, the survey highlights localised cold bridging around the brise soleil brackets attached to the original in-situ concrete structure (the brackets and immediate area were approx. 4°C warmer than the other surface render) (Figure 1). Other external features included ventilation losses from trickle vents that had been left open, and gaps in insulation boards behind the render. A distinct difference in emissivity between the rendered and metal clad walls was observed. With much lower emissivity for the metal cladding, it was very difficult to observe potential defects, as much of the radiation received by the camera would have been reflected from other sources (Figure 2). The internal survey identifies ventilation losses from open windows that would be contributing to a reduction in internal temperature. Also, differences in construction fabric were observed (Figure 3) and un-identified areas of heat loss beneath a window (Figure 4).

DISCUSSION

The case study façade selection featured no normative decision-making and little use of decision-support, reflecting the heuristic façade selection process suggested by the literature. Despite this, and the fact that VE greatly influenced the façade selection, the client's satisfaction in the building's aesthetics, and the improved 'wall' U-value and EPC rating demonstrate that success was achieved by the façade decision process. This success may have been helped by the fact that the central part of the building was clad with an insulated render system. As one of the cheapest forms of cladding, this façade choice remained unaltered during the project, ensuring that the larger building part was well insulated, while other parts of the façade (towers, louvres and spandrel panels) were value engineered. It also appears that façade success is linked to building type. In this case, attracting tenants is vital for a commercial building, and so façade decisions were made to ensure the building was attractive to tenants: aesthetic decisions for an attractive façade, insulation decisions for lower running costs, and a structural decision (reduced sill height) for improved internal environment. As money was only released from the SIPP as the occupancy grew, it was essential to pre-let the

space. In line with Mara (2010), the façade retrofit has given a new lease of life to this building and enabled it to start functioning while its occupancy gradually increases.

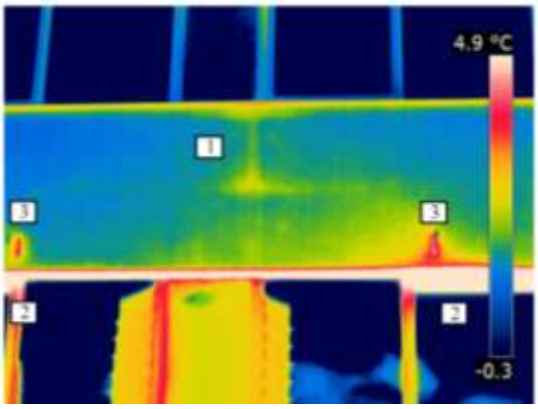

Figure 1: Gaps between insulation boards [1], trickle vents [2] and cold bridging through the brise soleil brackets [3].

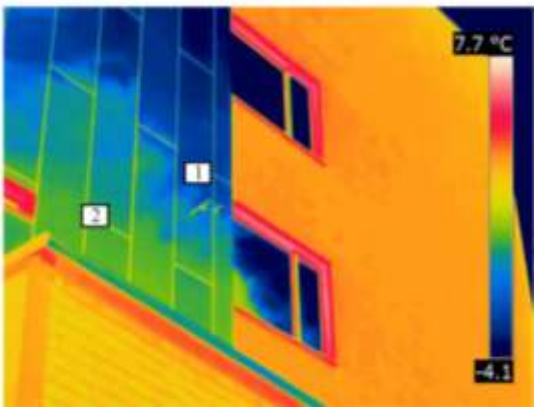

Figure 2: Emissivity difference between render and cladding, note seagull [1] and cloud [2] reflecting off the cladding.

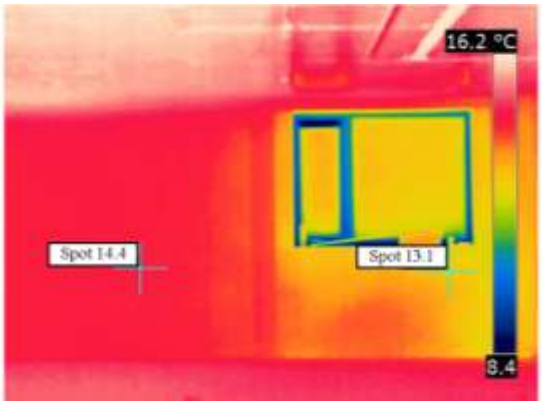

Figure 3: Differences (°C) in construction build-up either side of column.

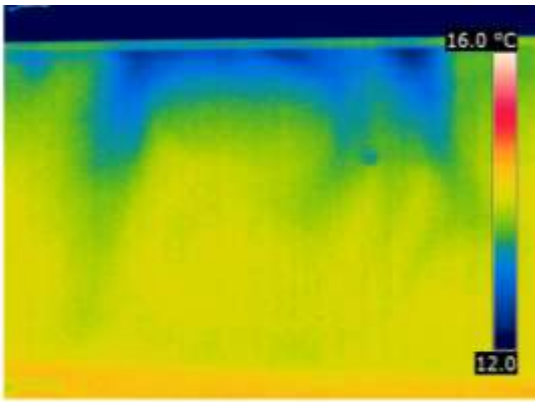

Figure 4: An area of un-identified heat loss below a window frame.

The thermographic survey visually demonstrates general success in the building's new thermal envelope. The survey does, however, also highlight potential quality control issues such as installation of the insulation boards. This information could be used to educate AEC industry members, such as the designer and contractor (Hopper et al. 2000) so that similar mistakes can be avoided in the future. Clients and contractors may be concerned that thermography is too expensive for projects with a tight budget; however, Snell (2008) suggests that using such a survey for retrofit can potentially be cost effective and provide a return on investment. The case study building was empty for 3-years prior to the retrofit, thus 37-years passed from original construction to the point of apparently needing retrofit. This reflects the approx. 30-year office retrofit cycle. The building was retrofitted in line with Part L 2006, so according to Chow and Levermore (2010) should be able to cope to at least 2080 with changes that may occur in climatic heating and cooling. Overheating was considered in the design, with the inclusion of brise soleil on the south façade. The brise soleil louvres were value engineered out (for the time being); however, forethought was shown by attaching the brackets, which were fixed to the in-situ structure prior to applying the render system.

CONCLUSIONS

This paper explores the façade selection process in multi-storey building retrofit. The façade decisions made during a UK commercial office building retrofit were shown as

relying on skills and knowledge borne of experience; they were heuristic in nature (as suggested by the literature), but readily utilised decision support from an insulated render supplier. Normative decision-making was not used. The evolution of the case study retrofit façade selection is mapped against the main project stages and the RIBA Plan of Work 2007. Value engineering greatly influenced the façade selection. Despite this, the client's satisfaction in the building's aesthetics, and the improved 'wall' U-value and EPC rating demonstrate that success was achieved by the façade decision process. Some façade success factors appear to be linked to building type; attracting tenants is vital in this commercial building case. Thermography showed the façade to be largely successful, while also identifying some quality control issues in the façade retrofit that AEC decision-makers could learn from when making similar future façade design decisions. Viewing a façade post-retrofit provides only half of the story. It is useful to thermally image a building prior to façade design decisions being made, as the survey can potentially provide a return on investment. Future case study research consisting of 'before' and 'after' surveys could observe how thermography could pinpoint areas for targeted improvements and indicate the success of the improvements. This work could be used to build a database of façade details in a thermal view for use by AEC decision-makers during retrofit façade selection.

REFERENCES

Ardente, F, Beccali, M, Cellura, M and Mistretta, M (2011) Energy and environmental benefits in public buildings as a result of retrofit actions. "Renewable and Sustainable Energy Reviews", 15(1), 460-470.

Arup (2012) Façade engineering. Available at: www.arup.com (accessed: 22.10.12).

Asadi, E, de Silva, M G, Antunes, C H and Dias, L (2012) Multi-objective optimization for building retrofit strategies: A model and an application. "Energy and Buildings", 44, 81-87.

Beach, L R (1997) "The Psychology of Decision Making – People in Organizations". London: Sage Publications Ltd.

Bohanec, M (2001) What is decision support? In: Škrjanc, M and Mladenić, D (Eds.) "Proceedings of information society: data mining and decision support in action!", Ljubljana, 86–89.

Bragança, L, Wetzel, C, Buhagiar, V and Verhoef, L G W (Eds.) (2007) "Cost C16 - Improving the Quality of Existing Urban Building Envelopes - Facades and Roofs". Amsterdam: IOS Press under the imprint Delft University Press.

BSI (British Standards Institution) (1999) BS EN 13187: Thermal performance of buildings – Qualitative detection of thermal irregularities in building envelopes – Infrared method. London: BSI.

Chow, D H C and Levermore, G J (2010) The effect of future climate change on heating and cooling demands in office buildings in the UK. "Building Services Engineering Research & Technology", 31(4), 307-323.

Clarke, J A, Johnstone, C M, Kondratenko, I, Lever, M, McElroy, L B, Prazeres, L, Strachan, P A, McKenzie, F and Peart, G (2004) Using simulation to formulate domestic sector upgrading strategies for Scotland. "Energy and Buildings", 36(8), 759-770.

Colantonio, A (2001) The use of infrared thermography in detection, remediation and commissioning of thermal comfort problems in office buildings. In: Rozlosnik, A E and Dinwiddie, R B (Eds.) "Proceedings of the SPIE 4360. Thermosense", 16 April 2001, Orlando, FL, 236-243.

DECC (Department of Energy & Climate Change) (2012a) Energy consumption in the United Kingdom: 2012. Publication URN: 12D/293. DECC.

DECC (2012b) Overall energy consumption in the United Kingdom: 2012. Publication URN: 12D/289. DECC.

Doran, D, Douglas, J and Pratley, R (2009) "Refurbishment and Repair in Construction". Caithness: Whittles Publishing.

Ebbert, T and Knaack, U (2007) A flexible and upgradeable façade concept for refurbishment. In: Bragança, L, Pinheiro, M, Jalali, S, Mateus, R, Amoêda, R and Guedes M C (Eds.) "SB07 Lisbon - Sustainable Construction, Materials and Practices: Challenge of the Industry for the New Millennium", Rotterdam, Netherlands, Vol. 2, 147-154.

El-Alfy, A E D (2010) Design of sustainable buildings through Value Engineering. "Journal of Building Appraisal", 6(1), 69-79.

Femenías, P and Fudge, C (2010) Retrofitting the city: reuse of non-domestic buildings. "Proceedings of the ICE – Urban Design and Planning", 163(3), 117-126.

Garmston, H, Pan, W and de Wilde, P (2012) Decision-making in façade selection for multi-storey buildings. In: Smith, S D (Ed.), "28th Annual ARCOM Conference", 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, Vol. 1, 357-367.

GOV.UK (2012) Policy – Reducing demand for energy from industry, businesses and the public sector. Available at: www.gov.uk/government/policies/reducing-demand-for-energy-from-industry-businesses-and-the-public-sector--2 (accessed: 04.03.13).

Haralambopoulos, D A and Paparsenos, G F (1998) Assessing the Thermal Insulation of Old Buildings - The Need for In Situ Spot Measurements of Thermal Resistance and Planar Infrared Thermography. "Energy Conversion and Management", 39(1/2), 65-79.

Hart, J M (1991) "A practical guide to infra-red thermography for building surveys". Watford: Building Research Establishment.

Hayter, S J, Torcellini, P A, Judkoff, R, Snead, B C and Hayter, R B (2000) Designing for Sustainability. In: "ASHRAE Conference", 20-22 September 2000, Dublin, Ireland, American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Holst, G C (2000) "Common sense approach to thermal imaging". Bellingham, Washington USA: SPIE - The International Society for Optical Engineering.

Hopper, J, Littlewood, J R, Taylor, T, Counsell, J A M, Thomas, A M, Karani, G, Geens, A and Evans, N I (2012) Assessing retrofitted external wall insulation using infrared thermography. "Structural Survey", 30(3), 245-266.

Jennings, D and Wattam, S (1998) "Decision making – An integrated approach". London: Financial Times Pitman Publishing.

Johansson, P (2012) "Retrofitting of old Exterior Wall with Vacuum Insulation Panels. Measurements of Thermal Properties, Moisture Performance and Practical Considerations". Unpublished Licentiate thesis, Chalmers University of Technology.

Klein, L, Li, N and Becerik-Gerber, B (2012) Image-based verification of as-built documentation of operational buildings. "Automation in Construction", 21, 161-171.

Ma, Z, Cooper, P, Daly, D and Ledo, L (2012) Existing building retrofits: Methodology and state-of-the-art. "Energy and Buildings", 55, 889-902.

Mara, F (2010) Technical & Practice - Retrofit. "Architect's Journal", 08.04.10 issue, 37-40.

Peréz, G, Rincón, L, Vila, A, González, J M and Cabeza, L F (2011) Green vertical systems for buildings as passive systems for energy savings. "Applied Energy", 88(12), 4854-4859.

Rey, E (2004) Office building retrofitting strategies: multicriteria approach of an architectural and technical issue. "Energy and Buildings", 36(4), 367-372.

Riabacke, A (2006) Managerial Decision Making Under Risk and Uncertainty. "IAENG International Journal of Computer Science", 32(4), 453-459.

RIBA (Royal Institute of British Architects) (2009) Outline Plan of Work 2007 - Amended November 2008. London: RIBA Publishing.

Robson, C (2011) "Real world research". 3ed. Chichester: John Wiley & Sons Ltd.

Rysanek, A M and Choudhary, R (2013) Optimum building energy retrofits under technical and economic uncertainty. "Energy and Buildings", 57, 324-337.

Sadineni, S B, Madala, S and Boehm, R F (2011) Passive building energy savings: A review of building envelope components. "Renewable and Sustainable Energy Reviews", 15(8), 3617-3631.

Sanguinetti, P (2012) "Integrated performance framework to guide façade retrofit". Unpublished PhD thesis, Georgia Institute of Technology.

Šaparauskas, J, Zavadskas, E K and Turskis, Z (2011) Selection of façade's alternatives of commercial and public buildings based on multiple criteria. "International Journal of Strategic Property Management", 15(2), 189-203.

Snell, J (2008) Infrared Thermography: (Nearly) A Daily Tool - The potential returns of using IR thermography for retrofitting of existing homes are immense. "Home Energy", March/April 2008 issue, 31- 34.

Soanes, C and Stevenson, A (Eds.) (2003) "Oxford Dictionary of English". 2ed. Oxford: Oxford University Press.

Sommerville, J and Dalziel, S (1998) Project teambuilding - the applicability of Belbin's team-role self-perception inventory. "International Journal of Project Management", 16(3), 165-171.

Stockton, G R (2007) Applications for Infrared Thermography as an NDT Method for Buildings. In: "IV Conferencia Panamericana de END", 22-26 October 2007, Buenos Aires.

UKTA (UK Thermography Association) (2007) "Building Thermography". Thermography Code of Practice - Number 1. Northampton: UKTA.

Walker, N J (2004) "Volume one - Principles and Practice. Infrared Thermography". Northampton: British Institute of Non-destructive Testing.

Yin, R K (2009) "Case study research – design and methods". 4ed. Thousand Oaks: SAGE Publications, Inc.

Zavadskas, E K, Kaklauskas, A, Tupenaite, L and Mickaityte, A (2008a) Decision-making model for sustainable buildings refurbishment. Energy efficiency aspect. In: "7th International Conference Environmental Engineering", 22-23 May 2008, Vilnius Gediminas Technical University, Faculty of Environmental Engineering, 894-901.

Zavadskas, E, Raslanas, S and Kaklauskas, A (2008b) The selection of effective retrofit scenarios for panel houses in urban neighbourhoods based on expected energy savings and increase in market value: The Vilnius case. "Energy and Buildings", 40(4), 573-587.

MODULARIZATION IN A HOUSING PLATFORM FOR MASS CUSTOMIZATION

Helena Johnsson, Gustav Jansson, Patrik Jensen

The problem of combining production efficiency with flexible product offers in housing design is well known. The platform concept is applied in housing to support design and production with predefined solutions. Modularization can be useful to meet both client demands on flexibility and production requirements on standardisation. To identify the module drivers in housing, ten projects at one off-site housing company were analysed. Furthermore, the cycle time for the modules was recorded. Client, design, purchasing, production and suppliers have different module drivers. When module drivers concur, modules are identified by; identifying clear and few interfaces, the availability of a supplier, and the cycle time for the design and production of the module in relation to the production pace. The results from the case study further show that fixed geometry on modules is a less successful concept than parameterised modules in housing. The ability to outsource technical solutions increased, when the module drivers were combined with a long term relationship with the supplier. Variant modules were successfully applied in the studied company to respond to client demands. Further research is needed on how to configure generic modules.

Keywords: case study, engineer-to-order, housing design, module drivers, module identification.

INTRODUCTION

There has been an increasing focus on the platform concept in the construction sector in recent years (Jensen et al. 2012, Thuesen and Hvam 2011). Construction seems to be struggling to balance between the power of flexibility given by project management of complex systems and the efficiency of using standardization of products and processes. The use of platforms, which store product, process and relationship knowledge, develops design and construction work continuously through system innovations (Johnsson 2011, Voordijk 2006). One way of mitigating client demands for variation with supplier requirements on repetitiveness is applying modularization (Baldwin and Clark 2000), where the product is decomposed into modules that constitute 'products-in-products' (Erixon 1998). Successful platform decomposition rests on balancing commonality with distinctiveness i.e. standardization with flexibility. Robertson and Ulrich (1998) argue that costs are driven by commonalities and customer value by distinctiveness. Modularization can complement commonality and distinctiveness if opting to organize the platform with predefined variants to limit the number of unique components and create mass customized products (Hvam et al. 2008). In the creation of modules, different module drivers exist (Erixon 1998), such as the module being a common unit in many designs or a supplier is available.

Johnsson H, Jansson G and Jensen P (2013) Modularization in a housing platform for mass customization *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 91-109

Construction is identified as one of the largest engineer-to-order (ETO) sectors (Gosling and Naim 2009). In an ETO situation like housing, where the client enters the process somewhere in the design phase, methods that handle uncertainty and client choices for flexibility are useful. Applying modularization in construction has been challenging since client demands tend to require more flexibility than the predefined modules can deliver. A number of investments in standardisation on component level have ended prematurely (Apleberger et al. 2007). Module decomposition could lead to less flexibility vis-à-vis market demands, brand segmentation, and product cannibalisation (Pasche and Sköld 2012). The industry expertise base is wide in housing and the knowledge that firms need to internalise to design and produce complex products is rapidly expanding. Potentially, different actors in the construction supply chain could have different drivers for modularization. The specialist knowledge and drivers that suppliers have is central for individual firms to master when designing complex products (Zirpoli and Becker 2011).

The aim of the research is to meet mass customization by using modularization in a construction supply chain. By analysing module drivers according to platform variants of five technical solutions, module identification was evaluated to the ETO situation. Given the ETO situation, modules in housing cannot always be fully predefined. Therefore, the cycle time for examples of modules in the housing design process was mapped to understand if the design and handling of a module is different from the original definition (Ulrich 1995).

PLATFORMS AND MODULARIZATION

By producing customized goods with low cost, mass customization enables companies to penetrate new markets to capture customers with needs that give them more than standard products (Ericsson and Erixon 2000). In the latest 15 years, housing in Sweden has been striving towards mass customisation using repetition of components and processes in the development of building systems. Companies have organised their effort in product platforms (Meyer and Lehnherd 1997), where component data, process descriptions, relationship conducts, and knowledge creation are stored (Robertson and Ulrich 1998). These assets are either commonalities in the platform, which are repeated in all projects, or distinctive unique parts, that are organised to create variability in products to meet client demands (Thuesen and Hvam 2011). Modules are a subset of the parts in the platform, a collection of parts that can easily be repeated between projects e.g. a balcony solution. Platforms can function without modules, though modules provide a way of predefining variability in the platform and organising the platform for module wise product development.

In an ETO situation, the platform standards and project input parameters are combined during the design phase. This work is made using support methods because the platform can never be fully predefined working ETO (Jansson et al. 2013). One support method is configuration, where predefined modules are configured to a product that fulfils client needs. A drawback with using product platforms is the tendency to favour commonality in physical components, which leads to less product distinction (Karlsson and Sköld 2007). The technical challenge is to create stable interfaces between common and distinctive components (Meyer and Lehnerd 1997). Decomposing the platform into modules is a method to separate and stabilise interfaces, which has been proven useful also in construction (Jensen et al. 2013).

The product architecture is the interrelation between the parts in the platform. Product architecture can be modular or integral. A modular architecture is composed of clearly

separable modules where modules and parts solve few functional requirements each (Ulrich 1995). In an integral architecture, one module or part is used to solve many functions. It is therefore more difficult to replace and refine the module separate from the product in an integral architecture.

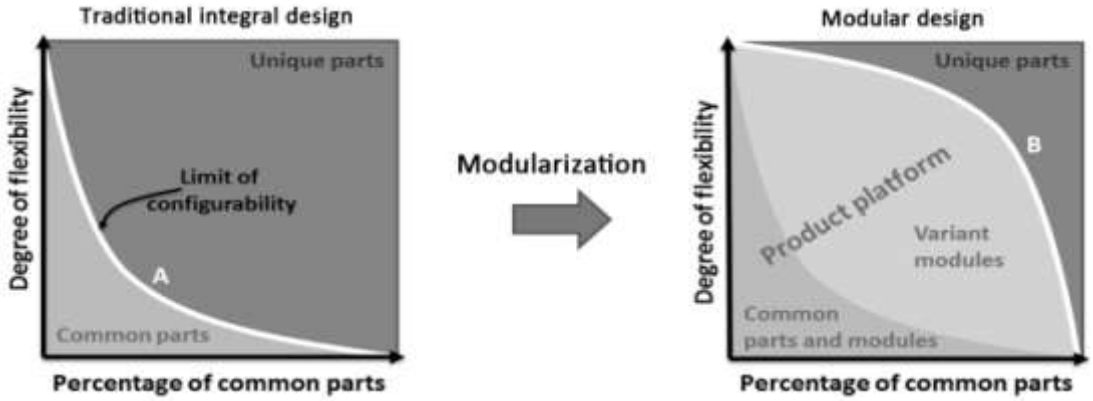

Figure 1. From integral to modular product architecture (Jensen et al. 2013)

In defining modules from unique parts, configurability is enabled with a high percentage of common parts combined with high flexibility, Figure 1, (Jensen et al. 2013). Modularization is to define the boundary between modules with a tight dependency between components inside the module and a loose interdependency between modules. The drivers for modularization differ between stakeholders and they could for the same product define different module boundaries. In a study of product development at Scania trucks twelve generic module drivers were identified by Ericsson and Erixon (2000):

1. Carry-over
2. Technological evolution
3. Planned design changes
4. Technical specifications
5. Styling
6. Common unit
7. Process and/or organisational re-use
8. Separate testing
9. Supplier available
10. Service and maintenance
11. Upgrading
12. Recycling

By using the twelve module drivers in a Module-Indication-Matrix and analyse technical solutions, Ericsson and Erixon (2000) state that the prediction of costs, flow, and production planning was made easier. Because complete modularisation is rarely achieved, interdependency across module interfaces becomes important for how flexible a module is to client demands. The conflict between stakeholder drivers has to be analysed with respect to the manufacturing chain (sales, design, production, maintenance) (Baldwin and Clark 2000).

Long-time relationships with suppliers enable outsourcing of modules and the option to keep core business in-house (Voordijk et al. 2006). By outsourcing the design and production of modules to sub-contractors or suppliers, one can make use of the power of specialists, but with the risk of differing goals and knowledge drain (Zirpoli and Becker 2011). Outsourcing of design, engineering and manufacturing are frequently used in construction as a solution to avoid investments in a large resource-base and to increase the speed in housing production (Lennartsson and Björnfot 2010). Component modularization needs to be communicated with suppliers, production, and engineers so that interfaces and modules yield expected performance of the building (Jensen et al. 2012).

METHOD

The research strategy was to identify a platform at a company where modularization was applied. Thereafter, a case study was performed in four steps: selection of building projects, identification of modules used in the projects, analysis of module repetition within and between projects, and analysis of cycle time for module exit and re-entrance within the construction supply chain. The case study company is a Swedish industrialised housing company, with a turnover of about 70 million Euros per year. The company uses a building system based on prefabricated timber-framed volumetric modules as the load bearing structure for multi-dwelling timber houses. The main process stages include an off-site production phase realised in a factory and an on-site production phase. Average cycle times are 17 weeks for design, 4 weeks for off-site production, and 4 weeks for on-site assembly followed by 6-8 weeks of on-site completion.

The strength of case study research is that the phenomenon is observed by actual practice in its natural setting and therefore could generate and develop new thoughts by meaningful and relevant theory (Voss et al. 2002). The case study gives an opportunity for exploratory investigation of the context of modularization in housing design, and to examine variables for the phenomenon of standardisation that are not all understood (Meredith 1998). Focus is on the degree of independence of modules, module interfaces and module drivers in relation to long term relationships to a number of external suppliers that deliver the studied modules: stairs, façades, foundation, balconies, and bathroom floors.

Observations of the design team have been made continuously by the authors to follow the use of platform standardisation in projects to see how stakeholder requirements and drivers cause variations in the product standard. Log book notes from building projects, drawings from building projects and documentation of product standards were used as core data and to verify observations applying a multi-methods perspective (Voss et al. 2002). To find module drivers and their weight for different technical solutions, structured interviews with one salesperson, two engineers, one production manager, and one supplier were conducted focusing ten building projects from 2012. Both tenancy and condominium projects with a living space from 2000 m2 to 8000 m2 were chosen to represent the client requirements the case company has to manage.

Analysis has been done to identify how the decomposition of modules was practiced, and to identify a modular or integral architecture. The module drivers for different stakeholders were identified and organised according to Eriksson's Module Indication Matrix. The cycle times for different modules were established by studying planned and actual cycle times in the ten projects.

CASE STUDY RESULTS AND ANALYSES

The platform is documented through rules and recommendations for design, purchasing, and production. The documentation of product standards focus component interfaces in the platform and recommends certain dimensions and production processes to be static between projects.

Modules

Bathroom floor

The case study company has together with a supplier developed a bathroom floor that is based on a glass-fibre reinforced sandwich construction with integrated drainage gutter and sleeves for toilet and sink. The underlying drivers for development of the bathroom floor were functional and legal requirements regarding moisture safety. The solution can have different types of finishing (tiles, carpet, and floor heating). Module drivers for developing the bathroom floor were to offer a moisture proof system with clearly defined interfaces that enable supplier production operations. Furthermore, a decrease in cycle time was sought, since the former solution encompassed curing times of several hours. The 6 predefined shapes of bathrooms with 24 dimensions in the platform were an enabler for efficient purchasing from external suppliers in batches, table 1. For the supplier, module repetition meant time savings in setup and production planning. Clients have demands on the interior finishing in their bathroom, but seldom require specific dimensions except for accessibility for the disabled. Using prefabricated bathroom floors, and organizing tiling off the production line saved a curing time of about 6 hours. As input, information about floor type, amount, delivery time, and finishing must be communicated to the supplier 14 weeks before production assembly starts in the factory.

Balcony

Prefabricated balconies have been developed following the same technical concept as the bathroom floor, with a glass-fibre coated massive timber slab hanging on steel tie rods secured to the outer wall. The underlying driver for developing the balcony system was to offer a light-weight solution without outer load bearing columns to meet aesthetical requirements. The driver from a design perspective was to repeat the interfaces (the tie rod and fixtures) while keeping the scalability in dimensions i.e. a parameterised solution. From a purchasing perspective, the repetitiveness enables easier purchase orders with 3 geometrical variants specified in the platform, table 1. The driver for modularization at the supplier was to find repetitiveness over projects for set up, production, and configuration of their production. Client requirements are posed on style, ease of use, safety in the railings, and ease of maintenance. The design of the balconies is decided late in the sales process; wherefrom the production flow is separated to the supplier and re-joined at the building site, figure 2.

Façade

Façade systems are separated from the structural system and can be varied between the shape of boards, bricks, plastered, vertical and horizontal wooden façades, table 1. Aesthetical client requests have been the underlying driver for standardisation of façades. Interface standardisation has been in focus, including the interface to the structural system, to the balcony, to the foundation, to openings, and to fixtures in the façade. The interfaces are realised partly in factory production, partly in on-site production. Suppliers mount the façade in the case of a plastered or brick façade, otherwise the case company mounts the board and wooden façade themselves. If using a sub-contractor, they need to provide a warranty for their work and have to meet

same pace requirements as the case company staff. The façade is the most disconnected module of the studied ones with unique geometrical solutions in studied projects. Already in the sales phase information is available to set up a subcontract with a supplier that fulfils the work during on-site completion, figure 2.

Foundation

Foundation works are most often sub-contracted using local firms for the specific site. Rules and tolerances for the foundation are stored in the platform and a time schedule is made to meet the production pace both off-site and on-site. The foundation module needs to meet tolerance requirements and loading requirements from the superstructure, as well as interface requirements from the façade, the stairwell, the service shaft, and the services connections. The case study firm often has the upper foundation surface as the contract boundary. Therefore, the properties both in dimensions and in concrete moisture content are strictly regulated in the sub-contract. Drivers for making the foundation a module is the lack of capacity and knowledge at the company to perform foundation works that are complicated. Information from sales and design are critical from a flow perspective, making foundation design the top priority in the early design phase, figure 2. The average cycle time needs to be about 18 weeks output from design to completion of foundation to conform to the production pace.

Table 1.Module variants in platform and customization in ten building projects

Technical solutions	Production variants in platform (customized)	Shape variants in platform (customized)	Geometrical variants in platform (customized)	External interfaces
Bathroom floors (modular)	prefab (crafts made)	6 (2 shapes)	24 (8 unique of 634)	Few (<10), Fixed
Balconies (modular)	prefab (crafts made)	6 (1 shape)	3 (58 unique of 375)	Few (<10), Fixed
Façades (modular)	board, brick, plastered, wooden (none)	5 (0 shape)	0 (all unique)	Many (>10), Fixed
Foundation (integral)	slab, basement (none)	0 (1 shape)	0 (26 unique of 56)	Many (>10), Tailored
Stairs (integral)	steel (timber)	5 (5 shapes)	0 (42 unique of 183)	Few (<10), Tailored

Stairs

The company has chosen to use steel stairs in their housing platform. The underlying driver for the limitation of structural stair material was to be able to offer a solution that resists abrasion, vibrations and fire, while being light-weight, tolerance stable, and possible to prefabricate. Drivers for standardising the stairs in the company were to develop solutions that have flexibility in meeting client demands on abrasion materials. Furthermore, the production pace was crucial, ruling out stairs that are assembled on-site. With the shortest lead time from design to completion (8-10 weeks), it was imperative to arrive at a standardised module that fulfils all requirements, can be designed swiftly, and offers enough distinctiveness (e.g. the

width ranges from 856 mm to 1200 mm founding the need for a parameterised module). The supplier driver for modularization was the repetition in projects enabling configuration of production robots, tool jigs and instructions. While standardising the step surface, on-site production put requirements on handling, where 5 shapes were stored in the platform and repetition in projects on 42 unique of total of 183 stairs, table 1.

Module drivers

In figure 2, the cycle time for the suppliers is displayed in relation to the overall building process at the case study company. Figure 2 shows that the shortest cycle time is given the stair supplier, while the longest applies to the façade sub-contractor. The modules differ in information content needed from sales and design. Stairs and bathroom floors need much information from design as these modules are immersed into the building, thus they become critical time wise both for the supplier and the case company. The balcony system with few interfaces to other systems and a long cycle time is easier to handle. The façade system does not need any design and therefore the sub-contractor for facades can plan their work over long periods of time. Foundations works are the most critical in the early phases of design as they not only are subcontracted and involve quite long curing periods for the concrete, but also as they need to be finished before on-site production starts.

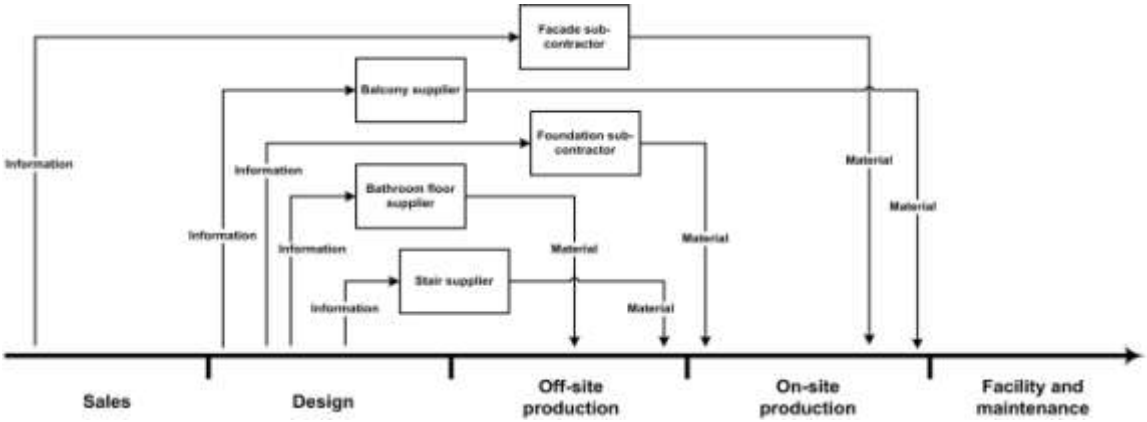

Figure 2. Parallel supplier and sub-contractor processes for the five studied sub-systems following the building process at the case company.

By the analyse using the Module Indication Matrix client drivers for Styling, Service and maintenance varies between technical solutions. Client drivers for modularization are, according to the interviews with sales personnel, related to a price perspective, which is why the first column in table 2 has been subdivided in private, public, and developer clients. Private clients, that develop houses for their own organisation to sublet, focus on economy, customer satisfaction through style, and functionality in internal equipment. They have fewer demands on repetition but wants specified choices. Public clients have higher demands on service and maintenance than private clients and pose demands on durable façades and granite laid steps in stairs expressing maintenance proficiency. Project developers have a short-term customer focus with high demands on styling and function for selling condominiums quickly resulting in weak and few drivers for client modularization, table 2. Technical specifications has drivers from al type of clients for functional requirements for moisture and structural stability on Bathroom floor, Balconies and facades.

The case company has to match the pace of production with client demands, which makes speed a prominent driver for modularization. Other case company drivers were carry-over between projects and common units inside projects, prominently for bathroom floor and balconies. Work process re-use is practiced in production for the modules, where the interfaces are similar although the components differ in size. Balconies, façades and foundation are all assembled on site with 2-3 variants of reusable processes. Off-site production was applied for the façades in 6 of the 10 studied projects. The interfaces are a shared responsibility between factory production, on-site production and external suppliers making it important to have a process owner to avoid sub-optimisation. Balconies and bathroom floors have a large amount of pre-defined parameters in the case company platform. The case company has long-time relations with these suppliers and the modules have few and standardised interfaces to other technical solutions.

Table 2. Stakeholder drivers using the Module Indication Matrix (Ericsson and Erixon 2000).

Module drivers / Technical solutions	Client (Private, Public, Developers)	Design/Purchasing	Production	Supplier/Sub-Contractor
Bathroom floors	4.Technical specifications ●●● 5.Styling ●○● 10.Service and maintenance ◐●○	1.Carry-over ● 2.Technological evolution ● 4.Technical specifications ◐ 6.Common unit ●	1.Carry-over ● 2.Technological evolution ● 4.Technical specifications ● 6.Common unit ○ 7.Process and/or organisational re-use ● 8.Separate testing ●	1.Carry-over ● 2.Technological evolution ● 4.Technical specifications ○ 6.Common unit ● 7.Process and/or org. re-use ●
Balconies	4.Technical specifications ○○○ 5.Styling ●●● 10.Service and maintenance ◐●○	1.Carry-over ● 2.Technological evolution ● 3.Planned design changes ◐ 4.Technical specifications ● 6.Common unit ●	1.Carry-over ● 2.Technological evolution ◐ 4.Technical specifications ● 6.Common unit ○ 7.Process and/or organisational re-use ○ 8.Separate testing ●	1.Carry-over ● 2.Technological evolution ● 4.Technical specifications ● 6.Common unit ● 7.Process and/or org re-use ●
Façades	4.Technical specifications ●●○	2.Technological evolution ● 4.Technical specifications ●	1.Carry-over ● 2.Technological evolution ◐ 4.Technical specifications ◐ 6.Common unit ◐ 7.Process and/or org. re-use ● 8.Separate testing ●	1.Carry-over ◐ 2.Technological evolution ● 4.Technical specification ● 7.Process and/or org. re-use ●
Foundation	4.Technical specifications ○○○	2.Technological evolution ○ 3.Planned design changes ○ 4.Technical specifications ●	4.Technical specifications ○ 7.Process and/or org. re-use ●	4.Technical specifications ● 7.Process and/or org. re-use ●
Stairs	10.Service and maintenance ◐●○ 5.Styling ●○●	3.Planned design changes ● 4.Technical specifications ● 6.Common unit ●	4.Technical specifications ○ 7.Process and/or org. re-use ○	1.Carry-over ● 4.Technical specifications ◐ 6.Common unit ● 7.Process and/or org. re-use ●

● = strong driver ◐ = medium driver ○ = weak driver

Supplier drivers for modularization are related to gaining repetition in the production through carry-over, technical specification and process and organisational re-use for all technical solutions in formwork, machine setting and production preparation. Suppliers and sub-contractors are depended on where in the process they get information from the main process about dimensions, choices, finishing, etc.

Modular or integral architecture

Many similar strong module drivers, table 2, for bathroom floor and balconies have led to a modular architecture (Ericsson and Erixon, 2000) and a long-term development together with suppliers. Stairs are another structure with an opportunity to become a module. They are still an integral architecture in the platform, due to many tailored interfaces, varied drivers from stakeholders and a short time relationship with the supplier. Foundation works seen as a module has few and weak drivers, but is still a module due to its early separation from the production flow.

Façades are a modular solution to create the outer climate shell for the building and is to a large extent independent from the platform apart from interfaces around openings in the façade. The number of different façade shapes is 5, which makes the definition of interfaces a viable task.

Modularization of housing platform

Components with a modular architecture are easier to standardise due to few number of interfaces with the rest of the platform (Voordijk et al. 2006). Some of the modules in the case study have been outsourced since long time relationships with suppliers. Façades and foundation have specialised suppliers providing the module and they work as subcontractors for many contractors. Two modules in the case study were created by the case study company in cooperation with small firms. The module drivers displayed in table 2, visualises the driving forces behind the modularization. The co-creation of the modules led to the smaller firms growing to become suppliers, at first to the case study company, but during later years also to other contractors. The stair module is in the case study identified as the possible next module to be outsourced due to some strong module drivers but especially to the few interfaces, table 2.

A risk with modularization is that it might lead to a focus on constructability instead of functionality for the client (Voordijk et al. 2006), which also must be focused when module drivers are analysed. The modularization in housing for platform use seems more dependent on shape and materials than on geometry, table 1. Thus, the case study shows that modules in housing seemingly need to use parameterisation as opposed to having a fixed geometry.

CONCLUSIONS

To meet mass customisation in housing platforms, where repetition is low and customisation is high, the findings in this paper suggests:

- Modularization is useful if the modules are parameterised as opposed to having a fixed geometry.
- For modularization to succeed there needs to be module drivers not only for the contractor and suppliers, but also for the clients.
- Different from modularization made in e.g. the automotive industry, modularization in housing needs to incorporate the cycle time in the engineering phase as modules are made to order i.e. not off-the-shelf products. Possibly this indicates that not only the supplier availability is a module driver in housing, but also the supplier cycle time.
- Modules in housing can provide both commonality and distinctiveness by the use of a partly defined platform.

Variant modules were successfully applied in the studied company to meet client demands, but need further research in configuring generic modules for the entire supply chain.

REFERENCES

Apleberger, L., Jonsson, R. and Åhman, P. 2007, Byggandets industrialisering: nulägesbeskrivning, Sveriges byggindustrier.

Baldwin, C.Y. and Clark, K.B. 2000, Design rules: The power of modularity, The MIT Press.

Ericsson, A. and Erixon, G. 2000, Controlling design variants: Modular product platforms, Society of Manufacturing Engineers, Dearborn, Michigan.

Gosling, J. and Naim, M.M. 2009, "Engineer-to-order supply chain management: A literature review and research agenda", International Journal of Production Economics, **122**(2), 741-754.

Hvam, L., Mortensen, N.H. and Riis, J. 2008, Product customization, Springer.

Jansson, G., Johnsson, H., Engström, D. 2013, "Platform use in systems building", Construction Management and Economics (in press), 1-13.

Jensen, P., Olofsson, T. and Johnsson, H. 2012, "Configuration through the parameterization of building components" Automation in Construction, 231-8.

Jensen, P., Johnsson, H.and Olofsson, T. 2013, "Product configuration in construction - principles and methods", Submitted to Journal of mass Customization.

Johnsson, H. 2011, "The building system as a strategic asset in industrialised construction" 6th Nordic Conference on Construction Economics and Organisation, 541.

Karlsson, C. and Sköld, M. 2007, "Counteracting Forces in Multi-Branded Product Platform Development", Creativity and Innovation Management, **16**(2), 133-141.

Lennartsson, M. and Björnfot, A. 2010, "Step-by-Step Modularity–a Roadmap for Building Service Development", Lean Construction Journal, 17-29.

Meredith, J. 1998 "Building operations management theory through case and field research" Journal of Operations Management, **16**(4), 441-454.

Meyer, M. and Lehnerd, A. 1997, The Power of Product Platforms; Building Value and Cost Leadership, The Free Press, New York.

Pasche, M. and Sköld, M. 2012, "Potential drawbacks of component commonality in product platform development" International Journal of Automotive Technology and Management, **12**(1), 92-108.

Robertson, D. and Ulrich, K. 1998, "Platform product development", Sloan management review, **39**(4), 19-31.

Thuesen, C. and Hvam, L. 2011, "Efficient on-site construction: learning points from a German platform for housing", Construction Innovation: Information, Process, Management, **11**(3), 338-355.

Ulrich, K. 1995, "The role of product architecture in the manufacturing firm" Research policy, **24**(3), 419-440.

Voordijk, H., Meijboom, B. and de Haan, J. 2006, "Modularity in supply chains: a multiple case study in the construction industry", International Journal of Operations & Production Management, **26**(6), 600-618.

Voss, C., Tsikriktsis, N. and Frohlich, M. 2002, "Case research in operations management" International journal of operations & production management, **22**(2), 195-219.

Ulrich, K. 1995, "The role of product architecture in the manufacturing firm" Research policy, **24**(3), 419-440.

Zirpoli, F. and Becker, M.C. 2011, "The limits of design and engineering outsourcing: performance integration and the unfulfilled promises of modularity" R&D Management, **41**(1), 21-43.

BUILDING HEALTHY CONSTRUCTION WORKERS BY BETTER WORKPLACE DESIGN: UNDERSTANDING THE CONTEXT

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Changing demographics and pension policies are reflected in the increasing age of workforces in the UK. Older workers are seen to be experienced, dedicated and reliable but also as being slower and tiring more easily. Staying fit and healthy for work is a key concern, particularly in the construction industry, where tasks are often challenging and adverse conditions prevail. Despite it being accepted that injury and ill health go hand in hand in the construction industry, older employees are still keen to work. The ageing workforce creates a demand for research which promotes productivity, workability and quality of life. Workplace design and ergonomics can have a substantial influence on working practices and an individual's ability to undertake aspects of their work, and research has shown that workers can successfully contribute to this. This research is therefore investigating the role of older experienced workers in healthy design in the construction workplace. It is hypothesised that healthy behaviours can be facilitated by good design and also by utilizing the experiences of older workers. Participatory ergonomics is key in this research; previous findings have evidenced the advantages of including workers, as they are the experts in their field. Older workers in particular will be included as a result of their extensive experience within the construction industry. This paper will present the rationale and context for a PhD study investigating ageing workers within the construction industry funded by Age UK.

Keywords: ageing, ergonomics, health, workers, workplace design.

INTRODUCTION

We are currently living amongst an ageing population, where it is predicted that within the next 50 years there will be double the number of pensioners (Frommert et al 2009). This shift in demographics is also being seen within the workplace, and construction in particular; since 1990 there has been an annual increase of 2% of workers aged over 40 (Cook et al 2009). The construction industry is heavily relied upon throughout the world for both economic and employment output (Helander 1991), but it is well known for being a tough, heavy manual and physically demanding industry. Many workers are suffering with musculoskeletal disorders, aches and pains, and in severe cases, disabilities which are forcing them to leave work early; 63% of all retirements within the construction industry are due to medical conditions (Arndt et al 1996). Gubéran and Usel (1998) claimed that on average there were no more than

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Eaves S, Gyi D and Gibb A (2013) Building healthy construction workers by better workplace design: understanding the context *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 101-109

50% of construction workers reaching the age of 65 being able to continue working. This is causing construction to lose experienced workers which may also be having a negative effect on the industry in light of the recent abolishment of the retirement age (BBC 2011).

The setup of construction projects - such as the layout of workspaces and introduction of new interventions - is difficult to alter, particularly due to the constantly evolving nature of construction sites. This research hopes to exploit the knowledge and experience of older workers, to encourage better design of the workplace and facilitate healthy behaviours. It is anticipated that these changes will enable workers to remain in the construction industry for longer, reducing the number of workers being forced into early retirement.

BACKGROUND TO THE RESEARCH

"Construction has one of the worst records of industrial safety" (Dester and Blockley 1995). Construction work involves a great deal of manual labour, heavy lifting and working in awkward positions for long periods of time; workers are often required to work at extreme heights, occasionally in bad weather and in dusty, noisy environments (Albers et al 1997; Lemasters et al 2006). The nature of construction work can naturally lead to issues with health later in life; musculoskeletal disorders are a common problem seen in construction workers, along with diseases such as dermatitis, a condition which makes skin sore and cracked, caused by the handling of cement and plaster for long periods of time (Cook et al 2009). These health issues can be exacerbated by the natural decline in physical abilities as workers age; muscle strength and stamina decrease and injuries take longer to recover from (Larsson, Grimby & Karlsson 1979; Lemasters et al 2006; Chau et al 2004). Although there is research worldwide into work and ageing, there is a lack of research into the roles that older workers take on in the construction industry as a result of their ageing and physical decline. This could be for a number of reasons, although the most likely is that many older workers are unable to continue in the industry and are forced to take early retirement (Gubéran and Usel 1998).

A small minority of older workers are able to take on more supervisory roles with decreased exposure to manual work and may also move onto training young apprentices in the industry (Gosling et al 2012). Older workers are considered to be reliable, produce work of a high quality and be experienced in their trade, however they are also perceived to be slower and less receptive to changes in the workplace (Dainty, Ison & Briscoe 2005; Leaviss et al 2008). The perception of older workers being slow outweighs any other positive perceptions, due to the nature of construction work being heavily reliant on high productivity for financial gain (Leaviss et al 2008). Previous research has suggested that older workers wish to remain in the workplace but that they have reported a dislike of power tools, preferring to use tools of a higher quality design due to the way in which they learnt the trade during their apprenticeships (Leaviss et al 2008). Older workers have also reported significantly more complaints in relation to their work, such as finding it more physically and mentally demanding, feeling tired and having complaints related to their vision, and upper and lower extremities (de Zwart et al 1999).

These findings support the premise that it is essential for the workplace to be designed in a way which accommodates changes in older workers to ensure they are able to remain in the workforce for as long as they wish. It is not only the workplace which can and should be adapted; behaviour based safety management, job rotation and

micro breaks have also been suggested as interventions in the industry (Lingard & Rowlinson 1997; Leaviss et al 2008; Albers et al 2005). Changes have been made in previous research however these are rarely as a direct result of adapting to the changes in older workers. Several studies have investigated the development and success of interventions; however the main reasons for these interventions are often of financial interest, or in an attempt to increase productivity (van der Molen, Bulthuis and van Duivenbooden 1998; de Jong, Vink and de Kroon 2003; de Jong and Vink 2002). Changes that have been made include modifications to tool design, new prototype tools such as a pneumatic powered wall lift for plasterers and extended windows in crane cabins to reduce the need for operators to be bending forwards to see to ground level (Li 2002; de Jong and Vink 2002; Mirka et al 2003; Ringen et al 1995).

Many of these studies did not involve the workers who would have been using the interventions; discussions were commonly led by management staff and project leaders, often with minimal input from ergonomic experts or manual workers. These previous studies, although successful in their implementation of interventions and prototypes are arguably missing the central point; it is the workers who hold the most in-depth knowledge of their trades, therefore it should be the workers who are consulted regarding their health and the methods used to protect it to prolong their work ability. Vink, Urlings and van der Molen (1997) conducted an intervention with 50 scaffolders using a participatory approach. They involved the scaffolders in each stage of the process and several modifications were made as a result of this, including the development of a special pallet truck, alterations to the planning of work and the introduction of shoulder protection in clothing. This approach meant that the interventions were relevant and specific to the workers' needs and this was supported by 60% of the scaffolders reporting that they felt they had enough influence in the study. This study reiterates the importance of input from the end users and emphasises their ability to reflect upon their requirements for healthy working. This project, funded by Age UK hopes to harness this experience and knowledge of older workers and use this to facilitate healthier design in the workplace.

PROJECT AIMS

This research is part of a bigger PhD project exploring construction workplace opportunities and barriers which can facilitate healthy ageing at work and healthy behaviours by design. The aims of this project are:

- To understand healthy ageing through design in the construction industry
- To capture workers' knowledge and experiences of 'healthy' design in the workplace

RESEARCH METHODOLOGY

A sample of 60-80 construction workers will be recruited from 2-3 large companies through personal and professional contacts in discussions with line and site managers. Although the focus is on ageing, workers of a range of ages from trades such as electricians, plasterers, bricklayers and joiners will be involved in order to investigate any differences in opinions or ideas between ages and trades. Inclusion criteria consists of trades which require physically demanding tasks such as being in awkward or cramped positions for long periods of time or having to perform repetitive awkward movements throughout the working day. Due to the peripatetic nature of construction sites, the sample of workers will be stratified by age (under 25, 25-34, 35-49, 50+) and a range of trades will be interviewed due to the variety of tasks within each trade.

This research will incorporate Reason's (1994) 'co-operative inquiry', which acknowledges and includes the contribution from the workers on the construction site; an integral component of participatory ergonomics. Participatory ergonomics is key within this research; although a relatively new concept, it has been used for over 60 years (Coch and French 1948). In order for the design of the workplace to be improved successfully, it is essential that the users of that workplace are involved. Participatory ergonomics has been proven to be effective in increasing productivity, motivation and success of implemented interventions (Vink, Urlings and van der Molen 1997; Hess et al 2004; Loch et al 2010). It has been shown that interventions suggested by workers themselves are more likely to be used within the workplace, such as shoulder support for scaffolders and a fold out bench device within work vans (de Jong and Vink 2002). During a trial of a production line made up of older workers, employees of a BMW factory were encouraged to put forward design ideas to increase workability and worker motivation (Loch et al 2010). This resulted in a production increase of 7% and an increase in participation throughout the trial period. Design ideas implemented included new flooring to reduce impact, which was causing discomfort, and new chairs to enable employees to have a relaxing break in between shifts. This trial worked so well because workers felt that their opinions and ideas were valued and given serious consideration; when suggested ideas such as the change in flooring became a reality, one worker reported that this showed them the project could make sense.

In this research, construction workers will be engaged in order to harness their experience and knowledge of the industry; their awareness and experiences of issues relating to the design of the workplace and healthy working behaviours will be investigated using semi-structured interviews. Semi-structured interviews have been shown to be successful in allowing the participants to speak of their own experiences in a relaxed environment, whilst allowing the interviewer to cover any topics of interest that are not naturally raised within the conversation (Leaviss, et al 2008; Choudhry and Fang 2008). The interviews will be conducted on site and will consist of four key sections, as shown in Table 1.

Demographic data will be collected to stratify the age and trade of the participant as well as their tenure of employment. Age is stratified as: under 25, 25-34, 35-49 and 50+. Participants will then be asked to describe their everyday working tasks, allowing the interviewer to gain a better understanding of their job. This also gives workers an opportunity to discuss the risks involved in their work and tasks that they find particularly strenuous, dangerous or demanding.

Regarding ideas and current changes, participants will be asked if they have ever altered or modified their workplace/tools to make their job easier, or if they have any ideas about how to do this. If the worker has no ideas, this is also documented. Participants will be asked about any advice they would give to a younger worker, or if they were ever given any advice about how to do their job. Trade specific questions are also asked where appropriate, such as electricians coping with poor lighting and bricklayers working outside. If changes have been made, further questioning includes who is responsible for instigating and maintaining these changes.

Following the open-ended questions, quantitative data will be collected using 3 questionnaires. The Stage of Change questionnaire, developed by Prochaska and DiClemente (1983) and adapted by Whysall et al (2007) for the reduction of work-related musculoskeletal disorders, utilises a 5-point scale to ascertain behaviour

related to the participant's 'readiness to change'. Workers are asked if they think change is necessary and if so, how urgently these need to be made to establish how they feel about themselves and their job. The answers from the participant translate onto the scale, putting them in one of 5 stages; pre-contemplation, contemplation, determination, action, maintenance or relapse. If an individual is in the "contemplation" stage they are more likely to consider design ideas and changes in the workplace and are thus in turn more likely to provide suggestions and solutions to problems. However if a worker is in the "pre contemplation" stage it is likely that they will have never considered the design of the workplace and feel it is acceptable how it is, suggesting they are less likely to be open to the concept of change and less likely to put forward any ideas for the design of their workplace. Secondly the Nordic Musculoskeletal Questionnaire (Kuorinka et al 1987) establishes the location and severity of any musculoskeletal symptoms participants may have suffered with. These are measured both as a 12 month period prevalence and a 7 day point prevalence alongside establishing the severity of the symptoms over the past 12 months. The questionnaire also allows the participant to consider whether these disorders have developed as a direct result of their work. The Work Ability Index (Ilmarinen et al 1991; Liira et al 2000) determines how able the participants feel to continue working as well as investigating the demands of their job. Participants are presented with a 10 point scale to rate their work ability from 0 (completely unable to work) to 10 (the best they have ever worked). This quantitative data is collected at the end of the interview to ensure that musculoskeletal disorders are not the focus of the participant, they are also used to validate any issues that may have arisen within the interviews.

Table 1: A summary of questions and issues discussed during interviews

	Questions and issues
Demographics	Age range. Occupation. Time spent in employment
Their Job	Everyday tasks? Tools and equipment used? PPE requirements and usage? Location of job? Awkward/cramped positions? Use of chemicals? Is there dust, noise?
Ideas & Current Changes	What ideas do you have to make your job easier? To make the workplace better? New/different equipment? Flooring, lighting, PPE, talks, workshops, job rotation, micro-breaks, better facilities? What advice would you give to a younger worker? What would you do differently? E.g. Plasterer- how do you cope with the weight of the trowel and wet plaster? Electricians- what do you do about extra lighting in smaller areas? Bricklayers- what issues do you face with working outside? Weather?
	What is being done right now to make your job easier? Who comes up with these changes? Who is responsible for implementing and maintaining these changes? Are you using different equipment? Altering current equipment? Order of jobs? Wearing knee pads / particular gloves / other clothing modification?
Health (Quantitative)	Stage of Change questionnaire (Prochaska and DiClemente 1983) Nordic Musculoskeletal Questionnaire (Kuorinka et al 1987) Work Ability Index (Ilmarinen et al 1991)

As this is a semi-structured interview, the researcher is at liberty to adjust questions or change the order or language of the interview; this is hugely advantageous considering the subjective nature of the topics being discussed. Construction, whilst being relatively uniform in its output, can consist of numerous methods and techniques, often unique to individuals and their trades. The semi-structured nature of the interview allows the participants to discuss their own personal experiences of their

work, and their own unique ideas and opinions on what they think constitutes 'good and healthy design' in the workplace. This also allows them to freely discuss any changes they have made, or would like to make in the workplace to improve their health and workability.

To triangulate data and investigate and evidence issues raised in interviews, observations will be conducted in the field where possible. This could consist of participants showing the researcher a particularly demanding task, awkward posture, or modification to their environment to make their job easier. Videos and photographs will be taken to supplement interview recordings. Observations will occur in the event of workers being unable to take time out to take part in an interview. This may be due to the nature of the work and the fact that many participants could be on 'price work' i.e. they are paid more money if they are more productive and finish either on or before the estimated deadline.

LIMITATIONS

There are limitations involved in the collection of this data. As previously mentioned, many construction workers may be working 'on price' therefore recruiting participants who are willing to take time out of their work to be interviewed may prove difficult. Building sites are peripatetic in nature, they are constantly evolving and changing; there are very few areas on building sites which are able to provide a quiet environment suitable for recording audible interviews. Notes can be taken by the researcher however this does not provide the richness and depth of coverage in comparison to an audio recording. The nature of this research is not only subjective as previously discussed, but also retrospective; workers will be asked about how their job has affected their health and also whether they have ever modified their environment (or wanted to) as a result of wanting to protect their health. Asking about modifications to the environment can be a very context-specific question, causing the workers to agree that yes, they have wanted to make changes at times, but they may experience difficulty when recalling what changes were needed, or why. Not only this, but any changes workers make are highly likely to be subconscious therefore it is anticipated that workers may struggle to think 'on the spot' of design ideas. This is an issue which will be emphasised if the worker has stepped away from their work station in order to take part in the interview. A solution to this context-specific limitation could be to interview participants in their workspace, however the nature of the data collection would require the worker to step away from their work at times in order to complete questionnaires. This would also make recording the interview inherently more difficult due to the high noise levels on construction sites and the dark, dusty environments. The "healthy worker effect" is a recognised phenomenon presenting an important limitation in this research (Svendsen et al 2004; Shephard 1999). This occurs when older workers appear to be healthy with high work ability because they are present at work; those who are suffering with musculoskeletal disorders, skin disorders, injuries and so on, are unlikely to be present at work and are therefore unable to be included in the sample. This limitation will be overcome by endeavouring to interview participants from a retired construction workers union further into the project.

CONCLUSIONS

Construction work is a tough, physically demanding job leaving many employees unable to continue in their work. Many older workers wish to remain in work, but the industry makes this difficult to do. Workers within the construction industry have a

wealth of experience and knowledge about their jobs, and this can be used to the advantage of future workers and their employers. A methodology is presented in order to harness the knowledge and experience of these workers so that the design of the workplace can be altered in order to encourage healthy working behaviours, thus increasing the work ability of older construction workers.

ACKNOWLEDGEMENT

The author would like to thank the Research into Ageing Fund (RiAF) and Age UK for selecting this project as a PhD Studentship in ageing and research.

REFERENCES

Albers, J, Estill, C and MacDonald, L (2005) Identification of ergonomics interventions used to reduce musculoskeletal loading for building installation tasks. "Applied Ergonomics", 36, 427-439.

Albers, J, Li, Y, Lemasters, G, Sprague, S, Stinson, R and Bhattacharya, A (1997) An Ergonomic Education and Evaluation Program for Apprentice Carpenters. "American Journal of Industrial Medicine", 32, 641 - 646.

Arndt, V, Rothenbacher, D, Brenner, H, Fraisse, E, Zschenderlein, B, Daniel, U, Schuberth, S and Fliedner, T M (1996) Older workers in the construction industry: results of a routine health examination and a five year follow up. “Occupational and Environmental Medicine”, 53, 686-691.

BBC (2011) Compulsory retirement age at 65 fully abolished. Available from http://www.bbc.co.uk/news/business-15127835 (accessed 20th February 2013).

Coch, L and French, J (1948) Overcoming resistance to change. "Human Relations", 1(4), 512-532.

Chau, N, Gauchard, G C, Siegfried, C, Benamghar, L, Dangelzer, J, Français, M, Jacquin, R, Sourdot, A, Perrin, P P and Mur, J (2004) Relationships of job, age, and life conditions with the causes and severity of occupational injuries in construction workers. "International Archive of Occupational and Environmental Health", 77, 60-66.

Choudhry, R and Fang, D (2008) Why operatives engage in unsafe work behavior: Investigating factors on construction sites. "Safety Science", 46, 566-584.

Cook, S, Richardson, J, Gibb, A G F and Bust, P D (2009) Raising awareness of the occupational health of older construction workers. In: RMIT, cib W099 International Conference "Health and Well-being stream", 2009, Melbourne Australia. RMIT, ISBN 978-1-921426-47-6, 33-43.

Dainty, A R J, Ison, S G and Briscoe, G H (2005) The construction labour market skills crisis: the perspective of small-medium-sized firms. "Construction Management and Economics", 23, 387-398.

Dester, W and Blockley, D (1995) Safety - behaviour and culture in construction. "Engineering, Construction and Architectural Management", 2(1), 17-26.

Frommert, D, Hofäcker, D, Heien, T and Andreß, H J (2009) Pension systems and the challenge of population ageing: what does the public think? In: R. Edmondson and H. von Kondratowitz, (eds.) “Valuing Older People: A Humanist Approach to Ageing”. Bristol: The Policy Press.

Gosling, E Y, Gyi, D E, Gibb, A and Haslam, R (2012) Ageing Productively through Design: A Survey of Cement Manufacturing Workers. "Aging and Society", 1, 1-23.

Gubéran, E and Usel, M (1998) Permanent work incapacity, mortality and survival without work incapacity among occupations and social classes: a cohort study of ageing men in Geneva. "International Journal of Epidemiology", 27, 1026-1032.

Helander, M (1991) Safety hazards and motivation for safe work in the construction industry. "International Journal of Industrial Ergonomics", 8, 205-223.

Hess, J, Hecker, S, Weinstein, M and Lunger, M (2004) A participatory ergonomics intervention to reduce risk factors for low-back disorders in concrete laborers. “Applied Ergonomics", 35, 427-441.

Ilmarinen, J, Tuomi, K, Eskelinen, L, Nygard, C, Huuhtanen, P and Klockars, M (1991) Summary and recommendations of a project involving cross-sectional and follow-up studies on the aging workers in Finnish municipal occupations (1981-1985). “Scandinavian Journal of Work and Environmental Health", 17, 135-141.

de Jong, A and Vink, P (2002) Participatory ergonomics applied in installation work. "Applied Ergonomics", 33, 439-448.

de Jong, A, Vink, P and de Kroon, J (2003) Reasons for adopting technological innovations reducing physical workload in bricklaying. "Ergonomics", 46(11), 1091-1108.

Kuorinka, I, Jonsson, B, Kilbom, A, Vinterberg, H, Biering-Sorensen, F, Andersson, G and Jorgensen, K (1987) Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. "Applied Ergonomics", 18(3), 233-237.

Larsson, L, Grimby, G and Karlsson, J (1979) Muscle strength and speed of movement in relation to age and muscle morphology. "Journal of Applied Physiology", 46, 451-456.

Leaviss, J, Gibb, A and Bust, P (2008) Strategic Promotion of Ageing Research Capacity Understanding the Older Worker in Construction. Available from http://www.sparc.ac.uk/media/downloads/executivesummaries/exec_summary_gibb.pdf (accessed 10th December 2012).

LeMasters, G, Bhattacharya, A, Borton, E and Mayfield, L (2006) Functional Impairment and Quality of Life in Retired Workers of the Construction Trades. “Experimental Aging Research", 32(2), 227-242.

Li, K W (2002) Ergonomic design and evaluation of wire-tying hand tools. “International Journal of Industrial Ergonomics", 30, 149-161.

Liira, J, Matikainen, E, Leino-Arjas, P, Malmivaara, A, Mutanen, P, Rytkönen, H and Juntunen, J (2000) Work ability of middle-aged Finnish construction workers – a follow-up study in 1991-1995. "International Journal of Industrial Ergonomics", 25, 477-481.

Lingard, H and Rowlinson S (1997) Behavior-Based Safety Management in Hong Kong's Construction Industry. "Journal of Safety Research", 28(4), 243-256.

Loch, C, Sting, F, Bauer, N and Mauermann, H (2010) How BMW is defusing the demographic time bomb. "Harvard Business Review", 88, 99-102.

Mirka, G, Monroe, M, Nay, T, Lipscomb, H and Kelaher, D (2003) Ergonomic interventions for the reduction of low back stress in framing carpenters in the home building industry. "International Journal of Industrial Ergonomics", 31, 397-409.

van der Molen, H F, Bulthuis, B M and van Duivenbooden, J C (1998) A prevention strategy for reducing gypsum bricklayers' physical workload and increasing productivity. "International Journal of Industrial Ergonomics", 21, 59-68.

Prochaska, J and DiClemente, C (1983) Stages and processes of self-change of smoking: toward an integrative model of change. “Journal of Consulting and Clinical Psychology”, 51, 390-395.

Reason, P (1994) Three approaches to participative inquiry. In: N.K. Denzin and Y.S. Lincoln (eds.) "Handbook of Qualitative Research". California: Sage Publications.

Ringen, K and Seegal, J (1995) Safety and health in the construction industry. “Annual Review of Public Health", 16, 165-188.

Shephard, R (1999) Age and Physical Work Capacity. "Experimental Aging Research: An International Journal Devoted to the Scientific Study of the Aging Process", 25(4), 331-343.

Svendsen, S W, Bonde, J P, Mathiassen, S E, Stengaard-Pedersen, K and Frich, L H (2004) Work related shoulder disorders: quantitative exposure-response relations with reference to arm posture. "Occupational and Environmental Medicine", 61, 844-853.

Vink, P, Urlings, J and van der Molen, H (1997) A participatory ergonomics approach to redesign work of scaffolders. "Safety Science", 26(1), 75-85.

de Zwart, B, Frings-Dresen, M and van Duivenbooden, J (1999) Senior Workers in the Dutch Construction Industry: A Search for Age-Related Work and Health Issues. “Experimental Aging Research", 25(4), 385-391.

JOURNEYS THROUGH THE CAVE: THE USE OF 3D IMMERSIVE ENVIRONMENTS FOR CLIENT ENGAGEMENT PRACTICES IN HOSPITAL DESIGN

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One of the benefits of the growth in BIM use in the design and construction industries is the opportunity for increasing the involvement of, and interaction with, various stakeholders and end users through the design process. This includes the use of virtual models in collaborative 3D immersive environments, such as the CAVE (Cave Automatic Virtual Environment), during critical moments of client engagement. These opportunities and developing work practices have, however, received little academic attention. These encounters provide the opportunity for stakeholders to virtually experience the proposed design of buildings and spaces ahead of construction, and for design teams to communicate in a sensory and embodied way that the contract and design requirements are being met. This research uses video-based methods to study the collaborative, 'real world' design review work undertaken during client engagement sessions in the CAVE, in the context of a bidding process for a new NHS hospital. In this immersive setting, the navigable space is both a site of interactive encounter and an architectural model. It is argued that design teams establish a narrative to support the navigable space which the client participants experience, through the careful consideration and planning of their journey including what can be revealed or concealed along the way.

Keywords: hospital; stakeholder; user participation; virtual reality; virtual prototyping.

INTRODUCTION

Major clients are increasingly demanding that 3D modelling is used on their projects, and there is a UK government mandate to make Building Information Modelling (BIM) compulsory on public projects by 2016. This presents new opportunities for allowing various stakeholders to virtually experience the proposed design of buildings and spaces ahead of construction, to which attention is turned in this paper in the context of hospital design.

Virtual, immersive environments offer a form of modelling and visualization that can compliment BIM technologies since, as Brandon (2008: xviii) explains, "CAD models

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Tutt D and Harty C (2013) Journeys through the CAVE: the use of 3D immersive environments for client engagement practices in hospital design *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 111-121

are mathematically defined, and they support a wide variety of analyses, simulations and visualisations, but they abstract away from tactility". 3D immersive environments, like the CAVE (Cave Automatic Virtual Environment), instead move towards providing end-users with physical and embodied experiences of building designs (CICRP, 2011). The CAVE is a multi-person, room-sized, high-resolution 3D collaborative virtual environment, which projects video onto three walls and the floor which can be viewed with active stereo glasses, one of which is equipped with a location sensor. As users move within the display boundaries, the perspective is displayed in real-time. One participant at a time (the 'driver') uses a joystick to travel through the environment.

Fig 1: The CAVE

This research concerns a project to relocate an existing specialist NHS hospital to the bio-medical University campus of a nearby town. The NHS Trust chose the Private Finance Initiative for the procurement of the new hospital, and one consortium utilised the CAVE as part of the tendering process. It was adopted to help better communicate the design of this hospital project to the NHS client, and to enable them to review the model of key spaces in the hospital design, including the main entrance atrium, an operating theatre, and an inpatient ward. Immersion in a 3D model can help to physically convey the sense of scale and space of a building, the size of single bed rooms etc., and to communicate to stakeholders in a sensory and embodied way that the contract and design requirements are being met. The collaborative work of navigating, and narrating, stakeholders' journey through the virtual model during the stage/s of design review is examined in this paper. This is done through video analysis of client engagement sessions in the CAVE during the bidding process for this new NHS hospital.

VIDEO-BASED RESEARCH METHODS

During this project, a researcher first followed, ethnographically, the early stages of the tendering process for the new NHS hospital, including attending design team meetings which took part from the preliminary Invitation to Negotiate (ITN) PFI phase up until the consortium were selected to participate in the final ITN stage. Team collaboration in the CAVE was then explored by studying interactions between members of the infrastructure provider and NHS client during design review, and to do this required analysing detailed social interaction with and around technology. For, while ethnography and video-based studies share a commitment to the study of social interaction, "it is not possible to recover the details of talk through field observation alone, and if it is relevant to consider how people orient bodily, point to objects, grasp

artefacts, and in other ways articulate an action…it is unlikely that one could grasp little more than passing sense of what happened" (Heath and Hindmarsh, 2002:102).

Video-based field studies provided unprecedented access to study social interaction around technology, in the sense that video captures multiple features of an event or scene (talk, body movement, physical context, use of technology etc.) which could be replayed over and over again. One particular affordance of video data was the opportunities it provided to share, discuss and debate 'raw' data with others. This practice of 'data sessions' (Tutt and Hindmarsh, 2011) involved the team undertaking collaborative, real-time video data analysis with other colleagues, to identify sequences of action and examine their construction and organisation, and to explore alternative, multidisciplinary perspectives. That version of events was then scrutinised, with fine-grained analysis of video fragments and transcriptions of the action, and in light of new analytic perspectives etc.

Rich video data recording of six sessions held within the CAVE were collected, involving various combinations of stakeholders: project and design managers, architects and designers, modellers and visualizers, NHS end users (clinical and managerial) and representatives of the client. These sessions took part between November 2011 and April 2012, by which time only two consortia were still left in the competition for the contract, and over 12 hours of video recordings of group interaction were collected in the CAVE environment. The data consisted largely of fixed camera footage, which was supplemented with a roaming camera and a ceiling/bird's eye view camera on occasions where the access to the social interaction was compromised (by multiple bodies in the CAVE or the view obscured by equipment etc.). The video data provided access to CAVE activity during this client engagement process, which involved presenting the models to the NHS client, to demonstrate diverse design requirements, ranging from the size of single rooms, the visibility of patients from nursing stations, to the amount of natural daylight utilised, and the design of interior objects and materials etc. The sessions also enabled design teams and contractors to explore and review the design environment more generally.

There is a long tradition of video-based field studies of workplace interactions that considers how technology can be understood as a feature of interactional work. Suchman (2007: 276) traces how the turn toward the social by computer scientists in the 1980s coincided with a growing interest in the "material grounds of sociality" among social scientists, particularly by ethnomethodologists and conversation analysts who already acknowledged the importance of nonverbal action in the organization of face-to-face interaction. These interests led to the emergence of a corpus of 'workplace studies' that attend to the accomplishment of work and interaction in various complex organizational domains, such as air traffic control rooms, emergency dispatch centres, newsrooms, and hospitals (See Hindmarsh and Heath, 2007). This work has helped explicate the different ways in which objects and technologies, such as the screen, are collaboratively used to help coordinate everyday workplace practices (Tutt and Hindmarsh, 2011).Video-based studies of social interaction have provided one way of examining collaborative design, that is, the ways in which the social, technological and material come together in and through the interactional practices of everyday work.

Attention has also been paid, in the extended fields of workplace studies and CSCW (Computer Supported Cooperative Work), to the collaborative work of coordination among stakeholders in the design process. For example, Tory et al (2008) provide a

video-based examination of the use of artefacts during the design development of a new building project to identify and resolve conflicts and accomplish design coordination. Luck (2010) has also studied the use of artefacts and drawings in early design conversations between architects and users. She argues that when artefacts are used in engagement with end-users, at the early stages of a building's design, they can act as 'mediating devices' as well as embodying the current status of the design. Indeed, Luck (2010: 641) stresses the importance of design representations and artefacts throughout a project as knowledge carrying and mediating objects, irrespective of whether they are material objects or virtual objects. However, the use of virtual prototypes and technologies, particularly immersive environments, and their role in interacting with clients during this crucial time of stakeholder engagement, is little understood and has been little explored in the literature.

Elsewhere close conversation analysis has demonstrated how participants in the CAVE need to develop new codes of interaction in order to first establish a 'shared seeing' of things before their design or collaborative work in the environment can be accomplished (Tutt, et al., 2012). During their group interaction, users are required to orient to the screens displaying the projected video, as well as to the physical and material environment of the CAVE room, and to each other. This all has to be done whilst maintaining proximity to the person wearing the 'headtracker' (active stereo glasses equipped with a location sensor), in order to view the optimal 3D perspective of the video. Yet a key difficulty in terms of the current use of this technology in the design process is that most end-users and stakeholders only enter into the CAVE for one or two sessions, or at least have limited engagement, and so will get a short opportunity to learn and develop the best ways to interact and collaborate in this environment. With this narrow window of time in which to make an impression and communicate the design, it is therefore logical that a large emphasis is placed by the design team on the marketing role of the CAVE experience in best 'showcasing' the prospective design to clients. In this paper, the video dataset is returned to with a new analytic inquiry, namely to examine how the design team construct a narrative to support the navigable space which the clients experience in the CAVE. Rather than fine-grained analysis of talk-in-interaction, this requires focusing on instances in the data set where the design decisions on what (/not) to show, edit, remove etc. from the model are negotiated, in practice, through the interactions of design review work, including how they are referred to and made sense of in discussion with clients. The data is analysed through the lens of new media theory, particularly revisiting Lev Manovich's Language of New Media and discussion of navigable space.

BACKGROUND: VIRTUAL PROTOTYPING AND STAKEHOLDER ENGAGEMENT

The need for identifying the clients or stakeholders and understanding their expectations for a construction project is of the upmost importance. Conflict often arises between logical changes and those that will be acceptable to the stakeholders, and Newcombe (2003) explains how this aspect becomes heightened "in public sector projects where a wider spectrum of stakeholders may express active interest in a project" (p.846). While a clear relationship often exists between designers and clients, gaps of understanding commonly exists between designers and the wider stakeholders and end-users (Nykänen, et al., 2008). On hospital projects these stakeholders and end-users of the facilities include diverse clinical staff of doctors, nurses etc., administrative staff, patients and visitors, facility management, as well as representatives of the NHS trust acting as client. Typically the design of healthcare

facilities involves building expensive full-scale mock-ups of critical hospital units, such as operating theatres, patient rooms etc. Dunston and McGlothin (2007) describe how virtual reality enables end users of the client healthcare organisation to have an immersive and interactive experience during design reviews with a multitude of hospital rooms and spaces (potentially an entire hospital) at a fraction of the cost of physical mock ups. However, while in this context Dunston and McGlothin (2007) used "demonstrations to obtain responses to the simulations" (p.8), the example in this research represents the use of virtual reality in a 'real world' project during the bidding process for a large new single bedroom hospital in the UK.

The CAVE visualization technology is essentially an advanced form of 'virtual prototyping', namely digital representations of design proposals which, subject to a process of exploration, testing, evaluation and refinement, may become physically realised. In principle these digital models typically need to be created anyway to serve as design documentation, so it is their integration and interoperability through the design process which needs to be developed on a project. As Morrell (2011) argues, in relation to the plans to make BIM compulsory for all public projects, "it makes no sense for designers to work in three dimensions and then suppress what was learned and hand on a 2D representation, also missing the opportunity to load the model with much other valuable information". As returned to in the later discussion of navigable space, prototypes differ from superficially similar artefacts such as movie set fictional buildings, historical reconstructions etc. by virtue of "its particular antecedent, functional relationship to the real thing" (Mitchell, 2008). Indeed, Dunston and McGlothin (2007) claim that practitioners exploring the virtual CAVE mock-up identified the same design issues known to be in the actual patient room (p.8).

DISAPPEARING WALL SOCKETS: BALANCING DESIGN ACCURACY WITH SELLING THE DESIGN

The potential for users to 'pick up' on errors in hospital design that have not been identified through 2D or non-immersive models was quickly identified as a major benefit by the NHS client in this research:

It works for us as well. You know- some of our recent schemes. We had things as simple as light switches or socket outlets that are in the wrong place…Everybody's missed it. It's been built like that and we've got like 500 rooms with a socket in the wrong place (NHS Client Rep)

In addition to helping users to identify design errors and to collaboratively develop a design, Mitchell (2008) also highlights the importance of virtual prototypes for providing "a basis for choosing among options or deciding whether to proceed to the next stage; and (in a less scientific spirit) to persuade decision makers" (p. xvi). In the context of this research, with the bidding process for a large new single bedroom hospital, this element was crucial, indeed was quite literal. For, the CAVE technology was utilised for stakeholder engagement when two hospital consortia were still left in the competition for the contract. The visualisation of design in the CAVE environment during client engagement processes is therefore fulfilling a different set of objectives beyond checking design accuracy. This is a bidding process for a contract, meaning that the virtual world is being designed to be viewed from a particular point of view and in order to be accepted by the client. This is explicit in the choice of or requirement to model particular rooms and spaces, but more subtle in the selection of lighting, placement of objects etc. Here, the same example of wall sockets is briefly continued, to illustrate simply how the main contractor design team have to negotiate

the job of representing the specificities and accuracies of the design along with problems users' may face in encountering the design as a 3D visualisation:

1 Pam:	Anywhere there's a white socket- just delete that
2 James:	Oh do you not actually want them on the wall here?
3 Pam:	Well. No ha:hha
4 James:	Ok alright
5 Pam:	They should be behind the TV. That's just the way they
6	were modelled in Revit so they're appearing to the-
7 Alex:	That's an interesting one Pam. If you put the- if
8	you show the plugs behind the TV which is where you
9	want them you can't see them=
10 Pam:	Exactly
11 Alex:	=in the model
12 Pam:	I know ha ha ha I didn't want those TVs

In the sequence above, the designers have effectively encountered clashes between various objects, outlets and spaces after importing the model into the CAVE. This requires the team to edit the virtual environment in order to solve issues around the visibility of objects and the objects appearance etc. Part of the issue here is concerned with the creation and management of objects within immersive environments like the CAVE, and carrying out further work of embedding metadata into the model, for example, would solve this. However, this would be costly in time and money through the work of virtual modellers and, in this example, the decision is taken to "just delete" the plug sockets for the purposes of the 'walk through'. Like any prototype, it can fail if its design is too incomplete and inaccurate (as in the incorrect positioning of sockets throughout the single rooms referred to by the NHS Client representative), or equally if it is unnecessarily elaborate and costly (Mitchell, 2008). At one level these are cost-benefit questions, but this example of clashing wall sockets also illustrates how these concerns are balanced with the best way of 'show casing' the design to the clients during this stage of the tendering process.

This research has started to assess what these immersive virtual experiences can provide at critical moments of client and stakeholder engagement, in this case during the design review process for a new hospital. Elsewhere it has explored what type of interaction it facilitates, through fine-grained video analysis of collaborative work sessions in the CAVE (Tutt et al., 2012). Here the narrative within which they are enacted is examined, in relation to the work of Manovich, in terms of showcasing the design and communicating that the design requirements have been met. Or, put more crudely, the work of balancing the accuracy of design specifications with selling the space and design to the client.

DISCUSSION: THEORIES OF NAVIGABLE SPACE AND NARRATIVE SPACE

In his seminal work The Language of New Media, Manovich (2001) describes in detail how navigable space – that is, the navigation through 3D virtual space – has become a key form for new media aesthetics. It is now a familiar, everyday interface in computer games, in addition to its use in other formats such as motion simulators. He also details how it has become a "key tool for labour" for interacting with any kind of data (p. 249). Navigable space has become a particularly important paradigm in human-computer interfaces, which, Manovich (2001) argues, should be seen as a particular case of data visualisation distinct from "architectural models or stock

market figures" (p. 249). However, in the case of collaborative working in the CAVE, the navigable space is both a site of interactive encounter and an architectural model.

Virtual worlds usually involve interaction and narrative, typically with the participant being represented by an avatar literally 'inside' the narrative space. They are usually seen through a rectangular frame, displaying only part of a larger whole, hence Manovich (2001) describes the experience as being "much closer to cinematic perception than it is to unmediated sight… [and] the designer of a virtual world is thus a cinematographer as well as an architect" (p.81-2). However, unlike film architecture which is designed for navigation and exploration by a film camera or, say, 'paper architecture' designs which are not intended to be built, the hospital design has a functional relationship to the hospital to be built (Brandon, 2008), provided that the design wins the bidding process. The CAVE model is also, as discussed, designed to be viewed from particular points of view, enabling stakeholders to review key spaces in the hospital design, namely here, the main entrance atrium, an operating theatre, and an inpatient ward. In addition to the interactional demands of physically collaborating in the CAVE, the users' experience of these spaces is also subject to a level of more discreet design decisions including, but not limited to, what are sometimes called 'perspective renderings'. These architectural representations have been described as being part of the design process itself (Houdart, 2008) and in this particular example include representing the connectivity between the hospital spaces, the selection of lighting, the placing of objects and furnishings, and even, as discussed in this section, altering or distorting the correct design specifications for the means of enhancing the immersive experience.

To first recap, in this example the CAVE environment is enabling the 'real world' design work of engaging with clients, rather than simply offering simulation or role play. It is a form of data visualization and an (immersive) architectural model. It is not viewed through the rectangular frame of VR, or through desktop 3D or Revit, but instead involves viewing and interacting with 3D video projected onto room-sized multiple screens. It is a navigable space, which the participants 'walk through', but also a narrative space constructed both through building a more detailed picture of the social context of use for the hospital spaces (provided by the client and clinical stakeholders' expertise), and, as will now be discussed, through the designers' 'showcasing' of the design to try and win the bid.

The benefits of allowing client and clinical end-users to probe at how a space can be used, and to re-asses the lived spaces of an architectural design in a way that non-immersive building design does not allow, are potentially considerable. This user knowledgebase is returned to later in this section in relation to the design of a hybrid operating theatre. Yet, in addition to the social context of use as a working space (in terms of clinical practices, facilities management etc.), is the more basic connotation of a space's usage and function, which can be taken for granted as being self-evident by designers but can too easily fail to be communicated in virtual models. A simple example is that of encountering a restaurant. Here, in the transcript below, the design team are trialling the 'walk through' of the atrium prior to bringing the NHS clients into the CAVE:

Alex: So when you're actually in this main reception area, Pam, you can't actually see people eating inside the restaurant
Pam: No you won't
Alex: So how does FM feel about that?

Pam: They're not happy about it

The designers decided against the use of avatars, which the team believed would bring a different set of problems. This included distracting participants from the design details, interrupting the group interaction, and leading participants to draw inaccurate comparisons of the avatars with the specifications of objects such as grab rails, and size of beds, single rooms etc. However, the use of the space as a restaurant could be conveyed in different ways as Alex concluded:

I think we can make a bit of an improvement on that bit by wayfinding or something that draws the attention- because at the moment, standing here, I don't know there's a restaurant … I'm supposed to know that behind that beautiful purple chair is a restaurant. I'd never know that (Alex, Director of Design)

A senior design manager felt that this is "another wayfinding thing, saying what these things are. I think these things are important but- we can add maybe reception text or something to this desk". Such issues of wayfinding in the complex organisational environment of hospitals are frequently encountered throughout the buildings' life (Rooke and Rooke, 2012). The opportunity to experiment with how the system works ahead of construction, especially with stakeholder input, again represents a real benefit of immersive environments. Visual wayfinding is also identified as key to selling the space and the design to the client, and hence of winning the bidding process. During a CAVE session, a senior designer for the main contractor described this as the "route you will take these people on- the journey". While the stakeholders potentially have the opportunity to engage and interact with any aspect of the model, the journey on which they are taken on by the design team is significant "to see that connectivity. For the visual wayfinding [of] how do you bring yourself through this space". The 'intro sequence' for the NHS clients led the participants virtually from the main entrance into the main atrium, which was selected to gives an impression of the space and dimensions, and the designers also announced that the journey would "show what the adjacencies were and where you could find your way out of the atrium to different spaces". However, the selective modelling of hospital spaces for the CAVE environment puts restrictions on the routes and physical movements that the participants can make. When looking towards the entrance at outpatients, it was remarked by an NHS client representative that it would be "nice to have that-to see something visual", with the view to outside and natural daylight considered a key design feature of these outpatient clinics. Yet, taking the decision to texture the 'end' of modelled spaces also lead to some confusion around the connectivity of the spaces as client participants navigated them. This is captured in the comment: "So in practice, that wall isn't a wall in fact". This brings us back to the earlier discussion of virtual prototypes and striking the balance between not making a design too incomplete and inaccurate, and equally not unnecessarily elaborate and costly.

The decision of what (/not) to show for the purposes of the engagement sessions with the NHS client extends to the objects, materials and equipment within the hospital spaces. The materiality of objects in immersive design environments is explored in greater detail elsewhere (Tutt et al., 2012), but here the paper briefly refers to how the designers virtually moved or removed prescribed equipment in certain modelled rooms (such as the operating theatre which will now be discussed) because of the effect it had on participants encountering them in the immersive environment. Yet, these alterations in the virtual model extended to altering the curve of a corridor, the height of grab rails and, as already discussed, the removal of plug sockets.

In this one particular example, the communication of a space's usage and function in the virtual model is questioned through the application of NHS clinical knowledge, which provides a social context of use for the room as a working space. In this case, however, there is not a failure to communicate the basic function of space (as in the restaurant example), but rather a failure of the model to match the complex, organisational procedures of surgery:

This isn't biplane, though is it? This must be- It's not biplane (1.2) set up (.) configuration. You normally have the image intensifier come over the top of a patient (NHS surgeon)

The surgeon assesses the immersive space as a future operating hybrid theatre that she will work in, and she picks up inaccuracies in the designed layout of the biplane platform, a system which will provide diagnostic imaging and accommodate multiple clinicians and ancillary equipment. Here, the sociotechnical knowledge and (clinical) expertise of the end-users, which was partly brought into the design review by the affordance of the immersive CAVE environment, starts to unpick the design accuracy of the virtual model. The decisions for the (re)moving of prescribed materials, equipment and other alterations are made fully transparent to the Trust clients as in the architect's explanation below:

[T]o be quite honest the first layout that we did there was too much stuff in here- that we actually took a few pieces- shifted them to the edges and um- Just so we can actually get in here (Architectural Assistant, Architects on project)

The intended use of the CAVE at the design review stage was not to subject the spaces to workflow scenarios as if they were fully-equipped mock-ups. However, this example is useful for an analysis of how the design team describe and make sense of this process of balancing the accuracy of design specifications with selling the space and design to the client. Indeed, it was referred to, during the design team discussion, as "strategically taking some of it out", but one designer related these decisions more directly to, what might be seen as, the careful structuring of narrative space. During discussion in the CAVE with the rest of the design team, he explained that "if you went to town on a space… there's something a bit climactic- and then you've got a problem". This comment again stresses the need to make sure a design space/model is not unnecessarily elaborate, but the word "climactic" also suggests sensitivity to the emotive, embodied and sensory experience of the spaces along "the route you will take these people on- the journey". As the client participants are taken on their 'journey', work has been undertaken to establish a narrative to support the navigable space which the participants experience. This careful planning of the journey (and what can be subtly revealed, concealed or distorted along the way) hints at an entire series of work practices and concerns which, by virtue of the increasingly important role of immersive environments and virtual prototypes, are becoming part of the design process itself.

CONCLUSIONS

This research uses video-based methods to study how a design team experiment with the virtual technologies of the CAVE to engage with clients and accomplish 'real world' design review work. These collaborative encounters are providing the potential for client and clinical end-users (without extensive or even any design expertise) to explore how a virtual building can be used, and to re-assess the lived spaces of an architectural design in a way that non-immersive building design cannot. Video-based

methods provide a way of accessing these emerging methods for design, and encourage a close and detailed consideration of interaction and the situated and contingent use of technologies and artefacts in the CAVE environment. This paper turns an analytic lens on to how client engagement sessions in 3D immersive environments are accomplishing different work, in attempting to demonstrate, in a sensory and embodied way, that the contract and design requirements are being met (e.g. that single bedrooms in the hospital are big enough), and in presenting (or selling) a design vision. The virtual world is being designed to be viewed from a particular point of view and design teams, tasked with convincing decision makers to proceed to the next stage during the bidding process for a contract, have the opportunity to use these sessions to best 'showcase' their design to the clients. During collaborative working in the CAVE, the navigable space is both a site of interactive encounter and an architectural model, and it is argued that design teams establish a narrative to support the navigable space which the clients experience through the careful consideration and planning of their journey, included what can be revealed or concealed along the way.

REFERENCES

Brandon, P and Kocatürk, T (2008) "Virtual futures for design, construction and procurement. Oxford: Blackwell.

CICRP (Computer Integrated Construction Research Program), (2011). "BIM Project Execution Planning Guide – Version 2.1." The Pennsylvania State University, USA.

Dunston, P, Arns, L, and McGlothin, J (2007) An Immersive Virtual Reality Mock-Up for Design Review of Hospital Patient Rooms, "7th International Conference on Construction Applications of Virtual Reality", University Park, PA, USA, Oct. 22-23.

Heath, C and Hindmarsh, J (2002) Analysing Interaction: Video, ethnography and situated conduct. In: T. May (ed.) "Qualitative Research in Action". London: Sage.

Hindmarsh, J and Heath, C (2007) Video-based studies of work practice, "Sociology Compass", 1 (1), 156–73.

Houdart, S (2008) Copying, Cutting and Pasting Social Spheres: Computer Designers' Participation in Architectural Projects, "Science Studies", 21 (1), 47-63.

Luck, R (2010) Using objects to coordinate design activity in interaction, "Construction Management and Economics", 28:6, 641-655.

Manovich, L (2001) "The Language of New Media". Cambridge, Massachusetts: MIT Press.

Mitchell, W (2008) Foreword - Virtual worlds, virtual prototypes, and design. In: P. Brandon and T. Kocatürk (eds.) "Virtual Futures for Design, Construction & Procurement". Oxford: Blackwell Publishing.

Morrell, P (2011) "BIM to be rolled out to all projects by 2016", Daily News 23/6/11, The Architects' Journal: http://www.architectsjournal.co.uk/news/daily-news/paul-morrell-bim-to-be-rolled-out-to-all-projects-by-2016/8616487.article

Newcombe, R (2003) From client to project stakeholders: a stakeholder mapping approach, "Construction Management and Economics", 21(8), 841-848.

Nykänen, E, Porkka, J & Kotilainen, H (2008) "Spaces meet users in virtual reality". In: A. Zarli and R. Scherer (eds.), "Proceedings of ECPPM 2008 Conference on eWork and eBusiness in Architecture, Engineering and Construction", Sophia Antipolis, France. 10-12th September 2008, 363-368.

Rooke J and Rooke C (2012) From Interpretation to Action: Unique Adequacy as a Common Standard for the Evaluation of Research in the Built Environment. In: S. Pink, D. Tutt and A. Dainty (eds.) "Ethnographic Research in the Construction Industry". London: Routledge.

Suchman, L (2007) "Human-Machine Reconfigurations: Plans and Situated Actions". Cambridge: Cambridge University Press.

Tory, M (2008) Physical and Digital Artifact-Mediated Coordination in Building Design, "Computer Supported Cooperative Work", 17(4), 311-351.

Tutt, D and Hindmarsh, J (2011) Reenactments at work: demonstrating conduct in data sessions, "Research on Language & Social Interaction", 44 (3), 211-236.

Tutt, D and Harty, C (2012) Collaborative Design Work in the CAVE, "Liverpool and Keele Ethnography Symposium", University of Liverpool, 29th – 31st August 2012.

CHALLENGES AND SOLUTIONS FOR MANAGEMENT OF FRP USAGE IN THE UK RAIL SECTOR

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The first Fibre Reinforced Polymer (FRP) implemented to a UK Railway Bridge was in 2001, since then a number of key railway bridge projects involving FRP have seen completion; six being fully FRP bridges. Although the potential use of FRP on the infrastructure was found in 1998 due to high strength to weight ratio, stiffness and good chemical resistance, the implementation of FRP to small scale rail bridges was found to have several challenges which are faced by industry. Past research studies have predominantly focused on providing further examples of the successful usage of FRP in bridges, the benefits to whole life cycle cost in comparison to steel/timber but fail to address the challenges. In that context, the study is aimed to identify the key challenges for managing the usage of FRP in large scale in UK rail sector and provide possible solution to overcome such challenges so that dependency on traditional materials on railways bridge can be reduced and improve material sustainability aspects. This paper explores the past research and takes a view from the project delivery level. A qualitative approach was adopted to collect the views from professionals associated with clients (Network Rail), designers and contractors using questionnaire. A total of 14 professional's views were collected through questionnaire and findings outlined. From the analysis, it was found that the lack of standard design codes for FRP, basic understanding of benefits, right price and reliability are key challenges for the management of FRP use in the UK rail sector. The paper concludes that the use of FRP will be an alternate solution in UK rail sector from the material sustainability aspects if confidence of stakeholders can be improved about reliability and the practical benefits of FRP.

Keywords: FRP, bridges, whole life cost, standards, network rail, perception.

INTRODUCTION

Fibre reinforced polymer applications in the arena of bridges has seen considerable progress since the mid-1990s. The driver of this has been the marrying of the materials properties to the requirements of bridge infrastructure and the need to modernise existing structures up to 21st century loads and standards (Hollaway, 2010, p 2430). FRP offers infrastructure owners, operators and maintainers the potential for quicker installation times; the high strength-to-weight (S/W) ratio allows for reduced capacity, more readily available, cranes and lifting equipment to be used. The strength-to-weight ratio/specific strength is a material's strength (force per unit area at failure) divided by its density. This provides more scope in the scheduling and

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Shah R, Walsh S and Ross A (2013) Challenges and solutions for management of FRP usage in the UK rail sector *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 123-134

planning for projects. Also the durability and chemical resistance offers the potential for reduced maintenance regimes, allowing for better whole life cost (WLC) performance and ultimately cost savings (Hastak, 2000, p103). The two largest operation and maintenance management organisations of bridge structures in the UK are the Highways Agency (HA) and Network Rail (NR). Both organisations have been active in the research and development of FRP to their infrastructure, with case examples being thoroughly published in papers. Within these two sectors a pressure exists to mitigate residual impact on their networks during the undertaking of construction schemes; more so with NR, having a limited number of lines and routes. Working line side on NR infrastructure is typically restricted by maximum 48hour possessions, to main line interfaces (Canning, 2012, p3). The closure to lines and disruption to the network is a core consideration to NRs WLC modelling of schemes. With NR set to enter their next control period (CP5) and a key aim being "deliver efficiency savings of 18%" (Rail, 2013, p3); FRPs proven potential benefits to infrastructure scheme costs (Bell, 2009, p121) may be able to serve the organisations needs outside its current trail focused experiences. The paper intends to highlight the experiences of FRPs use on NR infrastructure and to understand the barriers & challenges that exist within the sector affecting the implementation of FRP incorporated bridge schemes. The findings of the paper have the intension of increasing further awareness of the materials management, particularly in application aspects, within the rail sector.

LITERATURE REVIEW

A review of current literature found three major applications with the rail sector (Figure 1).

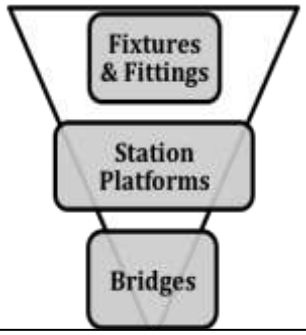

Figure 1: Hierarchy of acceptance

Bridges

Network rail own and operate some 40,000 bridges across 33, 800 km of main line railway (Bell, 2009, p119). It's for this reason why research into the bridge application of the material has been extensive. The properties of the material coupled with the requirements of bridge infrastructure makes for a theoretical match. FRP in this application, from research and case examples, is a jostling between the cost effectiveness of the material manufacture and the required resilience of the structure. From the late 90s NR has worked with a number of consultancies to build their understanding and portfolio of FRP onto its infrastructure. During this time controls such as requirements for use criteria, specifications, agreed design methods and post installation management recommendations for FRP refurbishment schemes were established (Bell, 2009, p120). NR has been driving forward its portfolio of experience with FRP bridge structures (Brinckerhoff, 2006).

Re-decking
FRP re-decking of a bridge structure is undertaken by the use of repeatable FRP cellular decking systems and whole plates. This is currently the most cost effective manner in which to manufacture and install the material (Canning, 2009, p2). Up to now the use of FRP decking systems as a form of refurbishment have seen several applications to NR bridges since 2001 (Bell, 2009, p119). Re-decking is commonly carried out to replace timber decked bridges, this form of structure is common on the infrastructure and design life is relatively low should regular maintenance not be carried out (Canning, 2012, p. 1). On the infrastructure to date the number of under bridge re-decking examples is limited; two know UK applied cases are Rubha Glas Viaduct and Calder Viaduct (Canning, 2012, pp 5-7). Due to the requirement of rail under bridges to have capacity for derailment load, FRP has to be designed with consideration to this. Over bridges have no such derailment requirement and from studies and cases carried out by the HA, NR see greater potential to this application (Bell, 2007, p28). The reduced weight of the FRP deck is of a significant benefit to dead load applied to the existing substructure; also required crane capacity could be minimised allowing for a greater scope of plant to be used (rail-mounted cranes) (Speight, 2009, p106).

Bonded plate strengthening
FRP bonded plates to bridge soffits, have seen the most prolific use on the infrastructure, over 20 examples (Bell, 2009, p119). Bonding of carbon fibre reinforced polymers (CFRP) plates to bridge soffits as a form of strengthening, the increasing of load capacity of structure has seen the most common application to date. With the controls established by NR and its partnered consultancies, successful applications have been achieved.

Whole new structures
A total six new FRP bridge rail structure found to date, for example: St Austell, Standen hey, Launder aqueduct, Bradkirk, River Leri and Dawlish. These structures consist of varying construction forms, but all are made entirely from FRP (Bell, 2009). The spans of the whole FRP rail bridge structures to-date lie around 10m; this is not a limiting factor, as greater spans are achievable. Proven examples of hybrid bridge systems involving steel beam and FRP slab arrangement can span approximately 25m (Canning, 2009for Mount Pleasant M6 over bridge.

Challenges and Barriers

First Cost ≥ WLC
Studies have outlined the possibility of FRP incorporated schemes being parallel in terms of time and cost to steel/concrete (Canning, 2009). This is based on the savings made on closures required to major infrastructure routes, and required lifting capacity in terms of initial cost, standards and experience (Figure 2). This aside, the first cost of the material is comparatively high to its counterparts (Speight, 2009, p106). This is the counterbalance to its WLC benefits. It has been said that this cost could be reduced by the grouping of a number of projects together, taking away the current bespoke nature which the manufactures work to (Bell, 2009, p123). Further to this, should standard modular bridge systems be developed a similar effect on manufactured cost would theoretically occur. This however is limited by span lengths for whole FRP bridges but not with hybrid FRP bridges (Shave, 2009, p 9).

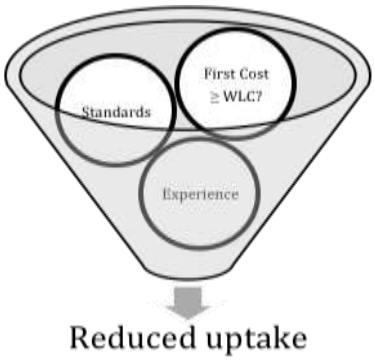

Figure 2: Challenges to uptake

Standards

Reasons for no formal design codes/standards are outlined effectively by (Farmer, 2009, p 142) "The limited use of FRP in structures; Variability of properties, depending on method of manufacture and orientation of matrix reinforcement; Insufficient compilation of project data; FRP manufacturers' unfamiliarity with construction industry standards of design and quality assurance." The lack of formal FRP design standards is at a disadvantage compared to steel/timber/concrete, which have design codes that are universally accepted and can be tested against.

Experience

High factors of safety have been applied to the schemes carried out so far, which have reduced the efficiency of designs (Hollaway, 2010, p. 2437). This suggests that the confidence in the material is a relation of this experience. Experience is seen as a barrier not limited to the design; quality control, testing and inspection and in service damage are all relevant. These factors have to be considered by NR on all its schemes and so limited experience with this presents a barrier (Bell, 2009).

METHOD

In this study, qualitative research approach was used to achieve the aims of the study. In this approach, semi-structured interview was selected as a research method for data collection because this allows for a dialogue of open exploration and a critical analysis into the subject matter. The participants in the questionnaire survey were targeted randomly from different stakeholders; such as client, designers and contractors, which are responsible for the acceleration in the use of FRP in the UK rail sector. This also allowed for a coherent comparisons and analysis of views gathered from the participants. A total of 14 responses from different stakeholders (see table 1) were gathered and used them to analyse using thematic approach to reveal the findings from the survey. The structure of the questionnaire was designed based on the key categories; such as experience, confidence, lack of standards and whole life cost. The questions were tailored to bring the responses in line with this research objectives and to analyse the perception and understanding about the foreseen barriers to confident use of FRP. The thematic approach was used to analyse the interview transcripts and the frequency of use was defined in thematic diagrams. The outline of views and opinions expressed are found under each category heading. Findings have been interoperated by the authors to analysis the meaning of the themes uncovered.

Experience

Table 1: Spread of individuals interviewed

Years' experience	6-8	9-11	12-14	15-17	18-20	>20
Network Rail	2		2			
Designers		2		2	2	1
Contractors		2		1		

FINDINGS

Confidence

Appropriate scenario
The material is not seen as a universal solution for all scenarios, each scheme undertaken is individual and to a certain degree bespoke. As initial cost is high, benefits in using FRP incorporated designs are invariably suited to a minimal array of scenarios; highly corrosive atmospheres (coastal) or sites of limited access (large plant required). This has been the driver for whole FRP/Re-decked bridge locations to date.

Bond durability/technology
The application of FRP comes with its own technique/installation methods; although it can be bolted into position, use will involve some degree of bonding and adhering. Invariably this is the area of most failures seen. The need for additional technics to be adopted in the construction process is understood as a further barrier may reduce the willingness of use.

Experienced Failures
The failures experienced are limited to the bonding/connections details and are few in number; overall this aspect has not been seen as reducing confidents in the material use. Understand between all parties involved that failures haven't stood with the material itself but with the site workmanship and/or design.

More study needed
Unlike examples outside the rail environment, road bridges over rail require standard H4A parapets which generate loads on impact that are difficult for current FRP products to restrain. The bonding and service life aspects of the material are currently under study at Southampton University, further work/research is keenly sought in this area. Fire resistant and performance under vandalism are core consideration and are yet not conclusively understood.

Correct Novel Classification
FRP use in the bridges arena is classified by NR as novel, this classification is well accepted among the individuals interviewed. Being novel means additional checking, known as a category three check, has to be undertaken on designs. This extra protection is regarded as being appropriate due to the current sensitivity of the materials reputation.

Design Code Lacking
The lack of formal design codes and how this affects FRPs confident use is discussed and expanded on in the following section; however it is worth noting it was mentioned by all levels as a direct reflection on the confidence in the materials use on the sector.

NR Internal variance
NRs infrastructure is split into routes being managed by individual asset teams; generally experience with the material is varied to only the routes where appropriate scenarios have been available and asset management teams having seen the potential

off the back of HA lead schemes (Mount Pleasant and West Mill bridges). A balanced level of understanding and awareness does not extend throughout all routes.

Prejudice, Caution and Reputation
The lack of formal design standards/codes is perceived to give an impression of still being an experimental material, also the connotation of being plastic is a stigma which sustains a prejudice in the mind-set of many engineers and is difficult to overcome. Lacking in understanding of the material allows for it to be easily dismissed.

Publishing success
The selling of success is seen as important in spreading confidence, it was noted this could be done better. The FRP champions within NR number one/two and have been the drivers of the material to-date; for wider opportunity the knowledge held by these individuals would benefit from being further publicised.

Lack of standards, the effect

Experience
A high level of experience with the material outranks any formal standards/codes, should they be produced. Classification would cease to be novel however the nature of designing with the material commands a level of experience/understanding, outside of what is currently written down. The development of standards would still leave a certain level of caution with application. Approved companies have capable/ specialised professionals which, NR is satisfied, meet the required level of experience. Should these individuals move on; NR confidence in the capabilities of the approved company to design in FRP would be compromised.

Client Approval
Due to the high risk environment of the railway, engineers are particularly conservative. FRP schemes conducted to-date has been subject to specific testing requirements monitoring performance for future schemes and approval engineer's peace of mind.

Sustains novel classification
It was said that this classification is perhaps sustained by the lack of formal standards. The novel classification may be a stigma to further use by engineers who see it as a red flag, and avoid whether the material be appropriate for their scheme or not.

Reduced design continuity
Standards would allow for correlation between designed projects. Currently it is viewed that the freedom given by the design guides means the schemes currently completed on the infrastructure have a degree of difference which is unnecessary.

Whole Life Cost (WLC)

Recent concept
FRP bridge schemes carried out to-date have been undertaken with initial time and cost being the key selling point of interest. Whole life costing attitude is set to shift in the forthcoming control period; underpinning the new asset management policies.

Initial Cost Priority
Many schemes have fallen at the wayside because the initial cost had been too high. An example included the replacement of a nine span footbridge south of Doncaster station. The structure was listed and in order to be replaced in line with this the associated costs stalled any further development. The new policies set to bring whole

life costing of projects to the forefront of considerations are based around an economic WLC. Three aspects are to be satisfied.

- Efficient - With resects to delivery
- Sustainable - Economically, costs don't accumulate over time
- Robust - Deliver the same required performance of the last CP(4)

Manufactures and high cost
Within the UK manufacturers of FRP structural products number in the range of 2-3 having limited experience in 'heavy' engineering (e.g. turbine blades). Unless a scheme has been outlined as FRP from the start by the client, project time scales have in the past caught out the manufacturer. The nature of the current production market doesn't allow for the flexibility seen in steel/concrete fabrication.

Standard designs
Currently there are 3-4 different types of common FRP decking systems for bridges. The preference of these types is scenario dependant, based on the trials to-date. The development of standard designs would theoretically allow for manufacturing costs to come down. Couple this with batching of schemes and the mass production of the units would make the investment in machinery and technology increasingly worthwhile.

ANALYSIS

Spread of data

The specific nature of the topic 'FRP in Rail', limits itself to a very narrow steam of professionals. The experience of the professionals involved in the study allows the views and options uncovered in the thematic data to justify the shallow pool of interviews undertaken.

Pockets of confidence

The view of varying degrees of confidence around NR is drawn from the nature of how the organisation is broken up into routes (Figure 3). The confident routes have a portfolio of example uses within their jurisdiction, which leaves future FRP bridge applications on the given routes, less susceptible to unnecessary prejudice or caution. The prejudice and caution is as a result of a lack of understanding of the material. An awareness of the potential benefits, limitation, past uses and success, lacks in these routes. The reasons to run with an FRP bridge scheme are not generally understood as well as the reasons against; which for inexperience engineers is a difficult aspect to overcome especially in a historically conservative rail environment. Publishing of success can only take the understanding of the material so far and will not have a dramatic effect on uptake alone. Like those routes of minimal experience, trailing the material on appropriate assets within the inexperienced routes has the potential to balance out the confidence levels within the organisation. Design considerations for fire and vandalism are areas which need further work adding to the lack in confidence to pockets of the routes and conations of being known simply as plastic need to be tackled with proven examples.

Figure 3: NR Routes (Rail, n.d.)

Standard of Experience

The argument given to the novel classification of the material and the lack of understanding means it is correct to sustain its classification, which has been suggested as intern maintaining a level of prejudice within NR. Understanding based on, experience and design guide knowledge are key to the successes of all the previous FRP schemes undertaken by NR. The current fragile reputation of the material dictates that this would have to remain the case until a formal standard/code has been created and even beyond this, in order to build a case for the material. The publishing of standards/codes would allow for an increased level of confidence to exist from the approvals aspect, as an engineer will have a credible reference to which a design can be certified against. Further too this additional level of understanding would be required; awareness, experience and knowledge are the aspect of understanding idealised for confident use.

WLC attitudes

The WLC modelling systems and policies coming though the new CP5 should make it easier for FRP to be seen as a more credible solution. The processes at which the models are used however pose a potential barrier to FRP. If knowledge and understanding of FRP lack within the local knowledge pool than it will not be used. It is fair to conclude that the power for implementation of schemes lies more with the regional route asset management than HQ, see Figure 4.

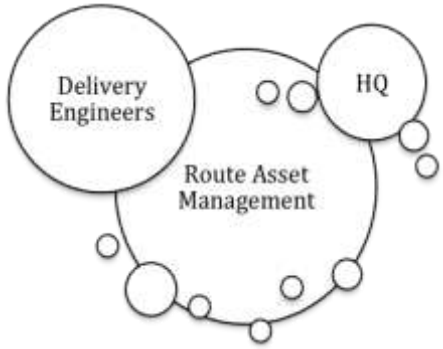

Figure 4: Power of FRP implementation

The new WLC approach underpinning the CP5 is based on an economic whole life costing. The schemes to-date that has proven a time and cost saving before WLC is

even considered are likely to be the model for which any future FRP schemes are to be based off. Proving at feasibility stage that the potential savings in man hours and equipment needed (relating to its S/W properties) fits more in line with the aims of the new strategy.

Marrying up appropriate scenario with the right price enables barriers which have formed the perception of the material as none-viable to likely fade. For this to happen, not only does the spread of understanding have to balance out as discussed, but the manufacturing of the material needs to be re-thought. For greater efficiency the batching and grouping of multiply schemes would make the production more economically feasible for the manufacturer and thus the client.

DISCUSSION

An economic WLC based system, would play to the potential benefits of using FRP on structures. The policy leans towards best WLC unless a good reason not to run is given; which for a government organisation stands to be the correct attitude towards its assets. The models run place the final decision on local knowledge and understanding which is where this has the potential to fail FRP; the spread of understanding of the material within the organisation is limited to only a handful of individuals. This may allow appropriate scenarios for FRP to be more readily overlooked. The ill balance in confidence though the different routes is based on a prejudice, lack of experience and awareness. Aspects such as fire and vandalism feature as concerns which exist and have not been fully satisfied.

Manufacturers have had a difficult time supplying the products for FRP bridge schemes in the past, having to heavily invest in machinery and technology without the forward outlook of production known. This maintains the bespoke nature of new FRP bridge schemes, intern sustaining the price and having a large impact on the efficiency aspects of the WLC modelling. This would theoretically allow for FRP to be more viable at the current manufacturing capabilities/cost.

Should standards be developed, it is foreseen this will only aid in reducing caution regarding client approval. High degree of control will remain on the individuals who are allowed to design FRP incorporated structures on the railway. The historically conservative nature of the sector ensures this. Sustaining a growth in FRP capable professional entering the profession though academic studies are needed, as should the pool of professionals capable within the sector currently retire/move on FRP will have no place.

Number of interviews undertaken was a limitation to the study as the more carried out would have increasingly added worth to the study. Additional input by individuals from Network Rail specifically the Asset Management teams would allow for a more worthwhile study as the findings raised are most relevant to this area. Time for the study has also been limited and so reduced the potential reach and exploration of the aims.

RESULTS

Enablers in Figure 5 are based on views, opinions and experienced analysed. Each represents what is needed for uptake in FRP to be confident within the sector.

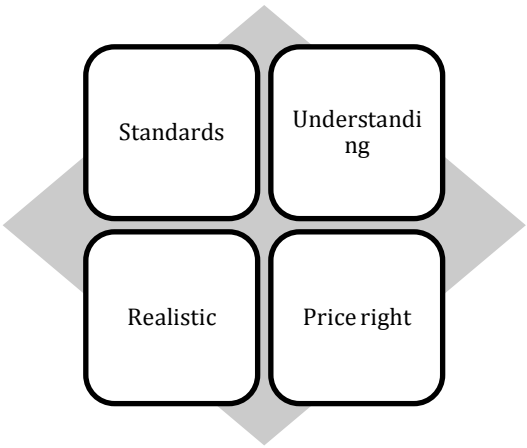

Figure 5: Matrix of enablers

Enabler, Standards

The production of formal standards/codes would only server the perceived experimental nature of the materials use; due to understanding being the overruling requirement. This said the prejudice that exists will continue to exist should formal standards/codes not be produced, despite updated design codes under production. As engineers it is built in to abide by a certified code and denying FRP this only serves as a disadvantage to its potential.

Enabler, Understanding

Having the right people with the right level of understanding enables the portfolio of FRP to grow without being plagued with failure. For this to continue Universities need to continue to include composites within their syllabus and the sector needs to actively encourage capable individuals.

Enabler, Realistic

The materials use in the bridge arena is not a universal solution. The sole benefits of FRP to WLC are not in line with the economic WLC strategy of NRs next control period. The success with schemes where savings to initial installation and time were made, are dissolvable into NRs WLC models.

Enabler, Price right

As the economic based WLC models are the way forward, outside the proven schemes. For manufactures to become more involved with the sectors need and in co-operation, set up standard designs to which can be rolled out in a generic scenario, cheaper and with greater quality control. In the interim should the price of steel/concrete accelerate, the comparable price may enable FRP to become more viable.

CONCLUSIONS

These enablers make up a collective set of requirements for FRP in the rail bridges arena to be successfully adopted confidently. Introducing formal standards would put rest to an experimental prejudice which may rest within the mind-set of cautious approval engineers. The understanding of the material is needed throughout the industry, only then will a wider uptake be seen. The capabilities of the designer are highly regard by NR, for this to be sustainable academia needs to continue to teach composites to new engineers. Also trailing of the materials use should continue with

funding made available to specifically target the routes lacking in experience. The benefits to use need to fit into the aims of NR, therefore savings to initial time and cost on projects is for the interim the most appropriate way for FRP bridge schemes to continue; until a broader portfolio is established and the WLC benefits alone are rated more by the client. Co-operation between the end client and manufacturers in the development of standard deigns would allow for batched schemes to become a realistic opportunity for FRP. Theoretically reducing the initial production costs and making a further case for being the best WLC option.

RECOMMENDATIONS

- A more extensive study into the perceptions of FRP is necessary in bridge application.
- Future study into the effectiveness of the material to withstand vandalism in urban environments is required to improve reliability of FRP.
- EU/UK Gov. funding should make available to carry out further trails on the infrastructure, preferably on routes with limited experience.
- The development of standard NR FRP Bridge designs codes is required.

ACKNOWLEDGEMENTS

Thanks to the participants who made themselves available to contribute towards this paper such as Network Rail, Sinclair Knight Merz, Tong Gee and Partners, Optima Projects Ltd, BAMNuttall, Carillion and Concrete Repairs Ltd. Special recognition is given to Simon Bishop of Network Rail for his cooperation and support.

REFERENCES

Bell, B (2007) The use of advanced composites in railway civil engineering in the UK. University of Bath, pp. 21-30.

Bell, B (2009) Fibre-reinforced polymer in railway civil engineering. "Institution of Civil Engineers", pp. 119-126.

Brinckerhoff, P (2006) "Fibre reinforced polymer (FRP) composited in the rail environment". Bristol: Network Rail.

Canning, L (2008) Mount Pleasant FRP bridge deck over M6 motorway. "Conference on FRP Composites in Civil Engineering", Zurich.

Canning, L (2009) "Development of Economic FRP Bridge Technology" London, pp 1-6.

Canning, L (2012) "Developments in FRP railway bridge applications" London, pp 1-10.

Farmer, D D N (2009) Replacement FRP bridge deck for vehicle loading. London. "Institution of Civil Engineers", pp 141-144.

Hastak, M H D (2000) Assessment of life-cycle benefit-cost of composites in construction. "Composites for construction", pp. 103-111.

Hollaway, L (2010) A review of the present and future utilisation of FRP composites in the civil infrastructure with reference to their important in-service properties. "In Construction and Building Materials" 24, 2419–2445.

Rail, N (2013) "Strategic Business Plan for England and Wales" s.l.: s.n.

Rail, N (n. d) Network Rail available at [Online]
Available at: http://www.networkrail.co.uk/aspx/10451.aspx
[Accessed date: 04 April 2013].

Shave, J S B (2009) "Economic Viability of FRP Road Bridges". Belfast, the University of Edinburgh.

Speight, L C N (2009) FRP railway decking – Calder Viaduct., "Institution of Civil Engineers", pp 103-106

DESIGN MANAGEMENT

EVOLVING DESIGNS AND STAKEHOLDER CONTRIBUTIONS TO THE BRIEFING PROCESS

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This paper examines how client stakeholders engage with a project in the briefing phase through the artefacts of design. The significance of stakeholder engagement and interpretation of evolving designs is emphasized by empirical evidence drawn from a research study into hospital construction project briefing and design practices. The paper reflects that whilst both the NHS client and hospital design teams attempt to "engage" and "understand" stakeholders, stakeholders have the capacity to interpret designs with their own cognitive understandings. The semiotic theories of Roland Barthes and Umberto Eco concerning the role of author and reader of signs and lexicons of knowledge provide a supportive analytical framework for the insights of the paper. It is noted that whilst the constitution of the client and the parameters of a project affect stakeholder management practices, the role of evolving design artefacts and stakeholder engagement and interpretation of them should be recognised. Stakeholders relate to a project via the artefacts of design, interpreting issues against personal individual understandings that may be different to those of construction professionals or externally appointed project advisors. The paper makes the case for more inclusive participatory design initiatives to embrace diverse and insightful stakeholder opinions and interpretations.

Keywords: briefing, hospitals, semiotics, stakeholders.

INTRODUCTION

Stakeholder management has been recognized as an important concept by the construction management academic community (e.g. Atkin & Skitmore, 2008) and by institutional bodies committed to the advancement of project practices (e.g. RIBA`s Certificate in Construction Project Management contains a stakeholder management element). However, there remains a lack of consensus on what strategies, practices and tools to employ to achieve stakeholder management on a project. Indeed, it has been argued that much of the stakeholder management literature is permeated with questionable assumptions and presumptions, often advocating the use of tools that lack validation (Collinge, 2012). This diversity of opinion does not assist in a clarification of ideals, principles or practices for the industry. Certainly, construction projects provide suitable contexts from which to study stakeholder influence and impact as each project brings diverse constellations of client, community and

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Collinge WH and Harty CF (2013 Evolving designs and stakeholder contributions to the briefing process *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 137-146.

corporate interests together. However, questions remain as to the optimum strategies and practices to employ and whether such approaches are effective from a client perspective.

This paper contributes to the field by presenting research findings from a study into the briefing and design of hospital facilities in the UK. It is reported that stakeholder management is very much integral to briefing and design work (not being considered a distinctly separate activity) and that although both hospital designers and the NHS client actively engage stakeholder interests on a project through various activities, the significance of stakeholder interpretation of a design is often missed. It is argued that in the briefing phase, stakeholders relate to designs with their own personal interpretations that may be significantly different to hospital designers, fellow client stakeholder groups and externally appointed client advisors.

Semiotics provides a supportive theoretical framework for the paper, with the work of Eco (1979), Barthes (1977) and the social semiotic insights of Hodge and Kress (1988) and Vannini (2007) being utilized to elaborate upon the significance of signs in the briefing and design process. The paper argues that stakeholders relate to a project through the artefacts and signs of design (i.e. words in a brief; drawings; visualizations; physical models, etc.). These ideas are evidenced by presenting stakeholder interpretations of different design artefacts relating to patient bedrooms within a hospital: the changing form and format of designs affecting how stakeholders understand and relate to a project. It is argued that although designers attempt to predict stakeholder interpretations of designs, actual stakeholder interpretations may be different, resulting in formulas being interpreted in unforeseen ways.

In broader terms, the paper advocates a move away from a conception that stakeholders can be “managed”, having their “power”, “interest” or “influence” tracked in some way by individuals qualified and able to do such task. It is maintained that in the briefing phase, gauging and understanding stakeholder interests is often problematic, compounded by contractual parameters (e.g. PFI: private finance initiative) that inhibit stakeholder communication and input into the design process. The paper provides evidence that stakeholders relate to a project via the designs of a project with their interpretations being valuable and important. The need for more participatory design work is therefore made explicit.

STAKEHOLDER MANAGEMENT

Stakeholder management is rooted in strategic management theory (Freeman, 1984), being adopted by the construction management academic community as an important concept for the completion of successful construction project work (Atkin & Skitmore, 2008). Carroll (1993) provides a succinct definition of stakeholders as:

“those groups or individuals with whom the organisation interacts or has interdependencies” and “any individual or group who can affect or is affected by the actions, decisions, policies, practices or goals of the organisation." (p.62)

In construction project contexts, large numbers of individuals, groupings and organisations could be conceived as stakeholders and scholars have classified them in variable ways. Leung & Olomolaiye (2010) and Olander & Landin (2008) categorize stakeholders as being either internal (clients; consultants; contractors) or external to a project. Publications have ranged in subject-matter from practical advice papers for stakeholder engagement (Chinyio & Akintoye, 2008), methodologies on how best to approach the subject (Fraser & Zhu, 2008), practical tools for utilisation (Walker et

al., 2008) and strategic needs analysis (Smith et al., 2001). Often supported by empirical evidence from case studies (e.g. Olander & Landin, 2008), the stakeholder management concept now embraces issues such as risk and uncertainty reduction on projects, sustainability, ethics and relationship management.

This paper explores stakeholder management from the perspective of hospital projects in the UK in the briefing and design phase. Hospital projects provide excellent contexts from which to study stakeholder management as hospitals embrace multiple stakeholder interests on both the client (e.g. clinicians; patients; visitors; FM; community groups) and construction (e.g. engineers; architects; designers; medical planners) side. Whilst hospital design teams must use optimal strategies and methodologies to embrace diverse stakeholder interests, the NHS client must also ensure that stakeholder interests are embraced and accounted for.

RESEARCH METHODOLOGY

As part of a study into the briefing and design of hospital facilities, a series of 21 semi-structured interviews were conducted with NHS client representatives and hospital architects, designers and engineers. The interviews were supplemented by the collection of materials from projects (e.g. schematic drawings; project documentation; power point slides). Interview questions were directed towards stakeholder management practices employed. Whilst interviewees provided insights regarding the methodologies and strategies of stakeholder management employed, hospital designer efforts to "understand" and "engage" stakeholder interests often oriented around the signs and artefacts of design and how stakeholders understood and interpreted these (i.e. words in a brief; schematic drawings; physical models, visualisations, etc.). As the construction project briefing and design process is characterized by stakeholders and designers communicating over various signs around which shared meanings and understandings are established, it was determined that a focused analysis of the communicative signs of design would be merited.

SEMIOTICS AND SIGN INTERPRETATIONS

Semiotics investigates how communicative signs utilised by people (e.g. spoken words, written texts, photographs) convey meanings and establish understandings between parties (Cobley, 2010). Semiotic scholars have explored and explained sign functionality in areas such as linguistics, literature and the arts, their analysis techniques having a potential utility and applicability to other fields. In “The Role of the Reader”, Umberto Eco (1979) explored processes of sign generation and interpretation through his Model Reader concept, establishing the importance of the cooperative role of the reader in message interpretation. Although Eco focused upon written texts, musical compositions and works of art, his insights are applicable for any occurring communicative act. Eco argued that a sign-generator should have a clear understanding of the interpretive abilities of the sign-receiver as understanding falters when the meaning of a sign is not understood by the message receiver. In a construction briefing context, designs are often formulated by designers with a client audience in mind: designers actively predicting how a design (e.g. drawing, picture) will be interpreted by the client.

Roland Barthes (1977), in his analysis of non-verbal communication systems, clarified how images have multiple meanings, demonstrating how signs (such as advertisements) work on several levels for an audience, making explicit the mechanisms of meaning embodied within the advertisement. Barthes noted how signs

within communicative artefacts can be identified, analyzed and explicated independently for their properties. For example, advertisements have denotative and connotative meanings (i.e. by picturing an apple, an apple is denoted; as the apple is fresh and appealing, concepts of health and well-being are connoted). For Barthes, a reader identifies denoted or connoted meanings depending upon personal levels of knowledge (or "lexicons"): denotative, or 1st levels of signification, requiring only basic linguistic and anthropological knowledge from a reader whilst connotative, or 2nd levels of meaning, require cultural or specialized knowledge. As Penn (2000) states,

"The reader`s interpretational freedom is dependent upon the number and identity of his or her lexicons. The act of reading a text or an image is thus a constructive process. Meaning is generated in the interaction of the reader with the material. The reader`s meaning will vary with the knowledge available to him or her through experience and contextual salience." (p.231)

Both Eco and Barthes emphasize the role of the reader in acts of interpretation and such issues are significant when designs are mobilized between client and designer as interpretations have a potential to affect the design process.

The work of Eco and Barthes has been taken forward by social semiotic scholars such as Hodge and Kress (1988) and Vannini (2007) who investigate how signs are used by people in social situations with motivations and objectives. As Vannini (2007) notes,

"Social semiotics tells us that signs work because people with specific interests and specific strategies produce signs to achieve their goals." (p.131)

However, as Hodge and Kress (1988) point out,

"Social semiotics cannot assume that texts produce exactly the meanings and effects that their authors hope for: it is precisely the struggles and their uncertain outcomes that must be studied at the level of social action, and their effects in the production of meaning." (p.7)

STAKEHOLDER MANAGEMENT PRACTICES

Both NHS Trust representatives and hospital designers confirmed the importance of stakeholder management in their briefing phase work, reporting a variety of methodologies as effective. NHS Trust interviewees reported lengthy and detailed meetings between NHS staff groups prior to the initiation of any project work with construction professionals. As noted by an interviewee, following project initiation, as many stakeholder interests are embraced as possible:

"Some project teams don`t allow the users to have that interface meeting, it would just be a person like me. But certainly I think we actually got a better design and better ownership of the project by engaging the users." (NHS Clinical Healthcare Planner)

Hospital designers reported that engaging with client stakeholders was often problematic due to the nature of the PFI procurement process:

"In the bidding process it is tricky. We rely on the Trust doing that work because the bidders can`t do it otherwise you would lose confidentiality between the bidders. The PFI model can be a problem issue. It depends on the quality of the technical advisors and how well they have captured that information and recorded it and then given it on to the bidders." (Healthcare Sector Leader)

A variety of methods to “understand” the NHS client more were reported by hospital designers, such as internal workshops, issue identification and profiling of key individuals from within Trusts:

“On a recent project, we had a company do profiles of all the non-executive team members, so we know a little bit about them. We try and man-mark them so that one person interfaces with that person all the time." (Project Director)

PFI hospital projects are characterized by design teams meeting various Trust stakeholder groups regularly in an iterative, closely managed process by the Trust (the competitive nature of PFI stipulates that competing teams must be given fair and equal access to the client). It is from within this closely managed process that stakeholders engage and contribute to the design evolution. However, the size of the NHS client does impact upon stakeholder management practices for both client and designer:

“There is a lot of democracy in hospital design which is mostly good news but sometimes can be quite trying because you are trying to take an awful lot of people along with you and you need to.” (NHS Healthcare Sector Leader)

Whilst the processes and mechanisms of effective stakeholder management work was noted as significant, interviewees also provided evidence of how actual stakeholder interpretations of design were arguably more important.

STAKEHOLDER INTERPRETATIONS OF DESIGN

The importance of stakeholder interpretation is now discussed through the insights of interviewees with regards to design artefacts relating to the design of patient bedrooms in a hospital. The design process itself is characterised by the development of communicative signs such as artefacts (e.g. drawings; models; visualizations) that facilitate discussions between client stakeholders and construction professionals. Application of social semiotic theories of analysis can assist in clarifying how issues of understanding, meaning and interpretation occur in project briefing contexts. As briefing and design work proceeds, designs are formulated and presented to stakeholder groups at various stages of the process, designs having their antecedents in Trust briefing documentation, where requirements are stated in written, textual formats.

The following written project statements relating to patient bedrooms were all drawn from a hospital project brief:

"Bedroom windows must be sized and positioned so that patients can view through them from wither a bed or a seat”

“Privacy and dignity of patients should be assured wherever possible and space allowances around patients should be sufficient to provide for this. This could include space for visitors to sit with patients and adequate space between chairs and seating.”

“It is essential that the ward layouts maximise views into and from bedrooms as there is need for continuous staff observation of the patient. Sight lines from bedrooms should be optimised for all users to enable outward visibility."

Architects and designers begin to formulate design solutions based upon a wide number of project requirements, including such specific statements relating to rooms.

Figure 1 is a schematic plan of a ward with 2 banks of patient rooms and 4 separate staff bases. Such schematics are used extensively in collaborative design team work, being important in the establishment of shared understandings (Valkenburg, 1998).

Figure 1: schematic drawing of ward with patient bedrooms

An interviewed NHS Design Development Manager gave a basic overview regarding stakeholder engagement with such drawings,

"Yes, it will start with a 2 dimensional, just a plan. We will look at their drawings, we will talk about it, and then whoever is really around the table will say what they do or don`t like. Or the matron might be there, and she will say that something will not work. There is an understanding issue. We can look at a drawing 10 times and not see an issue, but a matron will see it on first look. We get clinicians who say that we want this and this. But medics have their own interests."

The NHS Design Development Manager digressed on how important issues are often not recognized on such drawings. One example concerned the staff base configuration on figure 1 where male and female patients were monitored by separate nurse teams. The architects had not recognised that one team could monitor both sets of patients adequately,

"It would have cost £250k plus £250k to run that as 2 separate teams per year but if you just join these teams together, you will have 1 team, but the architect didn`t come along and think of that which was a bit of a surprise."

Another example relating to figure 1 was the inadequate space given for facilities use:

"Cleaner's rooms are undersized resulting in necessary cleaning equipment having to be stored remotely from the area in question; this often results from the designers not understanding how Facilities staff operate. It is unlikely in my experience that a Contractor would have any useful input here: more often or not they simply wait for the Client to tell them what is required." (NHS Design Development Manager)

In both instances, architects had been commissioned to produce drawings of proposed hospital area (incurring a cost to the Trust), but the designs themselves were flawed in some way (the staffing/financial implications of the ward and facilities management use). Reflecting upon how certain issues are not necessarily identified from drawings, the Design Development Manager stated,

"Sometimes I can`t believe conversations happen with management because if an architect turns up with a drawing and the right people are not looking at it with the right eyes then things go on until somebody (in this case me seeing the drawing lying around) spots something and says there may be an issue there…Issues like that can go quite a long way."

Figure 2 is a power point slide of a patient bedroom, providing a more visual and aesthetic image of the bedroom that gives a better idea of space and visibility issues (as specified in the written project requirements). Whilst slides give more visual detail for client stakeholders to relate to, they also have the capacity to be interpreted in multiple ways.

Figure 2: power point image of patient bedroom

An NHS Facilities Manager commented that functionality of room elements within such slides is often missed: for example, floor, furnishings, wall colourings and light fixtures within rooms have implications for functionality (and cost) of the space:

"They put things in like beautiful lights on the wall but there is no cover on the top and what happens in Summer? They are a very bad thing for hospitals…patients complain that lights are filthy because they get filled with spiders, flies and dust. They are almost impossible to clean because domestics are not allowed to touch electrical things…And people sitting in the room have nothing else to do, so they tend to look around and they see these and they think "what is that?"

The Facilities Manager commented that the practical and functional implications of colour choice, wall colouring and floor covering are often not recognized by designers:

"Architects are more concerned with appearance than practicalities…an architect always has an opinion of what the inside of this building should look like, what colour scheme should be in there, what kind of lighting, type of furnishing but not thinking this is a hospital and not a hotel…the type of people using this area and how long the lightings and furnishings would have to last as cost is of paramount importance to us in the NHS."

Although certain client stakeholders may be engaged in the briefing process, having their preferences reflected in design artefacts, the interpretation of the same signs by other stakeholders may be different. As the NHS Design Development Manager commented,

"Facilities matters are often sidelined, and possibly not involved in discussions at briefing times. This can lead to real operational problems." (NHS Design Development Manager)

These reflections on how different designs have denoted and connoted meanings for stakeholders aligns with Barthes` (1977) view that readers identify meanings depending upon levels or lexicons of knowledge. Eco`s Model Reader concept is also validated and clarified: designers do actively interpret designs from a client perspective but their interpretations can only be limited. The fieldwork examples are depicted in figure 3.

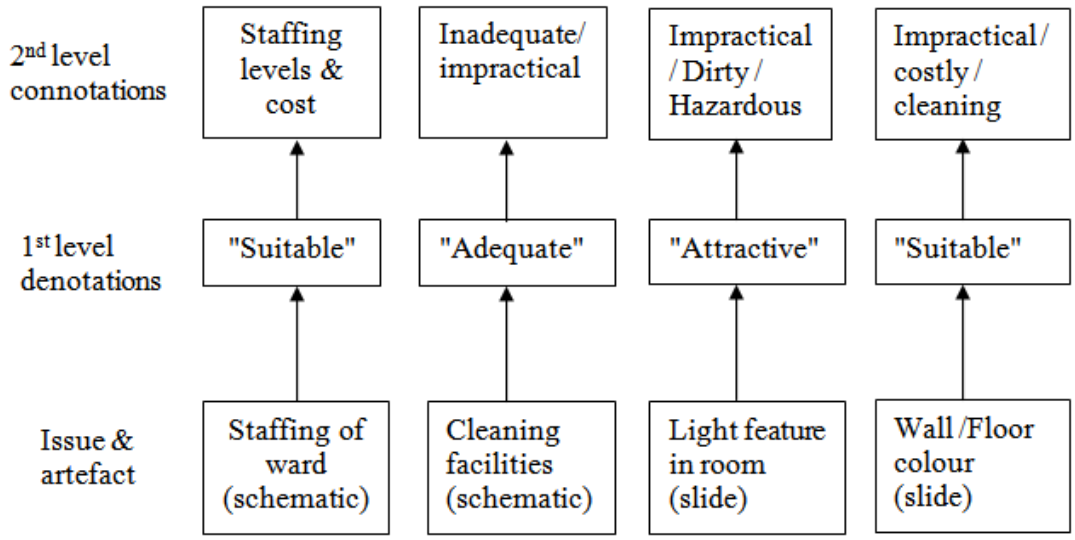

Fig.3: significations or "lexicons" of knowledge invoked by a design

PARTICIPATORY DESIGN

The importance of interpretation has been identified by construction scholars. In work exploring the role of artefacts in design settings, Luck (2007) noted that differences in interpretation between professional and non-professionals is an area requiring further investigation:

“By acknowledging the intermediary status of design representations, the “act of interpretation” is recognized as part of the design process...The problem is that there

seems to have been little, if any, research into how users understand these artefacts." (p.29)

In construction project contexts, both client and designers assume the role of readers and writers of various semiotic resources utilized through the briefing process (e.g. briefing documentation; schematic drawings; room data sheets, etc.). A semiotic oriented analysis engages with communicative resources to clarify the meanings, social motivations and consequences of resource use and the role of sign readers and writers in such interactions.

This paper has re-emphasized the importance of interpretation, urging the need for more participatory design initiatives. However, the reality of construction project work impinges upon the practicalities of conducting comprehensive stakeholder management work: the PFI procurement model for UK hospitals particularly affecting stakeholder management work (PFI being characterized by tight timescales, quick successions of meetings and limited communicative channels between client stakeholders and designers). These realities do effect stakeholder engagement and stakeholder input into the design process. However, as Prasad notes,

"Stakeholder consultation should mean true participation of key people in briefing and design. The people who will be relying on the building to deliver their services possess precious knowledge and unique insight that will immensely benefit the quality of the design." (2008, p.5)

It is perhaps valid to say that the interpretation of a design by a hospital cleaner may be of equal value to that of an Executive Board member, but having the mechanisms of stakeholder engagement in place is important if such contributions are to happen.

SUMMARY

The paper has outlined how hospital design teams and the NHS client attempt to embrace stakeholder interests in the briefing process whilst highlighting the important issue of stakeholder interpretation of designs. Whilst designers actively interpret design issues from a client perspective as they formulate drawings and slides, valuable stakeholder interpretations of a design may be missed because they are not engaged in the design process. Additionally, although designs may become successively more detailed and visual, the diversity of interpretation points to a need for effective stakeholder engagement work. Fieldwork research suggests that on occasion both hospital designers and expert advisors do not possess the same levels of knowledge as NHS staff when relating to design artefacts.

The communicative signs of design provide a vital link between the cognitive understandings of stakeholders and the potential realisations of design as formulated by architects, engineers and designers. Design functionalities are unlocked by engaging staff in participatory design work, allowing interpretation to occur, and by allowing knowledgeable people within the client organisation and the design team to contribute to the briefing and design process. In the briefing phase of hospital projects, optimal design solutions are reached by engaging and utilizing stakeholder interpretations of design to good effect. In this respect, stakeholders should not be "managed", but rather engaged, embraced and valued for their potential contributions.

REFERENCES

Atkin, B, and Skitmore, M (2008) Editorial: stakeholder management in construction. "Construction Management and Economics", 26(6), 549-552.

Barthes, R (1977) "Image, music, text". London: Fontana.

Carroll, A (1993) "Business and Society: Ethics and stakeholder management". Cincinnati: South-Western Publishing.

Chinyio, E A and Akintoye, A (2008) Practical approaches for engaging stakeholders: findings from the UK. "Construction Management and Economics", 26(6), 591-599.

Cobley, P (ed.) (2010) "The Routledge Companion to Semiotics". London: Routledge.

Collinge, W H (2012) Re-thinking stakeholder management in construction: theory and research. "Project Perspectives", 34, 16-23.

Eco, U (1979) "The role of the reader". Bloomington: Indiana University Press.

Fraser, C and Zhu, C (2008) Stakeholder perception of construction site managers` effectiveness. "Construction Management and Economics", 26(6), 579-590.

Freeman, R E (1984) "Strategic management: a stakeholder approach". Boston: Pittman Publishing Company.

Hodge, R. and G. Kress (1988). Social Semiotics. Oxford, Polity Press.

Leung, M and Olomolaiye, P (2010) Risk and construction stakeholder management. In: E.A. Chinyio and P. Olomolaiye, (eds.) "Construction stakeholder management". Oxford: Wiley Blackwell.

Luck, R (2007) Using artefacts to mediate understanding in design conversations. "Building Research & Information", 35(1), 28-41.

Olander, S and Landin, A (2008) A comparative study of factors affecting the external stakeholder management process. "Construction Management and Economics", 26(June), 553-561.

Penn, G (2000) Semiotic analysis of still images. In: M.W. Bauer and G. Gaskell, (eds.) "Qualitative researching with text, image and sound. A practical handbook". London: Sage Publications.

Prasad, S (2008) “Changing Hospital Architecture”. London: RIBA Publishing.

Smith, J, Love, P E D and Wyatt, R (2001) To build or not to build? Assessing the strategic needs of construction industry clients and their stakeholders. "Structural Survey", 19(2), 121-132

Walker, D H T, Bourne, L M and Shelley, A (2008) Influence, stakeholder mapping and visualization. "Construction Management and Economics", 26, 645-658.

Valkenburg, R C (1998) Shared understanding as a condition for team design. "Automation in Construction", 7, 111-121.

Vannini, P (2007) Social semiotics and fieldwork. Method and analytics. "Qualitative Inquiry", 13(1), 113-140.

‘REINVENTING THE WHEEL?': CASE STUDY OF RESEARCH INTO LINEAR/NON-LINEAR AND FRAMING PROCESSES

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‘No need to reinvent the wheel’ and ‘it’s just painting by numbers’ are expressions used by designers avoiding unnecessarily complex or over-simplistic approaches to design problems. These are extreme scenarios, but practitioners are under increasing pressure to minimise design effort and rationalise designs through repeated application of standardised solutions. This paper deductively tests and analyses interview data from building design case studies against analytical, conjectural and reflective theory models for repeat design solutions. A re-framing process for both clarifying a brief and selecting a design solution is shown to best match the described designer behaviour, with instances of linear analytical and non-linear conjectural processes occurring within that framework. It is inducted that designers in a repeated design adopted a strategy for rationalising the design, which they described as ‘modularisation’, although this had multiple meanings for different members of the design team. The strategy was driven in part by the ability to use parametric CAD models to duplicate the design. The case study data is based on a series of architecturally sophisticated projects with fairly unique standardised characteristics. This may therefore limit the ability to generalise these findings to more rationalised building types. However the conclusions of this research add to the understanding of approaches adopted by designers using pre-solutions for standardisation.

Keywords: client, brief, framing, design, efficiency, standardisation, modularisation

INTRODUCTION

‘Reinventing the wheel’ describes an activity that wastes time and effort, because it creates something that already exists (OED, 1989). However, there is a presumption in the use of the term wheel, that the problem to be solved is tangible and has discrete, definable parameters. In building designs, problems are more complex and interdisciplinary, and it is sometimes necessary to adopt a more ‘inventive’ approach (Lawson 2006). Paint-by-numbers is the very opposite of invention. Devised as a process for mechanically creating a copy of an original artwork (Palmerpaint, 2013) the expression refers to an activity that is unimaginative or un-natural (OED, 1989). The ‘artist’ does not require significant knowledge of the original process or the

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Robinson A, Austin S and Gibb A (2013) ‘Reinventing the wheel?': case study of research into linear/non-linear and framing processes *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 147-156.

artistic intention. Within the construction industry, when an outcome is necessarily rationalised and is repeated many times, a mechanical or industrial approach may be the most appropriate because of it offers consistency, speed and efficiency (Womack et al 1990).

This study analyses case study data considering reflective processes of design, described in literature as framing (Schon 1983; Atkin 1992), and compares these to more analytical and conjectural approaches.

The case study considered for this research is a large scale infrastructure project with several repeat designs: a series of high-speed railway stations, using a prototype station design with four specific designs developed simultaneously from the base design. The design team aimed to rationalise the process through the generic design with standardised components, sub-assemblies and pre-assemblies with parametric data using a shared Building Information Model. The team collectively described the process of prototyping, rationalisation and use of generic components as 'modularisation'.

DESIGN STRATEGIES

According to Zal & Cox (2008); p3 'Prototypical strategies' will avoid 'completely reinventing the wheel' when working with manufactured products. The same phrase is used when adopting 'typologies' from past solutions as design generators (Emmitt 2002; p122). These both suggest that there are ways of finding design solutions more quickly. As will be defined below, the use of previous solutions is just one of several methods used in design, with analytical techniques being used for well-defined problems and conjectural techniques being used for ill-defined problems.

Problem-solving Design Theory

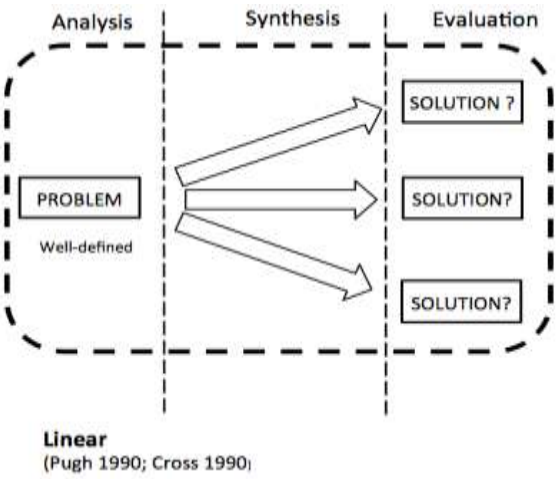

Figure 1: Linear problem solving

Concept, feasibility and detailed design are dynamic and creative phases of a design process and many models have been proposed (Austin et al 2001). Designers follow sequential steps and iterative cycles of design, although others argue (Lawson 2004) that a reflective process is more accurate description. Design methods and design science have been subjects of research since the 1960's (Bayazit 2004). Described as a separate discipline - a 'designedly way of knowing', thinking and acting (Cross 2001) - designers are trained heuristically to evolve processes to solve problems that have not yet been encountered (Lawson 2006). Designers tend to be solution focussed

accumulating knowledge they may use in later designs. Furthermore, the process from problem to solution is not consciously followed or straightforward (Lawson 2006).

Usually working to a time limit, designers aim to generate a satisfactory solution rather than instigate a prolonged analysis of a problem (Cross 1982). The more experienced rely on skilled behaviour reviewing many levels of design simultaneously, tacitly ignoring non-important issues (Cross 1982) knowing that it is impossible to assimilate all the constraints (Cross 1982). Solutions may emerge through intense team deliberations (Macmillan et al 2001) and therefore, as a result, designers do not necessarily 'know' how they design.

Linear and Non-linear processes

For well-defined problems, a linear process with cycles of analysis, synthesis and evaluation, (Pugh 1990, Cross 1990), is the most common model. In complex designs several competing solutions are investigated (Harper 1990), and an objective assimilation of the options is used to find the best solution (Figure 1).

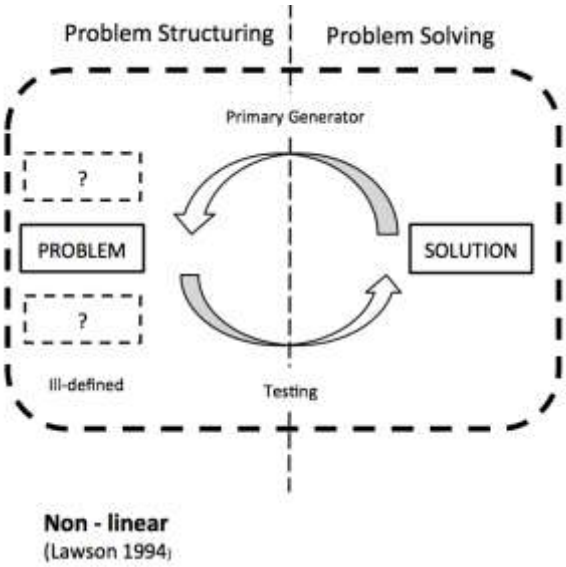

Figure 2: Non-linear problem solving

If problems are ill-defined, designers tend to use a more conjectural process: a cyclical non-linear model with problem structuring and problem solving (Lawson 1994), using a primary generator and testing process as shown in figure 2. The primary generator or 'proto form' is a way of short-circuiting an otherwise complex activity.

It has been recognized that, even in a linear design process, building design solutions may consist of overlapping and conflicting systems and sub-systems of components and assemblies (Groak 2002) further complicating the design process.

Schon (1988) questions the positivistic view on design, noting that most designers are responding to ill-defined problems, using intuition to deal with uncertainty and conflicting demands (Cross 1981). Therefore, the model of assimilation, synthesis and evaluation may be an inadequate description of the process (Lawson 2006) and, in any case, is not practiced widely (Atkin 1992).

Framing Process

Framing theory proposes that each building design is a mental frame (defining size, layout, architecture etc.), which acts as reference for future development of ideas (Atkin 1992). Architectural design is a form of experimentation (Schon 1983); the

framing of a problem is like a hypothesis to be solved through the design process. Framing defines boundaries and situations and is used as a way of describing generic perspectives (Schon 1983; Atkin 1992), leading to framing also being used in establishing building types.

However, research on design thinking and framing (Atkin 1992) has shown that this approach can lead to stereotyping. Atkins asserts that most designs are limited to a small number of generic design options, and 'experimentation involving conjecturing and rigorous refutation is not popular amongst designers' (Atkin 1992); p129. Usually working to a time limit, designers will settle on a familiar and satisfactory solution (Ball et al 1998) rather than instigate a prolonged analysis (Cross 1982) and may even be aiming for a final solution in the first attempt (Atkin 1992). This broad generalisation for design practice deserves further scrutiny to determine if on more evolved design projects this process of stereotyping is still followed.

More recent work on framing focuses on the interrogation of client briefs (Paton & Dorst 2011) as a method of clarifying a design commission shows that different stakeholders have their own perspectives of a brief and re-framing is used to form a common view. During the briefing process, designers confirm back to the client their opinions on the building by re-framing the brief to propose a solution that is realistic.

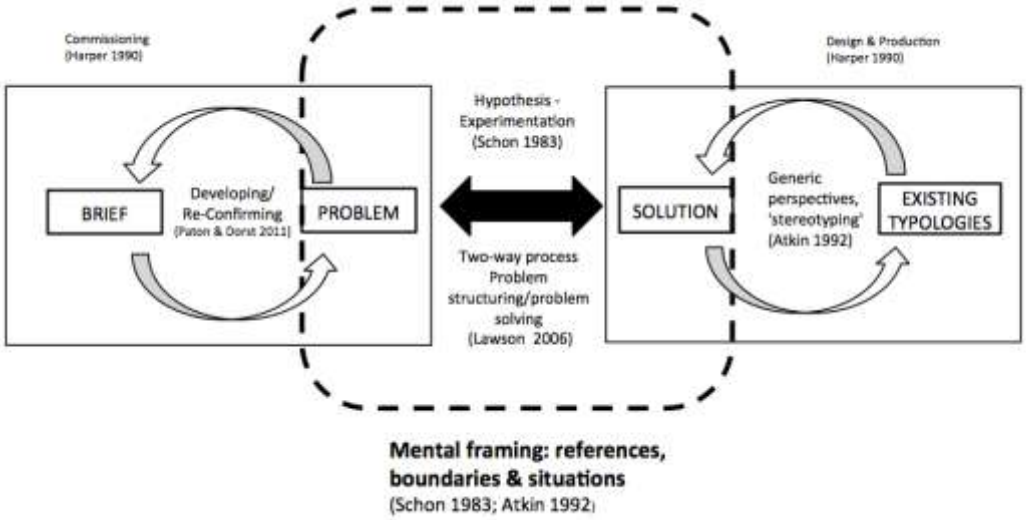

Figure 3: Framing of a design problem and solution

Figure 3 graphically summarises and collates the two current theories on framing activities for evaluating and reconfirming the brief (Paton & Dorst 2011) and framing of the solution with pre-existing typologies (Atkin 1992). The combined outcome of these two processes is a problem structuring/problem solving activity (Lawson 2006), defined through common boundaries (Schon 1983). Schon's experimental process of hypothesising is a testing, rejecting and refining using this mental frame of the project design.

These processes are non-sequential: the process of confirming the problem through the brief, exploring existing typologies and refining the solution, occur in a loosely structured relationship as shown in this diagram. The research will test out this framing model and also look for the presence of linear and non-linear processes, which are known to occur. Under this model they are proposed as episodes of design activity occurring within the framing events.

RESEARCH METHODOLOGY

Epistemologically, the research is testing and revealing a condition that already exists and is therefore empirical realist in nature. The ontological position is predominantly objective, but recognises that organisational behaviour will influence this study and therefore is open to constructivist perspectives. The chosen research method for collecting and analysing this data is a case study approach (Yin 2008). Using a theoretical statement to enable an explanation or prediction of theory the approach is deductive, using linear techniques for analysis. However, as found in many studies, the distinction between inductive and deductive research is blurred as both approaches may occur during different stages of the same research process (Bryman & Bell 2007). Bryman & Bell propose a variant of the deductive empirical research model, which ends with an inductive phase: a hypothesis is deduced from literature and preliminary data and is scrutinized in the normal way to see if the main findings confirm or reject that initial hypothesis and, depending on the outcome of those research findings, the theory is further revised through an inductive process.

Data was collected from 25 interviews (40 hours) as part of a set of end-of-project ‘After-Action' reviews (AAR) (Morrison & Meliza 1999), a hindsight process (Bartholomew 2005) intended to increase a group awareness of tacit knowledge. The team used memoranda and design models to communicate the design and these were interrogated along with project reports and drawings. The interviews were organised as structured conversations (Bryman 2007; Cresswell 2008) based around the topics of the AAR process.

Thematic analysis was used to extract data from the interview transcripts; a coding frame was developed for the analysis by:

1. Exploring themes and recurring topics, identifying repeated words and phrases
2. Sampling data from the interview transcripts based on descriptive statements referring to the design process
3. Sorting data under the key categories:
    a. brief development/problem structuring (Patton & Dorst 2011)
    b. problem solving/use of previous typologies (Atkin 1992),
    c. framing of the problem and solution (Schon 1983; Lawson 2006)
4. Sorting this data under sub-categories:
    a. analytical linear *(Pugh 1990; Cross 1990)*
    b. conjectural non-linear *(Lawson 2006)*
5. Drawing inferences from connected quotes, repeated topics, and occurring phrases

The design team followed a prototype-design approach because of the scale of the station project (>2 billion USD) and its repetition of designs. The modularisation approach created a philosophy for the team of 150 architects and engineers to follow. The case study is treated here as a singular project because the four stations were developed simultaneously from an initial prototype design. Being a unique example of its type it has justified a singular detailed case study investigation (Yin 2008).

Figure 4 shows a typical section through the station platform and concourse. Although two of the stations were through-stations and two were arranged as terminus

stations, they all had common repeated elements: linear platforms and canopies of varying length and arrangement, based on a repeated modular design.

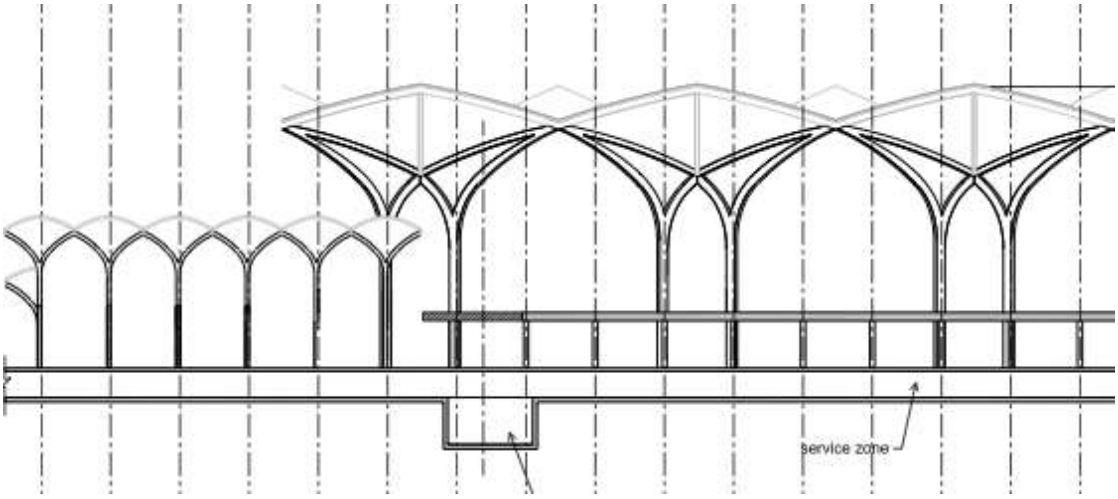

Figure 4: Typical cross section of similar building elements in stations.

The central concourse structures were of different scale, layout and number of levels, depending on their site and nature (terminus/through). The buildings had several other rationalised components and similar cladding treatments.

RESEARCH FINDINGS

The interrogation of drawings, reports and interviews was aimed at detecting the different strategies being used during the different phases of the project. The research findings are grouped under the three headings:

1. Brief development/problem structuring,
2. Problem solving/use of previous typologies,
3. Boundary framing of the problem and solution.

Brief development/problem structuring

Although the project started with the brief development, the observed evaluation/confirmation process continued throughout, including during the detailed design stages. Design outputs were presented to the client at each stage to reconfirm the way that the design was meeting the brief.

The client's brief was found to be under-developed; it contained a list of areas that the client would need for running and controlling the station, but there were no detailed requirements.

"It describes what the entrance should encompass etc.… but (there are) no standards" (Designer O; 2010).

The design team created a document to re-state the brief back to the client. "Our objective was to convert the client's brief into a working document, as well as telling him what we were going to do" (Designer O; 2010). This document contained specific design criteria and design proposals. With the client only having a partially formed idea, the design team were taking on the role of 'expert/artist' (Paton & Dorst 2011), with the framing process being largely led by the design team.

The report shows evidence of a detailed analysis of the brief including a deliberation and selection of design options. The reports also conveyed design ideas: "we would add in design criteria and sketches to show him what systems we were using"

(Designer O; 2010). The use of sketches suggests that these designs were preliminary and conjectural as to what the final proposal would contain. The designers were using their professional knowledge, including schemata and guiding principles (Patton & Dorst, 2011), to reframe the design problem.

Without full information on the operation of the railway, the JV appointed a sub-consultant as a proxy operator: "we all realised that we needed a rail operation specialist" (Design Manager AC; 2010). These separate consultants invented a virtual rail operation with a timetable, with generated passenger flows and station staffing levels in order to re-confirm assumptions about the size of the station concourse, platforms and accommodation. This process required both invention and detailed analytical processes to create the necessary data for understanding the design and operation. This situation confirms the need for a cyclical process of developing and re-confirming of the brief with the client (Paton & Dorst, 2011).

The client later appointed academics to assess the architecture. "The introduction of the professors post-concept, caused a delay to approvals as the design team needed to re-justify the design principles". This indicates that a continuing process of deliberations and approvals was taking place during and beyond the brief definition phase. "…once on-board, their (professors') subsequent endorsement of the scheme became useful later" (Architect AB; 2011. This shows that a building of relationships with the client body was helped through the framing process, and through the professors role the client team became more of a 'collaborator' with the architect (Paton & Dorst 2011).

Problem solving/use of previous typologies

For the layout of the public spaces and the architectural roof forms, the design team drew inspiration from their previous projects and airport buildings in particular. In the concept design documents, comparisons were made with repeating roof systems used in airport departure halls, as well as using local contextual references to forms such as arches and colonnades. Notwithstanding, there was little indication to suggest that design 'stereotypes' (Atkin 1992) were being used beyond the concept stage as idea generators. The airport precedents were closer to an initial framing technique using a primary generator for conjectural analysis (Patton & Dorst 2011). The options report detailed variations in repeating roof forms, with variations in pitch and grid spacing, showing a significant degree of analysis and synthesis with evaluation of these options. This process was "architect led", being "really about what worked spatially and for operation" with the structural engineer "helping (the architect) to see what worked as a column grid" (Designer M; 2010). Therefore the solution structuring process, which initially drew on other building typologies solutions, continued to be re-framed through a consideration of parameters (structural grid, jointing, vertical supports, optimisation of spanning structure) and within this process there were cycles of linear analytical design work.

However, the design team, led by the architects, operated a robust reviewing process called a design review board, occurring shortly before final design resolution at each stage in the project. As a result of these reviews, agreed detailed designs were frequently rejected, leading to re-designs.

The timing of these was chosen to make sure that the design leadership endorsed the design presented to the client. The review boards were also helpful in identifying the critical issues for the design, giving the lead architect and his the team fore-knowledge on which aspects of the scheme to push more strongly with the client, and which areas

where they could show more flexibility. However, for many in the design team the results of these reviews appeared unpredictable and the process highly conjectural. In effect, some non-linearity seemed to be self-imposed through the architect's review processes. Major design revisions would be made at these reviews: “they decided to punch a hole all the way through, to connect to the platforms of the two through stations…. but we had a fire compartment between the station and the platforms (Designer P; 2010). Internal design meetings also had unpredictable results. The architect’s team “would change designs the day after the meeting where decisions were made” (Designer M; 2010). “The frustrating thing from our point of view was that we were committing to delivering Stage E and beginning of stage F” (Designer Q; 2010). Stage E & F are detailed design and contract production stages; these accounts show that conjectural design activity was occurring at the same time as more focussed linear and analytical processes associated with delivery of information.

Boundary framing of the problem and solution

The project was of sufficient scale to appoint senior designers to oversee each of the key disciplines; their role was separate to the delivery team in order to maintain an over-view of their own discipline. They were also required to be able to contextualise the technical requirements of their discipline from the overall project perspective. This became important for the design board, because discipline leaders needed to be able to “articulate a design concept or story” in negotiations with other disciplines. They also needed to have a clear picture of the overall context “making it clear why certain choices are made’ (Manager AF; 2010).

The use of design notes was also considered an “absolutely crucial tool” (Designer Q; 2010) for defining the design thinking and process for all the stations. These instances of technical oversight and communication are evidence that mental frames described through a set of boundary criteria (Schon 1989) were being defined to manage the detailed design of the buildings and the framing activity was instrumental in assisting collective team knowledge and understanding of the design problems being tackled (Atkin 1992).

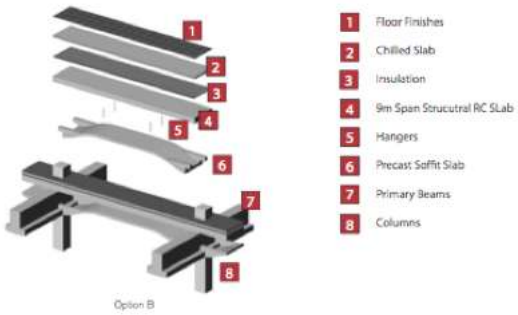

Figure 5: Concourse ‘kit of parts’ structure

For the concourse layouts the prototyping team had developed a ‘kit of parts’ for the structural components (figure 5). Simplified analysis models were sent to the station teams, who then worked them up into station specific models. The standard ‘kit of parts’ approach was also adopted for the drawings, with elements built-up piece by piece. This process was “tricky at the start, knowing where all the pieces went” and stations designers “needed to know design assumptions made for all the elements” but eventually it “became an incredibly fast tool” (Designer T; 2010).

"The most efficient way of doing this was to design the stations simultaneously. When we ran models, the same person would look at the same part on the other station, applying learning from the first station straight away" (Designer T; 2010). This shows that the framing of design problems was instrumental part of the evolved design solution using standardised components and sub-assembly designs.

CONCLUSIONS

To conclude that 'a structured design generation and synthesis is little practised by designers... and future designs are more likely to be combinations of previous designs…than representing a new line of thinking.." (Atkin 1992); p129, has not been evidenced in this study. The designers appeared to be using a structured approach to the design, they were synthesising problems associated with the brief, and developing original designs.

Reframing as a design theory is a convincing model for representing the overall process of design as shown in this case study; the design process is a non-sequential series of reflective mental activities grouped into loosely structured stages of briefing evaluation, solution testing and problem structuring/problem solving. The occurrence of each stage was interrelated with other stages; the brief process was negotiated, the testing out of building typologies was a conjectural and analytical process of testing and rejecting options, and the definition of framing boundaries for problem/solution was formally defined to become an important structure from which the detailed design emerged.

The modularisation process, based on an initial prototype was a predetermined strategy, in effect an evolved type of framing, with design parameters being defined through the prototype and then reconfirmed in the detailed design of the individual stations. Framing through modularisation as shown here is a productive technique for structuring and developing a standardised design.

REFERENCES

Atkin, B. (1993). Stereotypes and themes in building designs: Insights for model builders. Construction Management and Economics, 11(2), 119-130.

Austin, S., Steele, J., Macmillan, S., Kirby, P. & Spence, R. (2001). Mapping the conceptual design activity of interdisciplinary teams. Design Studies, 22(3), 211-232.

Ball, L. J., Maskill, L. & Ormerod, T.C. (1998). Satisficing in engineering design: Causes, consequences and implications for design support. Automation in Construction 7(2), 213-227.

Bekins, D. & Aliaga, D.G. (2005). Build by number: rearranging the real world to visualise architectural space. Visualisation 2005, VIZ 05. 23-28 October, pp143-150.

Bryman, A. & Bell, E. (2007). Business research methods. Oxford University Press, USA.

Creswell, J. W. (2008). Research design: Qualitative, quantitative, and mixed methods approaches. SAGE Publications, Incorporated.

Cross, N. (1982). Designerly ways of knowing. Design studies, 3(4), 221-227.

Cross, N. (1990). The nature and nurture of design ability. Design Studies, 11(3), 127-140.

Emmitt, S. (2002). Architectural Technologies. Blackwell Publishing, Oxford, UK.

Groak, S. (2002). The idea of building: thought and action in the design and production of buildings. Taylor & Francis.

Harper, D, (1990), Building, The Process and the Product. CIB, Ascot, UK.

Lawson, B. (2004). What designers know. Routledge.

Lawson, B. (2006). How designers think: the design process demystified. Architectural Press.

Macmillan, S., Steele, J., Austin, S., Kirby, P. & Spence, R. (2001). 'Development and verification of a generic framework for conceptual design', Design Studies 22(2), pp. 169-191.

Morrison, J. E. & Meliza, L. L. (1999). Foundations of the after action review process (No. IDA/HQ-D2332). INSTITUTE FOR DEFENSE ANALYSES ALEXANDRIA VA.

Dictionary, O. E. (1989). Oxford: Oxford University Press.

Palmerpaint, (2013). Palmer Paint Products. www.palmerpaint.com. (Accessed 20/06/2013)

Paton, B. & Dorst, K. (2011). Briefing and reframing: A situated practice. Design Studies, 32(6), 573-587.

Pugh, S. (1991). Total design: integrated methods for successful product engineering. Wokingham: Addison-Wesley Publishing Company. (pp. 44-45).

Popper, Sir K. (1972). Conjectures and Reflections, Routledge and Kegan Paul, London.

Robinson, A. C., Gibb, A. G., Austin, S.A. (2012). Standardisation of specification driven buildings with serial and repeat order designs. ARCOM conference, Edinburgh, 2012.

Schön, D. A. (1983). The reflective practitioner: How professionals think in action (Vol. 5126). Basic books.

Womack, J. Jones, D., Roos, D. (1990). The Machine That Changed the World. New York, Rawson Associates.

Yin, R. K. (2008). Case study research: Design and methods (Vol. 5). SAGE Publications, Incorporated.

ACCOUNTING FOR USERS: DESIGN TEAM WORK IN IMMERSIVE VIRTUAL REALITY ENVIRONMENTS

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The study examines how designers account for the use and users of their design in the situation of reviewing the design in an Immersive Virtual Reality Environment (IVRE). The focus is on the interactions whereby designers express the imagined perspective of being users, and on how the design meeting is configured with respect to the concern around the use of the future building by the real users. Observations are made around how designers express these 'narratives' around experiencing a design as imaginary users through various modes (verbal, graphical, behavioural) involving different procedures and forms of representation. The case study is an on-going construction project for a new hospital in the UK, where an IVRE was used performing design review sessions during the bid preparation stage. Drawing on data based on direct observation and audio-video recordings of multiple design meetings, the scrutiny is on how architects adopt the position of end- users in design sessions in which users do not participate. The aim is to examine the nature and dynamics of interactions inside a design team as they imagine users' needs in an IVRE. The focus is on how architects express and test the 'usage' of their design in this particular technological setting, where life- like movements and physical interactions with the design are possible.

Keywords: design, immersive virtual reality environment, interaction

INTRODUCTION

The aim of this study is to investigate how designers account for their users, from the perspective of examining instances where designers adopt the role of being a user in an Immersive Virtual Reality Environment (IVRE). Concerns around how the 'use' and users of an artefact are incorporated in the design process have been raised across domains of architecture, engineering, product design and software design (e.g. Luck 2007, 2012; Ball and Christensen 2009; Cross 2000; Arvola and Artman 2007). Within the construction field, the issue of how designers account for users tends to be oriented towards designers directly engaging with users (in creating together shared meanings of design schemes) or in using individual experiences and knowledge to imagine end- users' experience of the design. The case study is an on-going construction project for a new hospital in the UK, where an IVRE was used performing design review sessions during the bid preparation stage. The focus is on

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Maftei L and Harty C (2013) Accounting for users: design team work in immersive virtual reality environments *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 157-166.

how architects express and test the ‘usage’ of their design in this particular technological setting, where life- like interactions with the design are possible.

LITERATURE REVIEW

This section identifies two broad strands in the literature around designers and users: the first focussed on designers directly engaging with users, and the second strand investigating design sessions in which users do not participate. Within the second strand we identify two main modes whereby designers account for the use and users of their design: through drawing on their previous individual experience of an existing design, or through imagining an end- user's experience of the design being developed.

The first strand of studies focusses on how designers account for users through investigating design situations in which end users are being directly involved. Building on a participatory design approach, such studies stress the role of bringing users’ perspective on the use of a designed space (drawn on their insights from the lived experience in similar buildings) in conversations with architects, to collaboratively articulate design problems and solutions through establishing together a ‘spatial reasoning’ of a design scheme (e.g. Luck 2012). From a similar standpoint, work oriented on the conversational behaviour in design meetings in which architects engage directly with users in 'reflecting in practice’ discusses the role of describing the use of space to create shared meanings of the design proposal (Luck and Mc. Donnell 2006) or to coproduce design ideas (Luck 2007).

The second strand of research concerned with how designers address issues around the use of the design as final product draws the attention on the interactions inside designers' teams, and examine design situations in which users do not participate. These studies examine how architects reflect on the use of space from the clients’ perspective through simulating users’ experience of occupying the designed space, in various modes involving different procedures, technologies and forms of representation. In this sense, some studies focus on the role of mental or graphical scenarios accompanied by ‘narratives’ developed and expressed through verbal description and/ or through drawings and gest-draws, and discuss how architects imagine ‘stories’ about their users, in which they refer to “the ‘roles’ they play and to the ‘rituals’ in which they are set” (Lawson 2006: 205). It is also examined the use of ‘narrative’ as strategy for conceptualizing and testing design ideas (Lawson 2006:267), and of how new technologies mediate the expression of such ‘narratives’ through drawings and gest-draws (e.g. Buscher 2005). Other work examines how the embodied references to the design are mediated through multiple visual means and models (e.g. Buscher 2006), or discuss the use of various forms of design representations for enabling a viewing experience of the designed space, as similar to users’ perspective (e.g. Yaneva 2005- the scaling process, the use of physical mock-ups and of the model-scope).

In other domains of design, literature around designers enacting the role of users and/ or of system components of a design, discusses the role of ‘personal analogies’ in the creative process, as for example through imagining circumstances of being the user of a designed object, or a part of the designed system (Cross 2000). Studies around the social dimension of teamwork in design discuss how assessing the ‘human factor’ issue of a designed object is guided through designers’ personal knowledge on the use of their design, based on individual experience of a design situation (Cross 1995). Empirical studies of engineering design meetings (Ball and Christensen 2009) address issues of analogical reasoning and mental simulation in design with regard to features

of end- user's experience of the design. From a similar concern, other studies investigate how collaborating designers simulate experiencing a design through gestures and taking on the role of users or of system components (e.g. studies that examine types of enactments employed by designers to express a design concept - "means of expression", such as through gestures and improvising playing) (Arvola and Artman 2007). This study draws the focus on how architects adopt the position of end- users in design sessions in which users don't participate. Compared to the above studies, which focus mainly on the spoken interaction, this paper extends the scrutiny on how the visible means of enacting user's behaviours interplay with the verbal modalities of reflecting on and expressing the use of the design.

METHODOLOGY

This research examines the nature and dynamics of design interactions in an IVRE from the concern with how architects consider the usage and the experience of their design from the perspective of imagining themselves as users. This concern with understanding specific interactional aspects regarding the practical and situated accomplishment of design is consistent with the methodological choice of observing in detail how this set of practices are naturally performed in this particular setting. The case study is based on an on-going project for designing a new hospital in the UK. One of the requirements is that all patient accommodation is in single rooms, rather than traditional wards. Single room only accommodation is rare in the UK, and so a key issue for the client was ensuring that the rooms were of sufficient size. At the time of the research, the project was still in bid preparation stage. The project team opted to augment the traditional design and client engagement procedure with the use of a CAVE (a type of IVRE) at the University of Reading. This was to be used to demonstrate to the client that the rooms were of an appropriate size.

As particular type of IVRE, the CAVE is a surround large display visualisation technology that may allow multiple users to experience an immersive simulation of tri dimensional life sized virtual objects at a time. The classic CAVE (Cave Automatic Virtual Environment) as the one designed and implemented at the University of Illinois at Chicago in 1991, is a multi-person, room- sized, high resolution multi-display 3D video and audio environment, in which graphics are projected stereo onto the walls and the floor. It offers the user (equipped with 3D stereo glasses and a head mounted tracking device with location sensor) an active stereo and real-time interaction with the model. One user's movement in the space of the CAVE is being tracked and, consequently, the correct scene perspective rendering is displayed in a continuous responsive manner. CAVE participants see their arms and bodies and can easily interact between themselves during the simulation (De Fanti et.al. 2011). The CAVE at the University of Reading has three vertical projection screens (3m by 2.2 m) and a floor projection screen (3m by 3m).

The research used video recording and direct observation of a series of six sessions held within the CAVE, involving project and design managers, architects and designers, and modellers and visualizers, in various combinations. These were spread across five months, between November 2011 and March 2012. These sessions produced 12hours of audio-video recordings. Various combinations of video cameras have been used to capture the design meetings: one hand-held camera, a second camera fixed on a tripod, positioned in one corner of the CAVE and a third camera fixed on the CAVE's ceiling to offer an aerial top down view. In conducting the

research, we followed the University's ethical procedures regarding the participants' consent, and the confidentiality and data protection.

This study examines how designers account for their users and express this in an immersive environment. The focus is on the particular interactions whereby designers make sense of the 'usage' of the designed spaces and enact user's behaviours, and on how the IVRE is used in configuring these interactions. The analysis draws on a collection of such situated enactments whereby designers reference their actions to how the design might be experienced by their users. The empirical material has been structured in four episodes analysed below. The initial fragment has been selected to provide preliminary sense of the interactions that will form the focus of attention. The following episodes examine several instances whereby designers imagine themselves as users experiencing the space of the hospital. This approach draws on video ethnography based studies of workplaces and of interactions (Heath and Luff 2008; Heath, Hindmarsh and Luff 2010). The transcripts presented in the paper have been produced using a simplified transcribing system provided by Silverman (2006).

ANALYSIS

Between virtual and real: Simulating the experience of inhabiting the space

This fragment supports introducing a chronological frame of the design events occurring in the CAVE in the context of preparing the bid for the hospital project. The fragment is extracted from the first from a series of six sessions of reviewing the design in the CAVE, and it refers to how the architects and contractors teams first encountering the immersive environment perform a walkthrough of the hospital's virtual model. It has been selected to illustrate an instance whereby the design participants envisage potential benefits of using the CAVE for presenting the design to their client.

Figure 1.Episode 1 images

Episode 1 (E1)

Designer1 (09:00):	I can seat down.
(09:16):	((the designer is kneeling))
Contractor 1 (09:17):	And if you could look a bit further to the right? ((the contractor points the direction with the hand))
(09:19):	((the designer follows the suggestion and orients the head and gaze towards the right; the other participants take photos with the designer inside the space of the hospital))

Contractor 1 (09:20): And if you turn to the left?
((the contractor points the direction with the hand and dynamically gestures towards the left side of the model))
((the designer reorients the head and gaze towards the left))
Contractor 1 (09:22): That's go:od.
((the other participants take another set of photos with the designer facing the opposite direction of the reception area))
Contractor 1 (09:24): Now stand up!
(09:26): ((the designer begins to gradually stand up))
(09:28): ((the designer is standing up))
(09:30): ((the other participants take a final set of photos with the designer standing on the reception desk))
Designer 1 (09:38): You can actually d:o (.) like typing!
Designer 1 (09:46): ( ) You got to get the TRUST ((the client)) in here!

In the course of examining the main reception area of the hospital, the participants decide to record a series of photos with the spatial effect of the virtual model as previewed in the CAVE for demonstrating the compliance of the design scheme with the visibility requirement. In consequence to noting the advantage of a 3D life size scaled model which allows real- time interaction through physical motion, they decide to augment the sense of scale and realism in the photos by including a designer acting as nurse while performing activities at the reception desk, as personage in the picture. The project team employs an active simulation of the visibility scenario for illustrating various viewing angles of the reception area from different height levels around the desk as in the real use of the hospital. Following a contractor's guidance, the designer acting as nurse gradually changes the position of her body as from siting down on a virtual chair to standing up. A rich range of visual behaviour accompanies the verbal coordination between participants and the interaction with the imagery throughout this sequence of the design meeting. Multiple changes of gazes and gestures of pointing (with the arms and fingers) towards different areas of the hospital, or reorienting the head direction and body motion in the space of the CAVE are frequently being engaged.

After the project team's members consider they had recorded sufficient photos of the model displayed in the IVR, the designer which had acted as nurse continues playing the role of being medical staff, and spontaneously begins to engage in testing the experience of inhabiting the model. Finding herself standing near the virtual desk she notes how the model interactively responded to her body's motion within the space as in a real building (E1, 09:26-09:30). Observing how her arms seem to rest as on a real furniture object (the effect of the life size scaled model) she begins to move her hands and fingers in gestures of simulating typing on a real keyboard, imaginary placed on the virtual desk (E1, 09:30- 09:38).

The proximity of the virtual desk at a real like height and ergonomically placed as perceived in relation to designer's body stimulate her responsive reaction to simulate performing an activity in the surrounding model and generates the feeling of inhabiting the space: "You can actually d:o (.) like typing!" (E1, 09:38). Impressed by the strikingly compelling sense of being in the model (and the real-like perception of the hospital's space) she points the potential of using the CAVE in the design review and for presenting the design to the client: "You got to get the TRUST in here!" (E1, 09:46). The designer's sudden behaviour (between the moments 09:30 and 09:38 in the fragment E1) infers the effect of the immersive environment on stimulating

adopting a perspective analogue to being an end user experiencing the space. Also, the enactments of user's behaviour instantiated in this fragment reflect a rich interplay of talk with dynamic visual means expressed through body motion and gestures.

In the context of the on-going project for designing the hospital, these observations around the potential of the technology, such as enabling the immersed participants to simulate performing activities in a realistic way, influenced the project teams' members to consequently deciding to use the CAVE for presenting the design to the client. In summary, this analysis points towards how designers adopt the perspective of being users for testing the design requirements through employing a rich interplay of verbal and visual behaviour in the IVRE.

Reviewing the design in the CAVE: Designers imagining themselves as users

This subsection examines how the architects, designers and visualizers in the project team consider the activities performed in the designed spaces from the account of users. More specifically, it refers to how participants exploring the design in the CAVE interpret and make sense of the virtual model from the perspective of imagining themselves as users experiencing the space of the hospital. The focus is on how designers are moving the design review beyond discussing issues of form and function to address the experience of occupying the space, and on the modes of expressing this design concern in the immersive environment.

The following fragments are extracted from an early design review session when the architects' team is concerned with the compliance of the design scheme to meet the client's requirements and with how the geometry of space fits the functionality, and also with the visual experience of the model (e.g. lights, colours, textures).

"Can I look at the bath?" "( ) The door looks wide" "The door is wide"

Figure 2.Episode 2 images

Episode 2 (E2)

Designer 1 (15:44):	The door seems wide.
Designer 2 (15:45):	Can I look at the b:ath?((shows the direction with her arm))
Designer 1 (15:46):	Wh::at?
Designer 2 (15:47):	He thinks I'm wide…((laughs))
Designer 1 (15:49):	Ha, ha, I don't know how you got the conversation that way! ((general laughs))
Designer 2 (15:52):	I'm gonna go in the toilet.
Designer 3 (15:53):	The door looks really wide.
Designer 2 (15:54):	The door is wide=
General	=The door is wide

This episode depicts an instance when the design team examines the door separating the bedroom and bathroom areas in the patient's room. In previewing the door from

the bedroom, one of the designers estimates the door's dimension as appropriate to allow a person's way between the two adjacent spatial units: "the door seems wide" (E2, 15:44). This infers a lack of certainty about the door's dimension, as the accuracy of the evaluation is not based on a precise measurement tool (like it would have been available on a scaled drawing on paper, or on a scaled physical or virtual mock-up visualised on a computer screen): "seems". It also implies another mode of measurement through considering how the door fits its use and referencing the door's width to the human body's size (therefor the door is described as "wide"). This remark relates with the immediately following moments when the way in which the designer leading the navigation formulates the intention to move the examination of the model in the bathroom as "Can I look at the bath?" generates a reaction of surprize in the first designer's in exclamation "Wh::at?". This constitutes an interestingly atypical reaction during a design review, in which shifting the spatial analysis between different areas of the design, as these are progressively being examined, is a routine procedure. The element of surprise is further augmented in the second designer's reaction: "He thinks I'm wide…" (E2,15:47). Being aware that she is visually situated in close proximity to the virtual door, previously estimated as wide, the second's designer (wearing the head trackers) ton of amusement questions the sense of relating the door's width with the size of her own body. The immediate response "I don't know how you got the conversation that way!" marks a particularity of the immersive design review and infers the overlay between the real-life like behaviour in the virtual hospital and a mode of relating design dimensions to own bodies and of referencing the ergonomics of the design to designer's enactments in the virtual space.

The sequence between the moments 15: 44 and 15:49 captures an example of how, consequently to being immersed in the virtual space with their own physical bodies, the design participants begin to perceive in a real like manner not only the design information, but also the way in which they interrelate with the virtual model and among each other. As the designer enters the bathroom through the virtual door, the other participants which are visually following her movement note the ergonomics of the space to accommodate her action (E2, 15:54). Almost simultaneously, the designer confirms that, as person wearing the head trackers, she has a similar perception of the door's dimension and augments her verbal utterance with visual gestures (raises and opens her arms to indicate the door's width) (E2, 15:54). Her verbal and visual demonstration brings about the final confirmation of the group: "the door is wide " (E2, 15:54).

Summing up, this episode shows how the designers immersed in virtual environment enact the experience of imagined users of the real hospital. Also, it reflects how multiple members of the design team organize the review by behaving like a group of end-users.

Inspecting the bathroom Counting grab rails "Would have been nice ( ) a window"

Figure 3. Episode 3images

Episode 3 (E3)

General (15:58): Yuh:::u!!!

	((entering the bathroom))
Designer 1 (15:59):	Would have been nice if there was a window. ((gestures pointing towards the blind wall of the bathroom))
General (16:02):	It ((the room)) looks giant!
Designer 2 (16:05):	These ((toilet, basin, etc.)) don't look centred
Designer 1 (16:07):	One, two, three,..., seven, eight grab rails! ((counting the grab rails in the room and following this action with hand gestures of indicating their location on the wall))
Designer 2 (16:11):	It is, yes, cause they have to be!

The design team's members express a general enthusiasm when, consequently to the designer's wearing the head trackers motion through the space of the CAVE, they find themselves in the patient's bathroom. The group notes the satisfactory dimensions of the room, which is unanimously perceived as having a better size than expected from the previous examination of the model via other non-immersive and smaller scale representational modes (Revit model, on screen). Examining how the design meets the clients' requirements and corresponds to typical norms of a hospital bathroom scheme, their review addresses the geometrical and functional configuration of the design with regard to issues of area, heights, and the location of sanitary objects in the room.

The instance whereby a designer remarks that a window would have enhanced the quality of the bathroom's space (even though it was not a compulsory design requirement) (E3, 15:59) constitutes an example of reflecting on the perception of the space from both a professional angle, and, also from assuming how real users might perceive the design. As it does not address the specific focus of review (it is not compulsory like, for example, the grab rails that "have to be"- E3, 16:11), the observation around the window which would have enriched the quality of the space is not further expanded in the meeting in a collaborative discussion, like other spatial elements previously examined. The way in which the remark about the window juxtaposes in the sequence infers the effect of being immersed with own body on the direct perceptual experience of the designer who formulates it. Therefor the situated review of the design becomes constituted through interlacing both observations around meeting the specific design requirements (e.g. eight grab rails, 1.7 metres height for the mirror- E4,16:37) and also spontaneous reactions of the design team encountering the space with their own physical bodies and imagining the perspective of users. This episode reflects a particular mode of reviewing the design not only through measuring a space by moving through it, but also through testing the experience in the space. It moreover illustrates an example of designers making sense of the space both through the design knowledge of a scheme, and from assuming a real user's perception of the not yet built hospital.

"This basin needs to be centred" "( ) basin's moved" "This mirror should be up like that"

Figure 4. Episode 4 images

Episode 4 (E4)

Designer 1 (16:25):	The basin on the wall is off centred.

Designer 2 (16:29):	( ) It looks ok (0.2) Quite low, though.
Designer 2 (16:37):	Eye level, 1.7 ((metres))
Designer 3 (16:40):	If you're a tall person you have a different point of view
Designer 1 (16:43)	So if you're saying it looks low, it must be low
Designer 1 (16:48):	Does it seem low to you?
Designer 2 (16:50):	Yes, it does.
Designer 2 (16:52):	And this mirror (0.2) should be up (.) like that.
Designer 1 (16:56):	And this basin should be centred between the two rails! ((the other designers change gazes and reorient their heads towards the left side of the room))

In this fragment, the design team continue the exploration of the bathroom. The designer wearing the head trackers is the person having the most accurate visual perception of the rendered model, and who interacts directly with the imagery (her motion in the space of the CAVE drives the active real time animation of the virtual model). After examining the door, the window, and the grab rails, designers moving around in the bathroom employ a thorough examination of the wall with the sanitary objects. Their situated behaviour infers that the group acknowledges that the designer wearing the head tracker is experiencing the simulation of the model in the most similar way to how a real user of the bathroom might perceive it: "( ) if you're saying it looks low, it must be low" (E4, 16:43). Consequently, the collective judgement in reviewing the space becomes organized around her perceptual feedback.

The sequence of reviewing the position of the mirror on the wall develops through referencing the height levels in the virtual space to the designer's body. This reflects both in how she becomes the comparison point to give sense of scale to the model and she is integrated in the visual examination of the group, and also through how the designer enacting the use of space makes sense of the height and formulates her evaluation: "( ) this mirror should be up ( ) like that". This is complemented through expressing a visual way of describing the height when the designer gradually raises her arm above the head's level to indicate the position of the mirror. Examining the present, past, and future states of the design ("it looks ok", "is off centred", "should be up", "has moved") is realized through interlacing a multitude of gestures like pointing the directions or indicating the location of sanitary objects by moving arms, fingers and reorienting the head direction and changing gazes. As instantiated in these episodes, the awareness of own body size in reference to that of the designed building via interacting with the virtual model rendered in the CAVE enables designers to explore the space in a manner resembling to how users might experience it.

This fragment reveals how the design team members organize their collaborative evaluation around the perception of the designer who is acting the role of user. This is mediated through a complex interplay of both verbal and visual behaviour employed in simulating the experience of a user, in communicating it within the design team, and in collaboratively making sense of the design.

CONCLUSIONS

The findings showed that the specific context of interacting with the building model and around it among designers immersed in the virtual environment in a real-like manner (responsive interactions in real-time through body motion in the virtual space and seeing own bodies and other team members) mediated a particular way of accomplishing the review. This consisted in: realising spatial measurements through referencing design elements to designers' physical body size; evaluating the

ergonomics as referenced to designers' body motion through the virtual space; testing the visual and functional perception of the design through spontaneous enactments of inhabiting/ using the design (instances of taking on the role of users performing activities in the designed spaces). Regarding the issue of how designers imagined themselves as real users, the study suggested that the team made sense of the review both in instances of multiple designers playing roles of users, and in sequences of organising the collective judgement around the perception of the designer taking on the role of the user. Also, the study reveals that the design team members accomplished the review and configured end-users' enactments in the IVRE employing a complex interplay of both verbal and visual behaviour (gestures, gazes, body movement and change of orientation). This suggests the potential to augment addressing the end- users' experience of a design in the process, and to complement other design methods like bringing users' participation in developing an architectural project.

REFERENCES

Arvola, M and Artman, H (2007) Enactments in Interaction Design: How Designers Make Sketches Behave. "Artifact" I(2), 95- 113.

Ball, L and Christensen, B (2009) Analogical reasoning and mental simulation in design: two strategies linked to uncertainty resolution. "Design Studies", 30(2), 169- 186.

Buscher, M (2005) Social Life Under the Microscope? "Sociological Research Online", 10, 1-30.

Buscher, M (2006) Vision in motion." Environment and Planning", A (38), 281- 299.

Cross, N (2000) "Engineering design methods: Strategies for product design". 3rd ed. Chichester: Wiley.

Cross, N and Clayburn Cross, A (1995) Observation of teamwork and social processes in design. "Design Studies", 16(2), 143- 170.

De Fanti, T A et. al. (2011) The future of the CAVE. "Central European Journal of Engineering", 1(1), 16- 37.

Heath, C, Hindmarsh J, and Luff P (2010) Analysing Social Interaction in Everyday Life. Introducing Qualitative Methods. In: Silverman, D (ed.) "Video in Qualitative Research". London: Sage.

Heath, C and Luff, P (2008) Video and the Analysis of Work and Interaction. In: Alasuutari, P, Bickman, L and Brannen, J (eds.) "The Sage Handbook of Social Research Methods". Chapter 29, 493-505. London: Sage.

Lawson, B (2006) "How designers think. The design process demystified". 4th ed. Oxford: Architectural Press.

Luck, R (2007) Using artefacts to mediate understanding in design conversations. "Building Research & Information", 35(1), 28-41.

Luck, R (2012) Kinds of seeing and spatial reasoning: Examining user participation at an architectural event. "Design Studies", 33(6), 557-588.

Luck, R and Mc. Donnell, J (2006) Architect and user interaction: the spoken representation of form and functional meaning in early design conversations. "Design Studies", 27(2), 141- 166.

Silverman, D (2006) "Interpreting Qualitative Data". 3rd ed. London: Sage.

Yaneva, A (2005) Scaling up and Down: Extraction Trials in Architectural Design. "Social Studies of Science", 35(6), 867-897.

HEALTHCARE BUILT ENVIRONMENT IMPACTS, CONSTRUCTION PROJECTS AND ORGANISATIONAL CHANGE

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Understanding the links between a building and outcome measures relevant to the purpose of the building should be an important issue for those commissioning, designing, delivering and operating facilities. In project teams that concern is often tacit and understanding is limited. The links are complex, under-researched and hard to demonstrate. Progress has been made in the context of healthcare infrastructure - an influential body of literature has demonstrated the role of the built environment in achieving good healthcare outcomes. However, applying such knowledge often requires new building or adaptation of existing buildings. These are process of change undertaken by healthcare organisations and others. Building change and organisational change happen together and influence each other. And both can be expected to subsequently influence organisational and healthcare outcomes. These relationships are explored using the findings from a mixed-method, longitudinal case study of the design, construction and operation of a new day surgery ward. The analysis draws on built healing environment, health management, organisational research and value management to propose ways in which the impact of the built environment can be mediated through construction/organisational change projects and potential implications for construction practice.

Keywords: architecture, building performance, organizational analysis, value management, project management

INTRODUCTION

Architectural theory and research has been concerned with understanding the relationship between building and purpose for decades (e.g. Studer, 1969; Stitt, 1985; Groák, 2002). This relationship between 'form and function' is central and one of the most challenging aspects of the building design process is for clients to convey to the designer what they want the building to do. Clients can find it hard to think of their requirements in abstract terms and designers have the difficult job of understanding and interpreting the client's vision and requirements and developing both a design 'brief' and a solution that meets the client's aspirations. Frequently the reality falls short of this difficult and theoretical process (Barrett & Stanley, 1999; Blyth & Worthington, 2001). Research in environmental psychology has attempted to provide an empirical basis for the effect of form on function and have accumulated evidence

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Davies R (2013) Healthcare built environment impacts, construction projects and organisational change *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 167-177.

of effects of specific individual features of the work environment e.g. light levels, noise, personalisation and layout (Bechtel, 1997). Understanding the links between a building and outcome measures relevant to the purpose of the building should be an important issue for those commissioning, designing, delivering and operating facilities. Unfortunately in project teams that concern is often tacit and understanding is limited as the relevant knowledge is specialised and the links are complex, under-researched and hard to demonstrate in practice (Anthes, 2009).

This is not just a concern for architectural theorists and psychologists however. Assumptions about the ability to make decisions based on knowledge of the causal effects of building design and construction on outcomes that owners and users of buildings care about are at the core of a number of persistent issues in construction management and an implicit foundation of some recent innovations. Included in this are briefing, design management more broadly (particularly the tracing of requirements through the design process (Delgado-Hernandez et al, 2007)) and value engineering/value management (Short et al, 2007). Project management practices such as business case production and agreement (Gannon & Smith, 2011) and the operation of gateway review processes (OGC, 2007) in client-specific and generic methodologies also assume a robust understanding of the implications of decisions. The same is true for post-project activities such as post-occupancy evaluation and managed handover (Way & Bordass, 2005) and the current concern with occupant behaviour as a component of built environment's contribution to sustainability policy (Pilkington et al, 2011). More broadly understanding these links are necessary to realise the potential of innovative business models such as performance-based contracting (Gruneberg et al, 2007) and service-led construction (Leiringer et al, 2009).

This paper seeks to contribute to an aspect of this understanding through exploring these relationships using some findings from a mixed-method, longitudinal case study of the design, construction and operation of a new day surgery ward in a National Health Service hospital in England. The paper introduces specific research on the 'healing environment' and work on organisational change that incorporates aspects of the built environment. The case study is described and discussed, drawing out implications and suggestions for further research in the relationship between; buildings, projects and organisations.

HEALTHCARE BUILT ENVIRONMENT AND ORGANISATIONAL CHANGE

An emerging and increasingly influential body of academic literature has demonstrated the importance of the built environment in achieving good healthcare outcomes. Reviews have found relationships between design and: staff stress and effectiveness; patient safety; patient and family stress and healing; improved overall healthcare quality and cost; and patient satisfaction (Ulrich & Zimring, 2004). There is an increasing awareness that the built environment does not just accommodate healthcare organisations and care delivery practices but can, and should, significantly contribute to their effectiveness (e.g. CABE, 2006). At the same time, in an environment of resource limitations, capital budgets compete with those for improved medical technologies and drugs – both of which have better developed procedures for determining efficacy and value for money. Justifying the allocation of resources for improved and high-quality healthcare environments away from immediate operational care ('stealing from patients'), can be culturally and politically difficult in the NHS

(Boyd & Chinyio, 2006). There is a need to ensure that investment decisions are soundly made and the greatest possible benefit derived from them. Improving the assessment of the outcomes of healthcare infrastructure projects is, therefore, politically and organisationally as well as scientifically important.

This ‘built healing environment’ research has mainly studied steady-state relationships between aspects of buildings (e.g. light levels, configuration) and healthcare outcomes (e.g. patient satisfaction, care quality, recovery time). Constructing or changing buildings to achieve the potential of such knowledge requires designers, builders and healthcare organisations to come together in projects. These projects necessarily contain elements of building change and organisational change that can influence each other and can be expected to subsequently influence organisational and healthcare outcomes. Some healthcare building types are intended to achieve organisational objectives such as collaboration or integrated working by bringing together disparate services. Example of this include mixed-use buildings like diagnostics & treatment centres, some joint primary care and local authority projects or, more broadly, coordinating IT projects like the NHS care records programme. The use of technology to achieve organisational or practice objectives has been documented by health services researchers. Crump (2002) found that, “medical and technical staff expect integration to occur [...] It is mainly thought about as a technological problem and, as such, an answer to it will be provided by some form of technical innovation or development” (p111). The physical design and layout of hospitals, as with other buildings, also reflect organisational arrangements. Esian & Rich (2005) describe how, in order to manage complexity, the hospital system has specialised activities into functional departments. Healthcare organisations “create boundaries between departments and often support these with physical boundaries” (p84).

METHODS

The research from which these findings and analysis are drawn was a longitudinal, multi-method case study of the design, construction and operation of a new healthcare space, a day surgery unit (DSU). The aim of the research was to study the design and use of the DSU with particular focus on the role of, and interactions with, a new 'care pathway'. Methodologically, the research conduct and analysis adopted what has since been characterised as an abductive approach (Timmermans & Tavory, 2012) in which the researcher enters the field with a variety of theoretical and explanatory frameworks and an expectation of anticipated findings but remains open to, and places analytical importance on, 'surprise' in the form of either novelty (a new experience) or anomaly (an unexpected experience). The methods that generated data drawn on in this paper include; interviews (transcribed, semi-structured), informal discussions, un-structured non-participant observation, analysis of business performance metrics, document analysis, research meetings and seminars. A mixed methods approach is recommended for post-occupancy evaluation, of which the research presented here is a variant, to help "unpick the detail of what is affecting our performance in the workplace" (Turpin-Brooks & Viccars, 2006; 193). Trust performance data was used in post-hoc analysis alongside the qualitative findings in order for the two data types to interrogate each other in the analysis.

Case description

The research partner is an NHS acute trust (‘East Trust’) in the south of England that offers a full range of acute and other secondary services including accident and emergency. Although a good performer in some areas, the Trust identified itself as

under-performing with respect to its day surgery rates (at the beginning of the research engagement it was 66% compared to the NHS target of 75% and a national average of 68%). The Trust was engaged in an ongoing series of infrastructure and pathway initiatives with the objective of increasing its day surgery rates (the percentage of specified procedures delivered in a single episode in which the patient is discharged on the same day without an overnight stay). Those recently completed and currently planned at the time of the research included: internal modernisation project for day surgery; development of a generic day case and short stay surgery care pathway; work on patient flows in previous day surgery ward; design, construction and activation of the new dedicated DSU; development of new condition-specific care pathways; work associated with a national NHS IT programme.

The new DSU was designed and constructed during 2006-7 and opened in August 2007. The DSU project was an alteration and refurbishment of available space within the existing hospital building. Technically, the new DSU is a 'dedicated day ward' having no new operating theatres and using the main hospital theatres. The unit is adjacent to the theatres however (the theatre suite also has a designated 'day surgery theatre' although the remainder are allocated by specialty) and is designed to achieve a 'circular flow' model of care as envisioned by NHS design documentation (HBN 52: NHS Estates, 1993). The DSU accommodated the following activities (as well as the unit staff and necessary storage): reception and waiting; pre-operative preparation; post-anaesthesia recovery; pre-discharge recovery; and discharge. It is significant that the DSU project was an adaptation of available space. As such it represents a hybrid solution typical of Trusts trying to achieve targets within the limits of budgetary and other constraints.

A number of specific objectives for the DSU were outlined in the Full Business Case (FBC) for the project. This paper concentrates on the first objective which was also the only objective mentioned in the interviews with research participants. This was "Achievement of national day case rates". The FBC outlined that this was to be measured as "Day case rate as a percentage of total elective surgical workload" via the "Monthly trust performance report". Other objectives were: quality of care; and patient satisfaction and patient choice.

RESULTS AND ANALYSIS

Organisational changes

The organisational innovation most specifically relevant to the new DSU was the development of a 'care pathway' for day case surgery. A care pathway is an, "outline of anticipated care, placed in an appropriate timeframe, to help a patient with a specific condition or set of symptoms move progressively through a clinical experience to positive outcomes" (Middleton et al, 2001). Managers in the Trust claimed that they had designed the new DSU around the newly implemented care pathway. Introducing a care pathway is an organisational as well as a clinical intervention and can, through the process of introduction, provide a problem-solving approach for staff, encourage the integration of services, and help identify required changes to clinical and organisational practices (Currie & Harvey, 2000). Some researchers attribute the positive outcomes of care pathways to improved multidisciplinary collaboration in the broadest sense and even to the simple fact of multidisciplinary discussion and agreements about care in the early stages of pathway development whether or not a formal pathway is subsequently designed and implemented (e.g. Kent & Chalmers, 2006). Studies of pathway implementation in

detail highlight challenges including problems of integrating and standardising practice across disciplines, the difficulties of working and innovating across boundaries and the desire to maintain ‘safe and political enclaves’ (Crump, 2002).

Physically the pathway developed at East Trust was a multi-page, printed-paper care record and checklist. The pathway was generic in the sense that it was applicable to any surgical procedure suitable for treatment on a short stay basis. As such it was specific on the steps involved in the phases of pre-admission, admission, anaesthetic, theatre management, recovery, discharge and follow-up with a blank space provided for the details of the surgical procedure itself. This has meant that the content of the pathway is medically uncontroversial and has had no effect on surgical practice. This was explained in terms of budgetary constraints and the unacceptable cost of producing procedure-specific documents. It is likely though that the difficulty of standardising consultant work will have been a factor here too (see Crump, 2002). It was championed and produced by a nurse matron in consultation and negotiation with a variety of internal stakeholders.

Accounts of the rationale behind the introduction of the pathway and its development stressed the administrative benefits. The pathway was described as achieving outcomes in terms of collating and streamlining multiple paper forms preventing re-work, lost information and error. It was not been presented as having contributed significantly to either clinical or efficiency improvements and was not formally evaluated as such. However it was believed to have contributed to a reduction in process inefficiencies by ensuring that necessary actions have been performed, e.g. ensuring that a day surgery patient has a carer scheduled to collect them from the DSU before the end of the day. The development of the pathway was part of a wider service improvement project with the aim of increasing the trust’s day surgery rates. As such, the development process was described as a symbolic change management initiative as much as a technical or administrative one.

Day surgery unit changes

The new DSU was an alteration and refurbishment project converting a large former canteen area into patient reception, recovery and discharge areas. Although the DSU was "designed around the care pathway" the care pathway as described above played a surprisingly small part in the design and briefing of the DSU. Instead the DSU was designed around the idea of a patient pathway with patient flows analysed from scratch for the purpose of decision making about the unit. Practically, this took the form of the surgery management team and surgical nurses mapping the existing process in the previous unit by walking through the process as it was done.

Before the construction of the new DSU the day surgery team worked in a surgical ward with a central nurse’s station and twelve trolleys (beds) arranged on two or four bed bays. The ward was adjacent to normal surgical and medical wards and a considerable distance from theatres. Patients were admitted to, transported on, and returned to the same trolley and bed bay. Due to the distance from theatres, patients were wheeled on trolleys down a number of corridors across the hospital site – this was regarded as a process inefficiency and also problematic for the privacy and dignity of the patient. The layout of the old day surgery ward was considered “static”. The new DSU was designed as a series of distinct spaces including: main reception; pre-operative waiting (including separate changing and consulting rooms); link corridor (through which patients walked to theatres); post-operative recovery (a single large space with fifteen trolleys); step-down recovery (furnished with reclining

chairs); and post-discharge waiting area where patients could wait for their escorts/carers to arrive. The layout of the new DSU was designed to encourage “flow” with patients entering the unit them progressing broadly clockwise through stages and spaces outlined above. The notion of step-down recovery was a small but significant innovation intended to free-up trolleys in the recovery areas and increase utilisation of the unit.

The new DSU was designed and constructed during 2006-7 and opened in August 2007. Almost immediately, the pre-op waiting area and the consulting rooms ran into capacity problems resulting in patients being routed ‘against’ the intended flow – by using the final waiting area as spill over pre-op waiting and by doing pre-operative checks on the recovery bay trolleys. This event was surprising (Timmermans & Tavory, 2012) when set against the logic of construction project delivery which emphasises well-controlled project delivery to meet client requirements (Tuuli et al (2010). This event could be taken as evidence of a 'failure' of the construction process but it is perhaps more fruitful to interpret it as an illustration of the interconnectedness of built environment and organisational arrangements and changes. In this case patients were batched into morning and afternoon theatre lists, meaning that a surge of between twenty and thirty patients would arrive each morning at 7.30 to be processed and accommodated in a space that couldn’t accommodate them. Batching, queuing and buffering in healthcare buildings and processes has been identified as both common and wasteful (Esian & Rich, 2005) although it is often intended to maximising use of scarce and expensive resources in the system. Using the recovery bay trolleys for pre-operative checks was also organisationally significant as it maintained the previous working methods of some consultant surgeons who were used to having their patients for the day ‘lined up’ in adjacent beds rather than having to call them individually to a separate consulting room. The DSU was a nurse-led unit in both deign and operation and the capacity problems encountered in the early days of the DSU made it more difficult to maintain the intended change in the care model.

Effect on West Trust day-case rate

The performance of East Trust against its target of achieving 75% of National Audit Office ‘basket’ of procedures as day cases) is shown in figure 1.

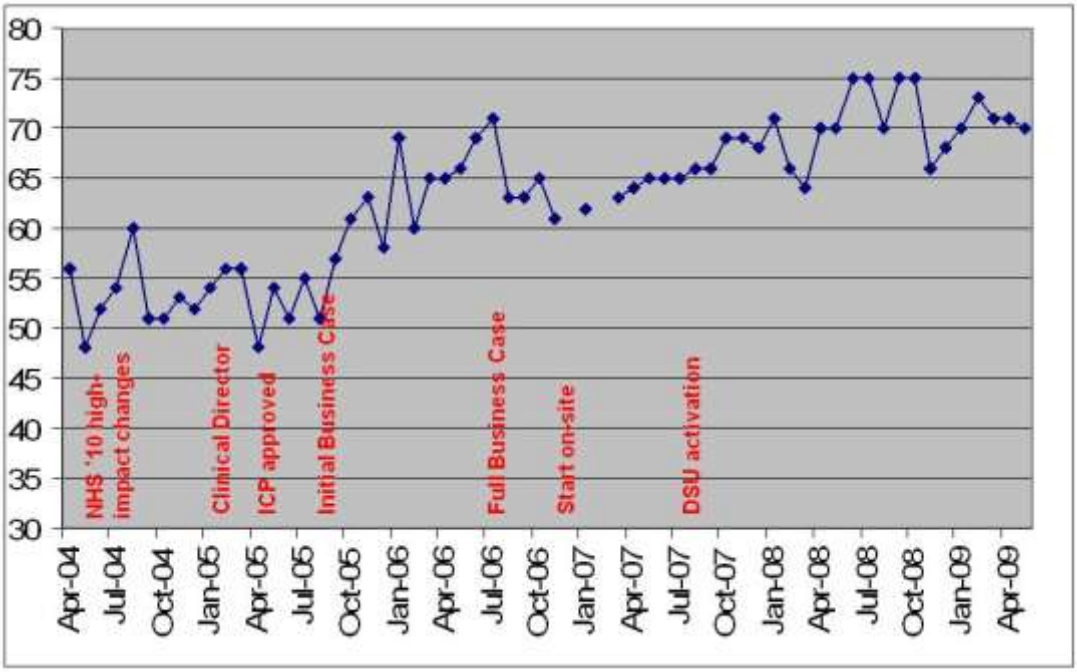

Figure 1: East Trust day case rates (as % of National Audit Office 'basket' of procedures)

Analysis of the Trust's performance against this indicator between 2004 and 2009 showed an improvement from a low of 48% to a high of 75% in July 2008 then settling to just over 70%. According to these figures, the DSU itself produced only a small gain in performance relative to target and failed to deliver its predicted benefit. Various mechanisms by which the DSU was intended to deliver the required performance were offered during the case study. The most technical concept was that the design of the unit and the introduction of "flow" into the process would accelerate throughput allowing more cases to be managed as day cases. This assumption was not measured directly as part of the research but there was little evidence that this was happening during observations.

Some problems with capacity and routing in the unit have already been discussed. A further issue was that the step-down recovery area was not used as designed as, being in a separate space to the main recovery area, nurses were unable to observe patients in the recliners so were reluctant to lose clinical control of patients that they had not discharged. This can be interpreted as a design error or compromise – failing to ensure sight-lines to the step-down recovery area: but also as a building change not achieving its desired effect because of the absence of a corresponding organisational change in terms of the nursing model for the unit. Also, the fact that the DSU did not have it's own operating theatres meant that it's workflow was dictated by the operating teams who would 'pull' patients from the DSU when they were ready for them (and often day surgery cases, being simpler, were undertaken at the end of theatre session after more complex procedures). Other mechanisms by which the DSU was expected to have an effect was through it's role in persuading reluctant consultants to perform procedures as day cases whether through reassurance that patients would be closer to the hospital core, the prestige of working out of a new unit or, simply, by removing what some managers saw as the "last excuse", namely that "we haven't got a day surgery unit". The Trust's financial commitment to the DSU was also used by managers as evidence of the seriousness of the day surgery target.

These mechanisms are a reminder that the DSU project was itself part of a wider initiative to increase day case rates. Figure 1 also includes some major events in the history of the DSU project as well as other day surgery related work within the Trust and suggests a number of sources of conjecture about the nature of the interactions between infrastructure projects and 'business' outcomes. In this case, before and during the business case process for the new unit a number of other initiatives had taken place (appointment of a clinical director for day surgery, development of the care pathway for day surgery, various procedure-specific changes). This activity coincided with the highest increase in day surgery rates .This correlation leads us to speculate whether the time, effort and extra activity necessary to develop and gain approval for a capital project may deliver a significant proportion of the potential improvements even before work has started on-site so that by the time the building work is done there is little scope for improvements attributable to the new infrastructure. In any change programme, initial improvements are easier to achieve as gross inefficiencies are addressed – subsequent improvements, often requiring wider changes, are likely to be more difficult. This has challenging implications for those seeking to demonstrate the benefit of built environment changes. More optimistically, it points to the important theoretical need to avoid splitting 'technical' and 'organisational' aspects of change programmes when assessing impact. In this case, although the data suggests that the activation of the physical infrastructure had a small marginal impact, the development of the unit can be seen as an integral part of the overall programme of activity that may have 'failed' without the existence of the capital project to provide a focus for apparently 'non-technical' activities.

DISCUSSION AND CONCLUSIONS

The research presented here has highlighted a number of linkages between buildings, organisations, people and projects. The first thing to note is the small apparent performance effect of the new DSU. In this illustrative case study it is not possible to establish this effect as a general empirical finding but the longitudinal nature of the data makes it strongly suggestive and a potential effect worthy of further study. An implication of this finding is that construction project benefits are gained, at least in part, via developing rather than delivering the project as found by Kent & Chalmers (2006) for organisational changes. An alternative explanation that would be important to consider is the possibility that the organisational effects of the built environment simply are small. Bechtel (1997) reminds us that "any normal physical aspect of the workplace is of marginal utility" and "[to] keep the physical environment in proper perspective" (p395).

Another feature of the data is the building project's role as a 'tangible' form of legitimisation of, and way of securing management and budgetary authority for, contested behaviour change. Thinking of the building and the building project in this way challenges the finding that the built environment has only a small effect on organisational change - rather, the wider construction and change project can be seen to be implicated in any effect. It could be that building projects represent a special case and opportunity for organisational change. It is recognised that greenfield sites in manufacturing represent and opportunity to introduce changes to working methods and organisation that would be too challenging to achieve in existing settings (Preece, 1993). Bragato & Jacobs (2003) describe pathways changes in healthcare that were would have not been possible if not attempted in a stand-alone unit. This possibility requires a wider sociotechnical (Clegg, 2000) view of projects that has significant implications for construction professionals and their engagement with their clients and

points to the need for active organisational change efforts alongside apparently merely physical built environment changes (Cherns & Bryant, 1984; Boyd & Chinyio, 2006). Even this partial report of a simple case study shows complex mutual interactions between built-environment, organisation and people as the project unfolds and as the building is used. This is an established principle in architectural theory (Brand, 1994) but the built environment is often elided from accounts of organisational change (e.g. McNulty & Ferlie, 2002).

The findings also point to a difficulty in applying evidence-based design insofar as the evidence-base is limited to narrow aspects of the physical built environment and the steady-state effect on users of the final building configuration. The rhetorical and evidential weight of the approach risks moving practices still further from the broader sociotechnical considerations that also take into account the effects of implementation practices. A promising mechanism with which to redress the balance might be through an extension to various approaches in value management (VM). Rather than seeing the construction process and its products as too complex and impractical to apply VM (Ellis et al, 2005) consideration of complexity would allow a high-level approach to functional analysis (Spaulding et al, 2005) in which the required abstraction and the emphasis on function/outcome would be supported. The broader project boundary implied suggests that VM could be applied to this wider project definition, perhaps through the application of 'soft' VM (Green & Liu, 2007) that might be better suited to developing a socially negotiated understanding between multiple stakeholders with differing viewpoints and interests.

REFERENCES

Anthes, E. (2009). Building around the mind. Scientific American Mind, 20(2), 52-59.

Barrett, P. & Stanley, C. (1999) Better Construction Briefing. Oxford: Blackwell.

Bechtel, R. B. (1997). Environment and behavior: An introduction. SAGE Publications, Incorporated.

Blyth, A. & Worthington, J. (2001) Managing the Brief for Better Design. London: Spon.

Boyd D, Chinyio E. (2006). Understanding the Construction Client. Oxford: Blackwell.

Bragato, L. & Jacobs, K. (2003). Care pathways: The road to better health services? Journal of Health Organization and Management, 17(3), 164-180.

Brand, S. (1994). How buildings learn: What happens after they're built.

Buchanan, D., Fitzgerald, L., Ketley, D., Gollop, R., Jones, J. L., Lamont, S. S.,Neath, A. & Whitby, E. (2005). No going back: A review of the literature on sustaining organizational change. International Journal of Management Reviews, 7(3), 189-205.

CABE (2006). Better public building. London: Commission for Architecture and the Built Environment.

Cherns, A B and Bryant, D T (1984) Studying the client's role in construction management. Construction Management and Economics, 2(2), 177–84.

Clegg, C. W. (2000). Sociotechnical principles for system design. Applied ergonomics, 31(5), 463-477.

Crump, N (2002). Managing professional integration in an acute hospital – a socio-political analysis. The International Journal of Public Sector Management, 15(2), 107-117.

Currie ,V.L & Harvey, G (2000). The use of care pathways as tools to support the implementation of evidence-based practice. Journal of Interprofessional Care, 14(4), 311-323.

Delgado-Hernandez, D J, Bampton, K E and Aspinwall, E (2007) Quality function deployment in construction. Construction Management and Economics, 25(6), 597–609.

Ellis, R. C., Wood, G. D., & Keel, D. A. (2005). Value management practices of leading UK cost consultants. Construction Management and Economics, 23(5), 483-493.

Esian, A. & Rich, N. (2005). Exploring patient pathways: A grounded approach to managing complexity. IN ,reforming Health Systems: Analysis and Evidence, Tavakoli, M and Davies, T (Eds). 83-97.

Gannon, M J and Smith, N J (2011) An effective outline business case to facilitate successful decision-making. Construction Management and Economics, 29(2), 185–97.

Green, S. D., & Liu, A. M. (2007). Theory and practice in value management: a reply to Ellis et al.(2005). Construction Management and Economics, 25(6), 649-659.

Groak, S. (2002). The idea of building: thought and action in the design and production of buildings. Taylor & Francis.

Gruneberg, S, Hughes, W and Ancell, D (2007) Risk under performance-based contracting in the UK construction sector. Construction Management and Economics, 25(7), 691–9.

Kent, P. & Chalmers, Y. (2006). A decade on: Has the use of integrated care pathways made a difference in Lanarkshire? Journal of Nursing Management, 14, 508-520.

Leiringer, R, Green, S D and Raja, J Z (2009) Living up to the value agenda: the empirical realities of through-life value creation in construction. Construction Management and Economics, 27(3), 271–85.

McNulty, T. & Ferlie, E. (2002). Reengineering Health Care: The Complexities of Organizational Transformations. Oxford University Press: Oxford.

Middleton, S, Barnett, J & Reeves, D. (2001) What is an integrated care pathway? Evidence-based medicine, 3(3), 1-7.

NHS Estates (1993). Health Building Note 52 Volume 1: Accommodation for day care day surgery unit. London: HMSO.

Office of Government Commerce (2007). OGC GatewayTM Process Review 5: Operations review and benefits realisation. London: HMSO.

Pilkington, B., Roach, R., & Perkins, J. (2011). Relative benefits of technology and occupant behaviour in moving towards a more energy efficient, sustainable housing paradigm. Energy Policy, 39(9), 4962-4970.

Preece, D. (1993). Human resource specialists and technical change at greenfield sites. In Clark, J. (Ed.). Human resource management and technical change. SAGE Publications Limited., 101-115.

Short, C A, Barrett, P, Dye, A and Sutrisna, M (2007) Impacts of value engineering on five Capital Arts projects. Building Research & Information, 35(3), 287–315.

Spaulding, W. M., Bridge, A., & Skitmore, M. (2005). The use of function analysis as the basis of value management in the Australian construction industry. Construction Management and Economics, 23(7), 723-731.

Stitt, F. A. (1985). Designing buildings that work. McGraw-Hill.

Studer, R. G. (1969). The dynamics of behavior-contingent physical systems. In Broadbent, G., & Ward, A. (Eds.). Design methods in architecture (No. 4). London: Lund Humphries., 55-70.

Timmermans, S., & Tavory, I. (2012). Theory Construction in Qualitative Research From Grounded Theory to Abductive Analysis. Sociological Theory, 30(3), 167-186.

Turpin-Brooks, S. & Viccars, G. (2006). The development of robust methods of post occupancy evaluation. Facilities, 24(5/6), 177-196.

Tuuli, M. M., Rowlinson, S., & Koh, T. Y. (2010). Dynamics of control in construction project teams. Construction Management and Economics, 28(2), 189-202.

Ulrich R, Zimring, C. (2004). The Role of the Physical Environment in the Hospital of the 21st Century:: A Once-in-a-Lifetime Opportunity. Report to the Center for Health Design for the Designing the 21st Century Hospital Project. Robert Wood Johnson Foundation.

Way, M and Bordass, B (2005) Making feedback and post-occupancy evaluation routine 2: Soft landings – involving design and building teams in improving performance. Building Research & Information, 33(4), 353–60.

ECONOMICS, COST AND FINANCIAL MANAGEMENT

A NEURO-FUZZY HYBRID MODEL FOR PREDICTING FINAL COST OF WATER INFRASTRUCTURE PROJECTS

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Nine out of ten infrastructure projects exceed their initial cost estimates. Accuracy of construction cost estimates remains a contentious area of debate within both academia and industry. Explanations for this have ranged from scope changes, risk and uncertainty, optimism bias, technical and managerial difficulties, suspicions of corruption, lying and insufficient required information for accurate estimation. The capacity for tolerance and imprecise knowledge representation of fuzzy set theory is combined with the learning and generalising capabilities of neural networks to develop neuro-fuzzy hybrid cost models in this paper to predict likely final cost of water infrastructure projects. The will help to increase reliability, flexibility and accuracy of initial cost estimates. Neural networks is first used to develop relative numerical weightings of cost predictors extracted from primary data collected on 98 completed projects. These were then standardised into fuzzy sets to establish a consistent framework for combining the effect of each variable on the overall final cost. A three-point fuzzy lower, upper and mean estimate of likely final cost is generated to provide a tolerance range for final cost rather than the traditional single point estimate. The performance of the final models ranged from 3.3% underestimation to 1.6 % overestimation. The best models however averaged an error of 0.6% underestimation and 0.8% overestimation of final cost of the project. The results are now being extended to a larger database of about 4500 projects in collaboration with an industry partner.

Keywords: artificial neural network, cost estimation, cost modelling, cost overrun, fuzzy set theory.

INTRODUCTION

Infrastructure projects have an 86% likelihood of exceeding the initial cost estimates and 9 out of 10 of them exceed their budgets (Flyvbjerg *et al.* 2002). A key example

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Ahiaga-Dagbui DD, Tokede O, Smith SD and Wamuziri S (2013) A neuro-fuzzy hybrid model for predicting final cost of water infrastructure projects *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 181-190.

is the case of the stadiums built for the 2010 FIFA World Cup games in South Africa. With overruns ranging between 5 to 94% of original cost, none of the 10 stadiums were completed within budget (Baloyi and Bekker 2011). There is overwhelming evidence in literature, and practice, which support the conclusion that cost overrun is endemic within the construction industry, irrespective of size, type, sector or geographical location of the project (see Jackson 2002; Flyvbjerg *et al.* 2004; Odeck 2004; Baloyi and Bekker 2011). Cost remains arguably one of the most important key performance indicators on most projects (Chan and Chan 2004; Yeung *et al.* 2008) so that statistics, such as the ones above, leaves most clients grossly dissatisfied, giving the industry a poor reputation regarding budget reliability (Agyakwa-Baah 2009).

Despite its importance, cost estimation is undeniably not simple, nor straightforward, largely due to the dearth of information required for detailed estimation. It is even made worse by the cloud of uncertainty that shrouds cost drivers in the early stages of the project (Hegazy 2002) and the changes that occur in scope and design of the project once construction actually begins (Love *et al.* 2011; Gil and Lundrigan 2012). It is an inexact science and estimators have to make decisions within an environment of uncertainty. Moreover, even though it is accepted that factors such as tendering method, type of client, location of project, procurement method, size of project etc. have an effect on final cost of a project, it is difficult to establish their measured financial impact (Ahiaga-Dagbui and Smith 2012). This complex web of cost influencing variables would make it seem that the decision-to-build, for most projects, is based on a somewhat unrealistic cost estimate that will inevitably be exceeded.

Against this backdrop, debates have not waned on causes and measures of cost overruns. A recent discussion on the Construction Network of Building Researchers (CNBR) left a number of unresolved questions. How accurate can estimates be? Is there an acceptable way to compare final cost of project to cost estimates? What is the most acceptable measure of cost performance on a construction project? Is it even possible to achieve certainty of cost estimates, when the very estimates are made in an environment of uncertainty? (see the Nov 2012 CNBR archive online).While the answers to these can be varied; even sometimes strongly opposing; it is difficult to disagree that clients and project financiers still require some form of reasonably accurate estimate of their likely financial commitment for a project before the project begins.

In this paper, the authors attempt to model the final cost of water infrastructure projects using gathered cost data and other project details such as location, procurement method, size of project, type of client, etc of 98 water infrastructure projects. This paper, a sequel to a previous that uses only neural networks for modelling final cost (see Ahiaga-Dagbui and Smith 2012) employs Neuro-Fuzzy (NF) hybrid models - a combination of neural networks and fuzzy set theory, drawing on synergies from the two techniques in an attempt to develop more accurate, reliable and consistent final cost models. The next section of the paper provides an overview of the two modelling techniques used in the paper- neural networks and fuzzy set theory, and then proceeds to develop a neuro-fuzzy cost estimation hybrid model before concluding with results achieved and potential extensions of this research.

NEURAL NETWORKS

Work on artificial neural networks stemmed from the curiosity to understand how the brain processes information. Haykin (1994) described the brain as a highly complex

and parallel information processing system, capable of performing very complex computations many times faster than many types of computer processors. Artificial neural network (ANN) is thus just a simplistic abstraction of the biological neural networks of the brain, endowed with the capability to learn from experience (or examples) and then generalise for new cases using the acquired knowledge even within sparse or incomplete data (Anderson 1995). They are able to adapt to changing environments (or datasets) and are often referred to as universal approximators because of their ability to closely map input to output spaces in different types of problem domains (Fausett 1994). They essentially seek underlying relationships between variables and are particularly suited for complex, hard-to-learn problems, where no formal underlying theories or classical mathematical and traditional procedures exist (Adeli 2001). Neural networks are very sophisticated modelling techniques capable of modelling extremely complex functions. In particular, neural networks are non-linear (Denton and Hung 1996). For many years linear modelling (Regression), has been the commonly used technique in most modelling domains since they have well-known optimization strategies. Where the linear approximation was not valid, which was frequently the case (Boussabaine and Kirkham 2008), the models suffered accordingly.

Arguably, the strongest argument against the use of ANN is its supposed 'black-boxness'(Olden and Jackson 2002)- it is difficult to extract knowledge from the neural network model or fully understand how it reaches its conclusions. In regression, for example, an equation with explainable physical properties is produced. This is not the case in ANN modelling - no equation results out of the model and the network weights and connections make little sense. How the inputs interact to produce the output is at best, only known to the model. In a previous model using the same data, only neural network is used to model final cost projects (Ahiaga-Dagbui and Smith 2012). In an attempt to illuminate the black-box of ANNs, the authors combine the learning and generalisation abilities of neural networks with the capacity for tolerance and imprecise knowledge representation of fuzzy set theory to develop a hybrid neuro-fuzzy cost model for cost prediction.

FUZZY SET THEORY

Fuzzy set theory is an aspect of contemporary mathematics which focuses on the ambiguities in describing events or classes. It is an attempt to formalise human abilities of conversation, reasoning, and decision-making in an environment of imprecision, uncertainty as well as conflicting and/or incomplete information (Zadeh 2008). It incorporates 'matter of degree' rather than crisp boundaries into decision variables (Tokede and Wamuziri 2012). Fuzzy set theory allows an approximate interpolation between observed inputs and output situations (Ross 2009) and provides a means for modelling human vagueness in judgment. It basically requires encoding certain decision parameters as fuzzy sets (Zadeh 2008).

The defining characteristic of a fuzzy set is embodied in its membership function (MF). According to Kim *et al.* (2006), an MF provides an effective way to translate subjective terms into mathematical measures. A variable in fuzzy logic could have a set of values, characterised in linguistic terms, such as short, medium or long duration of project, or poor, moderate and good ground conditions. MFs can be generated in a number of ways either using intuition or some other algorithmic or logical operations (see Ross (2009) on how to use genetic algorithm, neural networks, rank ordering or inductive reasoning in developing MFs).

Ross (2009) stipulates that fuzzy relations are analogous to classical mathematical functions and basically represent mappings for sets. Fuzzy relations share the mapping potentials exhibited by neural networks and hence provide a compatible interphase in problem solving. Relations exhibit mathematical properties such as reflexivity, transitivity and symmetry which ultimately helps in interpreting attributes in fuzzy systems (Zadeh 1994). Chen and Huang (2007) used fuzzy relations in estimating the possibility-of-meeting the completion time of a construction project.

Fuzzy relations could be also employed in establishing the strength and possible association between different pairs. This can be achieved through the composition operator - a mathematical operation that seeks to establish the relationship between similar elements in different universe of discourse (Zimmermann 2001). Two common variants of the composition operator are the max-product and max-min. According to Zimmermann (2001), the most frequently used composition operator is the max-min; though both procedures produce comparable results in many instances. The max-min composition operation basically implements the strength of one chain as equal to the strength of its weakest link; the maximum of this then represents the overall chain strength in the fuzzy system (Ross 2009). Applications in civil engineering and construction research have been reported in Ayyub (1997). For cost and risk evaluation, fuzzy sets helps in quantification of variables, whose nature could be considered as complex and fit for description within a range of options (Tokede and Wamuziri 2012). An overview of fuzzy logic applications in construction management is provided by Chan *et al.* (2009)

NEURO-FUZZY

Neural networks solves problems by identifying the underlying patterns between the variables in the data it receives (Ross 2009) and then makes predictions based on the knowledge acquired (Adya and Collopy 1998). They are powerful, easy to use (StatSoft Inc. 2011) and can deal with large number of variables and non-linear relationships (Denton and Hung 1996). Yet, they are limited by their 'black-box' nature (Patterson 1996; Olden and Jackson 2002). They also perform best when using numerical or continuous data (StatSoft Inc. 2011). The majority of the data used in this research happen to be categorical in nature - location, type of client, procurement method, etc. Fuzzy sets represent composition of graded categories using mathematics based on logical reasoning (Belohlavek *et al.* 2009). It attempts to formalise decision making in an environment of uncertainty and incomplete information (Zadeh 2008), the kind that aptly describes cost estimation of construction projects.

Tokede and Wamuziri (2012) suggest that fuzzy set theory may not function at its optimal best as a stand-alone mathematical framework. Its practicality and utility is enhanced by combining its logic with pre-existent mathematical formulations. NF hybrid models thus have the potential to effectively represent modes of reasoning and decision making that are approximate rather than exact (Zadeh 1994), the case of construction cost estimation. Yu and Lin (2006) present an NF model for mining information from incomplete construction databases whilst Bilgehan (2010) uses NF models predict concrete compressive strength. Boussabaine (2001) similarly presents NF models for modelling the likely duration of construction projects

MODEL DEVELOPMENT

The NF models reported in this paper have been developed in three main stages - the first using statistical methods to pre-process the collected data, the second using

neural networks to develop relative final cost weightings of predictors and lastly using fuzzy sets to predict final cost. These stages are detailed below.

Stage One: Data and Data Pre-processing

Details on 98 water infrastructure projects completed in Scotland between 2007 and 2011were collected. The nature of the projects ranged from construction of water mains, water treatment plants, Combined Sewer Overflows (CSOs), installation of manholes or water pumps and upgrades and repairs to sewers. All the projects were target cost contracts with values between £9,000-£14 million and durations from 1-22 months.

The collected data is processed so as to structure and present the data to the model in the most suitable way. For this research, extreme values and outliers were either re-coded or deleted from the sample set and missing values replaced with the mean or mode. Input errors were corrected and all cost values were normalised to 2010 with the base year 1995 using the infrastructure resources cost indices by the Building Cost Information Services (BCIS 2012). Screening of variables to the smallest number is desirable because simpler models are easier to deploy - a model with 15 variables means information has to be known about all these variables before the model can be used for prediction. Redundant predictors - variables that do not add new information to the model because they basically contain the same information at another level with other variables were detected using spearman ranking, bi-variate histograms or cross-tabulation. Further variable screening using scree test, mean plots and optimal binning in Statistica 10 software, suggested the optimal number of variables for predicting final cost to be between 5-7 predictors.

Stage Two: Neural Network Modelling

The neural network stage of the model developed was to determine a consistent numerical weighting for all the predictors depending on their relative contribution to determining the final cost of the project. Ten initial predictors[2] were used as inputs in a 3-layered feed-forward back-propagation neural network architecture with Final Target Cost as output of the model. The 98 project cases were split in a 75:15:10% ratio for training, testing and validation respectively. The best model was developed through an iterative procedure of continually tweaking the neural network parameters i.e. hidden nodes and activation functions, to produce improved model performance. Model performance was measured using the correlation coefficient between predicted and output values as well as the Sum of Squares (SOS) of errors below:

$$SOS = \sum(T_i - \mathrm{O}_i)^2 \qquad \text{Eqn. 1}$$

Where O*i* is the prediction (network outputs)
Ti is the target (actual value) of the *i*th data case.

The ten best networks were retained and further tested using the validation set to produce *Figure 2*. The validation set was not used in the training of the model so can be considered as an independent verification of the model's ability to generalise on new data. This gave a quick indication of the average error level of each of the models.

[2] Initial list of predictors for the neural network model: Type of Soil, Site Access, Type of Location, Contractor's Need for the Project, Frequency of Project, Type of Deadline, Awarded Target cost (transformed as logTC), Type of project, Tendering Strategy, Duration (transformed as logD)

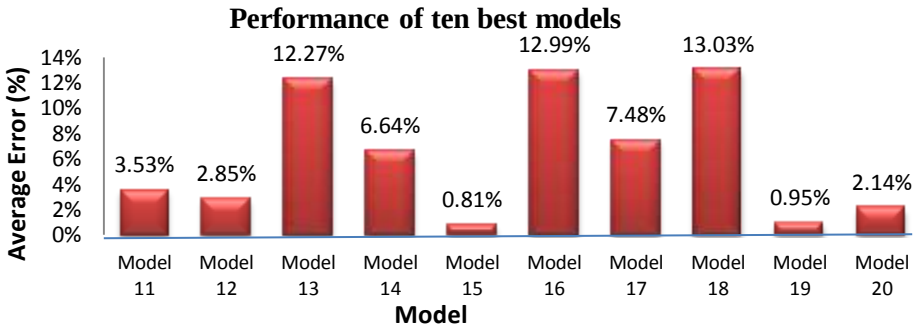

Figure 2: Performance of the ten best models

A sensitivity analysis was then carried out using the three best validated models in order to determine the contribution of each predictor to the model's performance. This was partly based on a test for parsimony using Ockham's Razor principle - one should not increase, beyond what is necessary, the number of entities required to explain anything and that all things being equal, preference should be given to the simplest hypothesis (Chase *et al.* 1996). This principle of simplicity is used to prune down the number of variables required in the model to predict the final cost, thus reducing inconsistencies, ambiguities and potential redundancies in the model. An initial ranking of all the predictors was generated based on their contribution to the model's performance. Then starting from the least important, one predictor was removed from the model at a time whilst measuring the performance of the model without that predictor. This was done until the model showed no further improvement or began to decay. The best set of predictors of final target cost after this stage are tendering strategy, site access, location, type of project, contractor's need for the project, type of soil, as well as estimated initial cost and duration (the common log of these were used in the model)

Table 1: Sensitivity analysis to determine relative ranking of predictors

Model	logTC	Tendering Strategy	Site Access	Type of Location	Project Type	Contractor's Need	Soil Type	logD
15. MLP 18-5-1	4.80	2.22	8.44	2.04	1.50	3.80	1.22	1.09
19. MLP 18-3-1	7.71	9.08	8.91	11.82	7.93	4.77	7.07	0.68
20. MLP 18-3-1	8.21	9.18	2.64	3.24	1.89	2.55	2.56	1.21
Average Weighting	6.90	6.83	6.66	5.70	3.77	3.71	3.61	0.99

Stage Three: Fuzzy Sets Modelling

Fuzzy set theory is applied at this stage of the modelling exercise to evaluate the subjective measures for each of the cost predictors in order to predict final cost. Using $\sum \ Normalized\ ranking = \frac{w_i}{\sum \ W}$=1 Eqn. 2. 2, the average weighted ranking for each of the variables from *Table* was normalized to unity in order to generate a standardised index for the subsequent fuzzy set computations (see *Table 4*)

$$\sum Normalized\ ranking = \frac{w_i}{\sum W} = 1 \qquad \text{Eqn. 2}$$

Where w*i* is the average relative weighting of the ith predictor
∑W is the sum of relative weighting of all predictors

Table 4: Normalized weighted values of the cost predictors from the neural network analysis

Factors	Tendering strategy	Site Access	Type of Location	Project Type	Contractor Need	Soil Type	Log Duration
Normalized ranking	0.22	0.21	0.18	0.12	0.12	0.11	0.04

With mean target cost to predictor plots, all predictors were fuzzified using the range set below:

$x \geq 5.8,$	Influence is Rather High
$5.6 \geq x \geq 5.8$	Influence is High
$5.4 \geq x \geq 5.6$	Influence is Medium
$x \leq 5.4,$	Influence is Low

The next stage of the fuzzy modelling involved developing membership functions. In developing these, the tolerance index is particularly relevant in evaluating and constraining the range of possibilities subject to a complex set of influencing variables, quantitatively and/or qualitatively defined. The tolerance index is vital in order to model the uncertainty in the cost values within a realistic continuum as opposed to a single figure-of-merit. For this study, the tolerances, β, were adapted to follow those indicated by Ayyub (1997) and reported in the table below.

Table 5: Values of tolerance. Source: adapted from Ayyub (1997)

β	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Poor/Low	1.0	0.9	0.7	0.4	0	0	0	0	0	0	0
Median	0	0	0.4	0.7	0.9	1.0	0.9	0.7	0.4	0	0
High	0	0	0	0	0	0	0	0.4	0.7	0.9	0
Rather High	0	0	0	0	0	0.4	0.7	0.9	1.0	0.9	0.7

Each of the project variables in the validation set was converted into fuzzy set variables using *Table 5*. According to Ross (2009), the fuzzy relation, $\tilde{T}$ of two sets, $\tilde{R}$ and $\tilde{S}$ can be defined by the set-theoretic and membership function-theoretic, mathematically expressed as:

$$\tilde{T} = \tilde{R} \circ \tilde{S} \qquad \text{Eqn. 3}$$

$$\tilde{\mu}_{T(x,z)} = \bigvee_{y \in Y} [\, \tilde{\mu}_{R(x,y)} \wedge \tilde{\mu}_{S(y,z)}] \qquad \text{Eqn. 4}$$

In Eqn. 3 above, R is a fuzzy relation on the Cartesian space X x Y. S is a fuzzy relation on Y x Z, and T is fuzzy relation on X x Z. In this cost estimation problem, R represents the set of cost predictors and S refers to the set of standard values of tolerance for linguistic descriptors of project attributes. The max-min composition operator is employed to deduce the strength and degree of relationship between specific relational pairs, which in this case, depicts the overall project cost as a fuzzy relationship of the normalised cost predictor weightings in *Table 4*, and based on the associated fuzzified project attributes deducible from *Table 5*.

The tolerance of each of the cost values in the validation set was computed, using Eqn.4 and defuzzified to obtain a 3-point estimate representing the fuzzy mean, fuzzy upper and fuzzy lower values as shown in *Table 6*. These three values provided a range of likely final cost rather than the customary single value estimate. *Table 6* shows the performance of the NF hybrid models in predicting the final cost of 10 different projects used in the validation set. This is summarised in

Table 7 along with the average model performance of the neural network model only.

The Fuzzy Upper best predicts the final cost and have the smallest percentage errors, ranging from 0.6% average underestimation to 0.8% overestimation of the likely final cost of the project. This represents an appreciable improvement in the results achieved using the neural network models only, also shown in

Table 7. The best three models at the neural network stage averaged a 1.2% under-estimation and 4.6% over-estimation of the actual final cost of the projects in the validation dataset. These results show significant promise in using neuro-fuzzy hybrid models to learn the underlying relationships between variables such as tendering strategy, site access, project location, type of soil or type of project and final cost of construction project.

Table 6: Neuro-fuzzy model validation results

		Model Prediction (log)					
Validation Cases	Actual Final Cost (log)	Fuzzy Lower (FL)	% error (FL)	Fuzzy Mean (FM)	% error (FM)	Fuzzy Upper (FU)	% error (FU)
1	5.78	5.65	2.4%	5.68	1.8%	5.75	0.5%
2	6.90	6.75	2.2%	6.77	1.9%	6.86	0.7%
3	5.41	5.35	1.1%	5.39	0.5%	5.46	-0.9%
4	5.22	5.09	2.6%	5.12	1.9%	5.20	0.5%
5	6.51	6.38	2.0%	6.41	1.6%	6.48	0.4%
6	5.95	5.85	1.7%	5.87	1.4%	5.95	-0.1%
7	6.91	6.78	1.9%	6.80	1.6%	6.89	0.4%
8	4.67	4.58	1.8%	4.62	1.1%	4.69	-0.5%
9	5.00	4.97	0.6%	4.99	0.1%	5.07	-1.6%
10	4.49	4.34	3.3%	4.36	2.9%	4.45	0.9%

Table 7: Summary of results from neuro-fuzzy model validation

	Summary of results			
	Neuro-fuzzy Lower (FL)	Neuro-fuzzy Mean (FM)	Neuro-fuzzy Upper (FU)	Neural Network Only
Average % Under-estimation	2%	1.50%	0.60%	1.2%
Average % Over-estimation	N/A	N/A	0.80%	4.6%

As already stated, even though it is agreeable that these factors affect the final cost on a project, it is difficult to assign cost measures to them as their relationship to cost are not thoroughly understood. The neuro-fuzzy hybrid models are possibly a step in the right direction in producing more accurate and realistic cost estimates at the initial stages of a construction project in an attempt to alleviate the problem of cost overruns

CONCLUSION

The research reported in this paper combines the learning and generalisation capabilities of artificial neural networks with fuzzy logic's ability to formalise human reasoning and decision making within an environment of uncertainty and incomplete information to develop neuro-fuzzy hybrid cost models for predicting the final cost of small water infrastructure projects. In particular, the research attempts to use some non-traditional cost predictors such as site access, location, tendering strategy, project and soil type to estimate likely final cost. The authors present a three-point range of possible likely final cost outcomes instead of the classical single point estimate. This

might allow estimators and clients to more accurately estimate likely contingency needs for their projects. In their extended form, these models can readily be converted into stand-alone desktop applications that can allow quick simulation of what-if scenarios and also allow the easy generation of different cost estimates should project parameters change. As a sequel to a previous paper that used only neural networks, the results here show an improvement in the predictive performance and thus the results are now being extended to a database of 4500 projects with an industry partner.

REFERENCES

Adeli, H (2001) Neural networks in civil engineering: 1989-2000. *Computer-Aided Civil and Infrastructure Engineering*, **16**(2), 126-42.

Adya, M and Collopy, F (1998) How effective are neural networks at forecasting and prediction? A review and evaluation. *Journal of Forecasting*, **17**(5-6), 481-95.

Agyakwa-Baah, A B (2009) *Risk Management in the Ghanaian Construction Industry* Master thesis Unpublished Thesis, Sheffield Hallam University, UK.

Ahiaga-Dagbui, D D and Smith, S D (2012) Neural networks for modelling the final target cost of water projects. *In:* Smith, S D (Ed.), *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK. Association of Researchers in Construction Management, 307-16.

Anderson, J A (1995) *An Introduction to Neural Networks*. Cambridge, Massachusetts: MIT Press.

Ayyub, B M (1997) *Uncertainty modeling and analysis in civil engineering*. CRC.

Baloyi, L and Bekker, M (2011) Causes of construction cost and time overruns: The 2010 FIFA World Cup stadia in South Africa. *Acta Structilia*, **18**(1).

BCIS (2012) BIS Construction Price and Cost Indices. In, http://www.bcis.co.uk: Building Cost Information Services, UK.

Belohlavek, R, Klir, G J, Lewis III, H W and Way, E C (2009) Concepts and fuzzy sets: Misunderstandings, misconceptions, and oversights. *International journal of approximate reasoning*, **51**(1), 23-34.

Bilgehan, M (2010) A comparative study for the concrete compressive strength estimation using neural network and neuro-fuzzy modelling approaches. *Nondestructive Testing and Evaluation*, **26**(1), 35-55.

Boussabaine, A H (2001) Neurofuzzy modelling of construction projects' duration I: principles. *Engineering Construction and Architectural Management*, **8**(2), 104-13.

Boussabaine, A H and Kirkham, R (2008) Artificial Neural Network Modeling Techniques for Applied Civil and Construction Engineering Research. *In:* Knight, A and Ruddock, L (Eds.), *Advanced research Methods in the Built Environment*. London: Wiley-Blackwell.

Chan, A P and Chan, A P (2004) Key performance indicators for measuring construction success. *Benchmarking: An International Journal*, **11**(2), 203-21.

Chan, A P, Chan, D W and Yeung, J F (2009) Overview of the application of "fuzzy techniques" in construction management research. *Journal of Construction Engineering and Management*, **135**(11), 1241-52.

Chase, S, Weiss, M, Gibbs, P, Hillman, C and Urban, N. *The Physics and Relativity FAQ* 1996 [cited 19th November, 2012. Available from http://math.ucr.edu/home/baez/physics/General/occam.html.

Denton, J W and Hung, M S (1996) A comparison of nonlinear optimization methods for supervised learning in multilayer feedforward neural networks. *European Journal of Operational Research*, **93**(2), 358-68.

Fausett, L V (1994) *Fundamentals of neural networks: architectures, algorithms, and applications*. Prentice-Hall Englewood Cliffs, NJ.

Flyvbjerg, B, Holm, M K and Buhl, S L (2002) Understanding costs in public works projects: Error or lie? *Journal of the American Planning Association*, **68**(279-295).

Flyvbjerg, B, Holm, M K S and Buhl, S (2004) What Causes Cost Overrun in Transport Infrastructure Projects? *Transport Reviews*, **24**(1), 3-18.

Gil, N and Lundrigan, C (2012) The Leadership and Governance of Megaprojects. In: *CID Technical Report No. 3/2012*: Centre for Infrastructure Development (CID), Manchester Business School, The University of Manchester, 18.

Haykin, S (1994) *Neural networks: a comprehensive foundation*. Prentice Hall PTR Upper Saddle River, NJ, USA.

Hegazy, T (2002) *Computer-based construction project management*. Upper Saddle River, NJ: Prentice Hall Inc.

Jackson, S (2002) Project cost overruns and risk management. *In:* Greenwood, D (Ed.), *Proceedings 18th Annual ARCOM Conference*, 2-4 September 2002 Newcastle, Northumbria University, UK. Association of Researchers in Construction Management, (Vol. 1) 99–108.

Kim, J, Lee, S, Hong, T and Han, S (2006) Activity vulnerability index for delay risk forecasting. *Canadian Journal of Civil Engineering*, **33**(10), 1261-70.

Love, P E D, Edwards, D J and Irani, Z (2011) Moving beyond optimism bias and strategic misrepresentation: An explanation for social infrastructure project cost overruns.

Odeck, J (2004) Cost overruns in road construction—what are their sizes and determinants? *Transport Policy*, **11**(1), 43-53.

Olden, J D and Jackson, D A (2002) Illuminating the "black box": a randomization approach for understanding variable contributions in artificial neural networks. *Ecological Modelling*, **154**(1-2), 135-50.

Patterson, D W (1996) *Artificial Neural Networks: Theory and Applications*. Singapore: Prentice Hall.

Ross, T J (2009) *Fuzzy logic with engineering applications*. 3ed. Chichester: John Wiley & Sons.

StatSoft Inc. (2011) Electronic Statistics Textbook. In, OK Tulsa: StatSoft, .

Tokede, O and Wamuziri, S (2012) Perceptions of fuzzy set theory in construction risk analysis. *In:* Simon, S (Ed.), *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK. Association of Researchers in Construction Management, 1197-207.

Yeung, J F, Chan, A P and Chan, D W (2008) Establishing quantitative indicators for measuring the partnering performance of construction projects in Hong Kong. *Construction Management and Economics*, **26**(3), 277-301.

Yu, W-d and Lin, H-w (2006) A VaFALCON neuro-fuzzy system for mining of incomplete construction databases. *Automation in Construction*, **15**(1), 20-32.

Zadeh, L A (1994) Fuzzy Logic, Neural Networks, and Soft Computing. *Communications of the ACM*, **37**(3), 77-84.

Zadeh, L A (2008) Is there a need for fuzzy logic? *Information Sciences*, **178**(13), 2751-79.

Zimmermann, H-J (2001) *Fuzzy set theory and its applications*. Springer.

EVALUATION OF ISLAMIC FINANCING PRODUCTS FOR HOUSING AND INFRASTRUCTURE DEVELOPMENT

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Housing delivery and infrastructure development are fundamental necessities for economic growth of any nation. However, the provision of these essential services on the required scale to meet demand remains problematic for most countries and governments worldwide. Lack of adequate supply of housing and infrastructure project finance has been identified as a major obstacle to such development. Previous studies and available literature have also highlighted that existing conventional finance and banking structures are unlikely to provide adequate funding streams necessary to address the acute shortage of housing and infrastructure particularly in developing countries. This paper evaluates the potential of Islamic financing products and services to contribute to housing and infrastructure finance. Firstly, a review of the principle features of Islamic financing products is provided. Secondly, the interest based conventional banking is compared with the Non-interest based Islamic finance which is currently gaining ground in many countries including the United States and the United Kingdom. Case studies of some Islamic banking products that have shaped the infrastructure landscape are provided. This study further evaluates and analyses the concept of cost of capital for Islamic finance models and products, and compares and contrasts it with conventional bank lending systems. The study finds that considerable potential exists for the construction industry worldwide to benefit from Islamic Finance which possesses business partnership characteristics that entail risks and reward sharing as opposed to the interest based conventional finance and banking systems. Furthermore, Islamic finance products are found suitable for housing and the construction industry. As a consequence, it is recommended, that individuals, clients, contractors, and business leaders should take a serious look at these products for their project and corporate finance needs for housing and infrastructure development.

Keywords: conventional banking, housing delivery, infrastructure development, Islamic finance, non-interest finance, risk sharing

INTRODUCTION

Housing delivery and infrastructure development at the optimal level contributes immensely to economic growth and development of any nation. The function of infrastructure as a major determinant for economic advancement, particularly in developing countries has been widely acknowledged in literature (Calderon and Serven, 2003; Estache, 2006; Sahoo and Dash, 2009). Direct investments in

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Adelekan S, Wamuziri S and Binsardi B (2013) Evaluation of islamic financing products for housing and infrastructure development *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 191-200.

infrastructure enhance housing delivery, increase production facilities, reduce trade and transactional costs, improve competitiveness, create employment opportunities and as such stimulate economic activities (Sahoo, Dash and Nataraj, 2010). However, housing delivery and infrastructure development on the required scale remains a daunting challenge for most countries and governments worldwide. The inadequacy of construction project finance has been identified as a major impediment to the delivery and development of these fundamental necessities. This is not unexpected in this period of the credit crunch and capital flight by lenders and investors. In such periods, investors will seek investment assets with potentially higher yield and low risk. Previous studies and the available literature underscore the fact that the existing infrastructure development finance structure through government budgets and conventional banking and finance systems are unlikely to supply adequate funding streams necessary to tackle the acute shortage of housing and infrastructure, particularly in developing countries. Many authors have also established that the current (one sided liability) interest based conventional banking system is fundamentally unstable (Friedman, 1969 and Simons 1948); this view was buttressed by the most recent economic downturn. Moreover the previous financial crises such as the German hyperinflation of the 1920's; Europe's oil shock inflation of the 1970's; the Argentina, East Asia and Russian defaults; Japanese banking crises; Enron bankruptcy and so on may suggest that there are inherent flaws in the interest based conventional finance system. However, it could be argued, that it is not the conventional banking system per se that is flawed, but the people operating the system who fail to adopt best practice and ethical values for business sustainability.

Islamic finance has been vindicated by its advocates in that it avoided much of the recent financial crisis not only because of its prohibition on speculations and uncertainties, but also for its emphasis on risk and profit sharing. This gives credibility to the Islamic finance model due to its characteristics which are different from conventional models. There is nothing to suggest that Islamic finance is flawless or devoid of risks. Indeed, Islamic financing institutions undertake risk evaluation and profitability analysis before taking any project funding decision in order to provide investors with some degree of certainty over their investments.

This paper evaluates the potential contribution that Islamic financing products can make to improve housing and infrastructure delivery. The principle features of Islamic finance products are reviewed and compared with those offered in conventional banking. Case studies of major projects where Islamic financing techniques have been utilised are analysed. Furthermore, the concept of the cost of capital for non-interest based Islamic finance models and products is evaluated and compared with the conventional finance system.

RESEARCH AIMS, OBJECTIVES AND METHODS

This paper reports a study in its preliminary stages investigating non-interest based Islamic banking and financing products as a viable source of funding for housing and development of major infrastructure projects such as power stations, water supply and sanitation, etc. The objectives of the study are these:

- To analyse the principal features of key financial products in Islamic project finance.
- To develop standardised models of genuine financial products and financial engineering in Islamic project finance.

- To evaluate and identify best practice in risk assessment and management approaches used by Islamic financial institutions for development of housing and major infrastructure projects.
- To develop standardised best practice models and approaches that combine conventional and shariah-compliant sources of finance in major projects.

A mixed methods approach will be adopted in this study to collect and analyse data and views of all key stakeholders in Islamic project financed infrastructure. Both primary and secondary data will be utilised. Interviews and focus groups will be used to gather primary data. Sources of secondary data will include existing literature and the Islamic Development Bank database. Case studies of past infrastructure projects involving Islamic financing techniques will be analysed to draw important lessons for the future.

ISLAMIC BANKING AND FINANCE

Islamic banking refers to a banking system that functions on the principles of the Shari'ah (Islamic jurisprudence) and its practical application through the development of Islamic economics. Although the Islamic finance concept can be traced back to about 1,400 years, its recent growth can simply be dated to the 1970s when Saudi Arabia and the United Arab Emirates launched Islamic banks. It is now estimated that worldwide, around US $1 trillion of assets are managed under the Islamic finance system. Shari'ah principles emphasises moral and ethical values in all dealings and prohibits both the acceptance and payment of interest charges (riba) for lending and borrowing of money. Due to the prohibition on interest based investments, Islamic banks are compelled to earn their income through profit sharing partnership or fee based investments. Business partnership subsists between participants in Islamic banking transactions as risks and profits are jointly borne by all parties. The products and Islamic financial mechanisms are equity-oriented which are based on a variety of profit and loss sharing formulas (Imady & Seibel, 2006). The code of conduct that guides the operations of Islamic banking and finance is derived from two religious sources; (i) the Shariah which comprises the Qur’an (Islam Holy Book) and the Hadith (i.e. the sayings and deeds of Prophet Mohammed (PBUH) and (ii) the Fiqh, which represents Islamic jurisprudence based on a body of laws deducted from the Shariah by Islamic scholars, established to create an equitable system of distributive justice and also to promote legitimate activities (halal).

The main principles of Islamic finance dictate that:

- Profits must be generated through lawful trade and asset-based investments.
- Investments must possess social and ethical benefits to the wider society beyond pure profit making motives.
- Risks and rewards should be shared in an agreed manner.
- All unlawful and harmful activities (haram) should be avoided.

Islamic finance system prohibits business activities involving; alcohol, firearms, tobacco, prostitution, pork products, speculation, betting, and gambling, debt financing without an underlying asset backing, avoidable risks (gharar) and all other trade and activities that provide goods or services considered contrary to its principles. The Islamic banking has same objectives as its conventional counterpart except that it operates in accordance with the rules of Shari’ah, known as Fiqh al-Muamalat (Islamic rules on transactions). Islamic finance principles disapproves of investments

made just for constant returns on investments without adequate consideration as to the nature of the venture on which the funds are invested. Many of these principles upon which Islamic banking is based are moral norms universally accepted all over the world for centuries.

PRINCIPLE FEATURES OF ISLAMIC FINANCE PRODUCTS

There are five principle features of Islamic banking. Its financial products and instruments must be - (i) interest free, (ii) trade related and demonstrate genuine need for funds (iii) performance related and equity oriented (iv) Non exploitative; no usury (v) ethically guided.

Islamic banks use a variety of transactions and financing methods to provide the required finance that meets their clients' needs. The most common are the Shari'ah-compliant bonds (Sukuk) under which no interest is paid; rather, the returns on investments are generated through physical economic activities by utilising or leasing the underlying assets. The project finance sector, particularly in the Middle East most often employ the Istisna'a-Ijarah structure, which is sometimes generally referred to as the "procurement structure" and the Wakala-Ijarah structure. It is worthwhile to provide a synopsis of some of these Islamic financial instruments and products with their application in project financing:

Al-Ijarah (Leasing)

This is the Islamic equivalent of a lease and an amalgam between the operational lease and the finance lease. The bank purchases and leases out assets required by their clients for a rental fee with the option to either purchase such assets during the period of rent or at the tail end of the contract. It provides the guarantee of regular payments all through the life of the financing with the flexibility of structuring the payment plan in a manner that makes it possible for Islamic financiers to accomplish a profit margin similar to that of conventional financiers. This is the most efficient and flexible way to facilitate high cost assets and technology related products. Ownership of the asset remains with the lessor bank, which will seek to recover the capital cost of the asset plus a profit margin from the lease or rents payable. Ijarah method is widely used for long-term projects like Independent Power Projects (IPPs) and Independent Water & Power Projects (IWPPs). These projects are in two distinctive phases (i) the construction phase and (ii) the operations phase. In reality a different method to suit the specific character of each phase is usually employed. For example, Ijara method is used as it is well suited, for the operations phase, while Istisna tend to suit and therefore used for the construction phase. Under Islamic finance, it is essential to finalise the contract arrangements for both phases before financial close, Ijarah is therefore structured as a forward leasing arrangement, known as Ijara Mawsufah Fi Al Dhimmah.

Al-Istisna'a

An Istisna'a is a sale contract where one party agrees to manufacture a particular asset to an agreed specification, to be delivered at an agreed time for an agreed price. Under Istisna'a finance arrangements for construction projects, the bank signs an agreement to undertake the construction project jointly with the client and transfers the same to the client. The traditional Istisna'a contract is designed in a manner that the financier (Bank) signs two different contracts, one with the client and the other with the construction company in charge of the project. The bank pays the construction

company by instalments based on the level of completion. The price of the asset and the date of delivery are established at the outset. While the liability for the bank to pay the instalments and the liability of the developer to deliver the assets is deferred to the future but specific dates. Although traditional Istisna'a contracts have been successfully used for infrastructure projects, the extra burden placed on the banks to enter into a construction contract directly with the contractor basically increases the risk profile of project financing for the Islamic banks. By entering into a direct contractual relationship with the contractor, Islamic financiers shoulder additional risks in form of construction, credit and performance risk of the contractor. To mitigate these risks, Islamic financiers are moving away from the traditional Istisna'a towards a slightly modified version (Istisna'a with a recognised right to sub-contract) and procurement variant techniques. Most projects are now financed under a parallel structure where the client agrees under the istisna'a contract, to procure the manufacture, delivery and construction of the relevant asset from the manufacturer.

Istisna'a-Ijarah

The procurement variant is an Istisna'a-Ijarah contract structure. The istisna'a contract is applied to the construction phase, while operations phase is done under the Ijarah contract. In order to mitigate the significant (construction, credit and performance risk of contractors) exposure of the Islamic financiers, the borrower enters into an Istisna'a contract to procure the manufacture, delivery and construction of the relevant asset from the manufacturer. Concurrently, the borrower also undertakes a construction contract with the contractor wherein a pass over of the Istisna'a contract terms and condition is incorporated allowing the contractor to subcontract the project, thereby spreading the risk between the Islamic financiers, the borrower and the contractor. The project financiers release payments by instalments based on certified level of completion and on an agreed timescale. On completion of the construction phase of the project, the Ijarah contract comes into effect when the completed project is leased out by the Islamic financier (lessor) to the borrower (lessee). Under the Ijarah contract, legal and beneficial ownership of the asset remains with the lessor bank. However, a transfer clause is usually included in the Ijarah contract whereby the Islamic financier (lessor) agrees to transfer the leased asset to the borrower (lessee), either during the term of the lease or at the tail end of the lease period. This is in many ways similar to the conventional equipment lease but certain responsibilities such as care and maintenance of the assets as well as the insurance obligation are usually performed by the borrower (lessee) on behalf of the Islamic Financier (lessor).

Despite the fact that the Istisna-Ijara Mawsufah Fi Al Dhimmah is mostly used in IWPPs in the Middle East, the Shariah boards of some banks in some countries, particularly Saudi Arabia do not seem to favour this technique. The importance of avoiding unnecessary complexity in the contractual structures to eradicate the element of avoidable risks is stressed by Shariah Scholars. According to some of these scholars, the combination of Istisna and Ijara is unacceptable as it amounts more or less to two contracts in one; the two contracts seem to be mutually dependent and interconnected .An alternative structure called Wakala-Ijara Mawsufah Fi Al Dhimmah is employed by some Islamic financiers so as to overcome this controversy.

Wakala – Ijarah

The alternative type of contract but similar to the Istisna'a -Ijara and frequently used in project financing involving Islamic tranche is referred to as Wakala-Ijarah Mawsufah

Fi Al Dhimmah structure or “Wakala-Ijara structure”. In this contract arrangement, the borrower is engaged as an agent or "Wakil" to the Islamic financier under an agency agreement referred to as Wakala agreement. But for the agency agreement where the connection between the financier and the borrower is a principal to agent contractual relationship, the Wakala - Ijarah agreement functions more or less in the same way as the Istisna'a-Ijarah contract. Both types of procurement contracts apply the Ijarah agreement at the operations phase. The design, engineering, construction, testing, commissioning and delivery of the asset specified in the Wakala-Ijarah agreement are procured by the borrower in the capacity of an agent to the Islamic financier. Although the same rights and obligations in respect of asset transfer exist in both techniques, unlike the Istisna'a-Ijarah, the Wakala-Ijarah does not incorporate separate purchase and sale agreements. The Wakala-Ijarah arrangements seem to be widely accepted in Saudi Arabia and all IWPPs in that country have used this technique.

Al-Mudarabah

This Islamic finance product is basically similar to equity finance; it is a profit partnership agreement between the bank and the client, whereby the bank supplies total funding, while the client invests and manages the capital using their expertise in return for a percentage of the profits – provided there are no losses. Profits are shared as specified in the finance agreement; however, there is no guarantee that profits will be made, neither is it certain that the capital will be recovered. Mudarabah as an Islamic Finance product promotes good administration and concrete business arrangements. In practice, the Islamic banks act as investment managers on behalf of investors or customers who deposit funds with the bank.

Al-Murabahah

Murabahah is a purchase and resale agreement best known as a sale-based instrument. It is a cost plus contract; instead of a loan agreement, the bank purchases the required asset for which the loan would have been provided from a third party and re-sells it at a predetermined higher price (Cost plus profit) to the party that requires the property. By paying this higher price over several instalments, the capital user has effectively obtained credit by paying a premium as opposed to interest.

CONVENTIONAL VS ISLAMIC BANKING

Economic development and growth of any nation requires an efficient banking and financial system. In reality, successful implementation of monetary policies, which are utilised by governments to control and manage numerous macroeconomic factors, are facilitated by flexible and accessible financial systems. The overall strength and stability of an economy is largely determined by the prevailing banking system which constitutes a key component of the financial system. All the economic units of a country are connected together by the banking and financial systems, hence any uncertainties, instability, and lack of confidence within the banking system has severe implications on the economic situation of that country. In essence, banking systems direct financial transactions, operate as the financial intermediary and help in wealth creation (Akkizidis and Khandelwal, 2008).

For several decades, conventional banks have acted as financial intermediaries. Most of the income generated by these banks is principally interest based. According to Khan and Porzio (2010), Christian churches had already condemned Usury (any form

of interest claimed on a loan), prior to the time Prophet Mohammed rose to defend debtors against the voracious demands of their lenders. Therefore, it can be argued that both Christianity and Islam condemn or prohibit interest. Questions have been raised by Islamic scholars on the necessity and validity of interest in the process of financial intermediation. Islamic finance systems consider interest as a form of exploitation since it is charged on money without added value. In its quest to offer sustainable and justifiable distribution of wealth and income, Islamic finance has endeavoured to develop alternatives to the conventional financing system.

INFRASTRUCTURE PROJECTS FUNDED WITH ISLAMIC FINANCE PRODUCTS IN THE MIDDLE EAST

More power projects are now required in the Middle East due to economic growth in the region. Funding for such projects in the past was through conventional means; however the use of Islamic finance is now on the increase. All power projects in the Gulf Cooperation Council (GCC) may be financed in the near future under Islamic laws through the use of Sharia'h Compliant financing products. The Islamic financing of power in the region is expected to be given a boost for many reasons. First, the Power project sponsors in the GCC countries are keen to enhance the status of Independent Power Projects (IPPs) and the Independent Water & Power Projects (IWPPs) among the Islamic investors and wish to achieve this objective by utilising Shariah compliant financing products. Secondly, the risk enthusiasm of Islamic banks is growing and thirdly, the governments of GCC nations are encouraging Islamic banking in the region. Almost all the recently launched IPP/IWPP schemes by the GCC to open the sector to private investments were successfully backed by Islamic project finance.

For example, the Ma’aden Phosphate company’s mining project in Saudi Arabia worth about $5.50 billion includes the construction of power and desalination plants. The project involved 2 Islamic tranches totalling US$1.8 billion and one of the largest Islamic project financing to date. The Istisna-Ijara Mawsufah Fi Al Dhimmah and Wakala-Ijara Mawsufah Fi Al Dhimmah structures were utilised. The Al Waha Petrochemical project totalling US$526.55 million financing of a private petrochemical project in the Kingdom of Saudi Arabia was the first project financing in the Middle East. It was wholly executed with Islamic finance. Another recent project in the IWPP sector is the Al Dur project in Bahrain in 2009.

Case Study: Al Dur Independent Water & Power Project (IWPP)

In 2009, the contract to construct the 218 000 m3/day water desalination and 1234 MW power project in Bahrain was won by a consortium comprising GDF Suez of France and Gulf Investment Corporation of Kuwait. The cost of the construction project was estimated at US $2.1 billion. The first unit was expected to commence in July 2010 and to attain full operation capacity by July 2011. The project funding was from debt and equity in the ratio of 75:25 with the Power and Water Project Agreement (PWPA) tenure of 25years.The $1.7billion fund for the project was achieved from multiple sources which includes; Islamic financing, export credit agencies and commercial financing. This was the first Independent Water & Power Project transaction with multiple Islamic tranches. The Islamic financing worth $300 million consists of Istisna-Ijara Mawsufah Fi Al Dhimmah and Wakala- Ijara Mawsufah Fi Al Dhimmah. The financial deal for the project was achieved and successfully closed in July 2009 within an adverse market condition. Since long-term

liquidity was not available, the project was only able to settle for eight year tenure and a balloon of 80 per cent for the Islamic and commercial tranches. The financing structure was referred to as "mini-perm". The main documents for the Istisna-Ijara Mawsufah Fi Al Dhimmah tranche are the Istisna agreement, the forward lease agreement and the service agency agreement. While the documents for the Wakala-Ijara Mawsufah Fi Al Dhimmah tranche were the Wakala agreement, the forward lease agreement and the service agency agreement respectively. In the forward lease agreement, the actual lease commenced only from the date the assets were delivered and the passing of the assets title to the Islamic banks (PEI 2010).

Case Study: Shuaibah- Power and desalination Project: Independent Water & Power Project (IWPP)

In July 2004, the international competitive bidding process for the 900 MW net oil-fired steam power plant and an associated 880 000 m3 desalination plant was launched by SWEC (Saudi Water & Electricity Company). A Saudi-Malaysian consortium comprising of: ACWA Power Projects of Saudi Arabia and Tenaga Nasional Berhad, Malakoff Berhad and Khazanah Berhad of Malaysia was selected in June 2005, as the highest ranked bidder to Build, Own and Operate (BOT) the Shuaibah IWPP. In August 2005, the Saudi cabinet approved the formation of the Shuaibah Water & Electricity Company (SWEC); the project company. SWEC awarded the consortium of Siemens Power Generation and Doosan Heavy Industries and Construction Co the contract for the turnkey Engineering, Procurement and Construction (EPC) of this steam power plant with associated desalination facility to be located in Shuaibah. Siemens was the lead member of this consortium.

The Power and Water Purchase Agreement (PWPA) was signed in Riyadh Saudi Arabia on 15th November 2005. The financial deal for the project was achieved and closed in January 2006. The total project costs of $2.5 billion was funded by a multi-tranche financing involving 23 banks on a debt to equity ratio of 80:20 comprising; Islamic financing of $210 million, $455 million from Export-Import Bank of Korea ("K-Exim"), commercial facilities of $875 million, and export credit financing of $400 million from Hermes while the balance was raised from funds internally generated from the project and equity bridge loan of approximately $500 million. In addition, the financing also included $72 million of standby commercial debt and $18 million of standby equity bridge loan to cover any cost overruns. Off-take risks were addressed by signing the Power and Water purchase agreement before financial closure with a grid company. The tenure of the concession is 20 years and the Islamic financing product used was the Ijara Mawsufah Fi Al Dhimmah (PEI 2006.)

THE CONCEPT OF COST OF CAPITAL

Capital invested in a company or a project could be derived from different sources such as equity shares, preference shares, Islamic financing or debt. Every capital funding is acquired at a cost; however, the cost of capital varies depending on the source. Cost of capital can be defined as the cost of acquiring funds which is equal to the average rate of return expected by an investor for providing the funds. The cost of capital is the minimum expected rate of return that a project must earn to breakeven. Cost of capital is usually expressed in percentages with appropriate allowance made for tax purposes in order to get a correct picture for the cost of capital. Islamic finance is based on core principles of justice, equity and welfare with the aim of providing socio-economic justice and equitable distribution of income and wealth (Hassan, 2009). Debt servicing requirement under Islamic finance is connected to the

performance of the underlying project to be financed. Whereas, under the conventional banking system, there are two major characteristics that affect the value of money, namely time and investment decisions made by investors most often without due consideration to the ethical and moral elements of the investment. Time dimension to the value of money is a widely accepted phenomenon in conventional banking which is calculated practically as the interest earned on a given amount over a period of time. Therefore, specific amounts of increase in the volume of money is expected by investors in the interest–based economies irrespective of the nature of the venture (Sidawi and Meeran, 2010). The second aspect is the investment decisions which can be defined as the process of choosing ventures and projects in which to invest in order to increase the amount of money. Conventional banks as investors apply both aspects of this theory in all their business transactions. Factors affecting the asset value are first considered over a specific period of time after which the potential risks, losses and gains are calculated in order arrive at an investment decision. While under Islamic finance system, the rules are set by the Islamic Shari'ah with its authority derived from two main sources which are the Quran and Hadith strictly observed by the jurists and interpreters of Islamic law.

CONCLUSIONS

In many cases, Infrastructure project financing requires contributions from a consortium of banks or financiers due the complex nature and huge financial requirements of such projects. In the quest to attract adequate project finance and with the Islamic investors seeking acceptable investments, the major challenge is how to strike a balance and develop project financing products that are not only attractive to international project financiers but also shariah compliant. Multiple tranches whereby project sponsors use a combination of Conventional and Islamic finance structures appears to be the main solution. However, capital providers may now be compelled to use profit sharing structures since the Shari'ah principles prohibit interest-based financing.

Despite the advantages in the use of Islamic finance, the risk sharing and asset ownership requirement creates potential bottlenecks in structuring financial deals as well as project management. For instance, the part project asset title retention requirements by the Islamic financiers could increase the level of risk from the conventional co-financier's perspective in case of project default due to the divisible collateral backing of the loan. In a bid to overcome this challenge and also to accommodate the various shariah boards' requirements particularly in the GCC countries, wholly multiple Islamic tranches have been used in most of the recent project financing transactions as a viable alternative.

Allocation of risks to all parties is an integral part of the delivery process. Islamic finance stipulates risk sharing which indeed forms one of the basic requirements for the funds to be provided. This is a positive indication that such finance is well suited for construction projects including housing and infrastructure development. Unlike the conventional interest based one sided liability, Islamic finance is asset based. It can be argued that Islamic finance is ideal for housing and infrastructure development as they are both assets. Islamic finance is rapidly gaining recognition in many countries including the United Kingdom and the United States. Some of the opportunities posed by Islamic finance are; it may lower the overall costs of financing a project; it could pave way for viable projects that may not proceed due to poor credit ratings and it may bring a ray of hope to projects that do not have access to conventional finance.

Top executives directing infrastructure projects in the GCC countries are now more than ever before, keen to finance them under Islamic rules as many of their investors are seeking long-term investments that are ethically and religiously acceptable. This is an indication that Islamic investors are likely to invest in Islamic banks as against the conventional banks in the near future. The construction industry worldwide should consider looking into how to access the growing Islamic investments currently estimated at $1Trillion (USD) and must also be proactive so as to meet the project sponsors' requirement of funding future projects using Islamic financing products.

REFERENCES

Akkizidis, I. and Khandelwal, S.K. (2008) "Financial Risk Management for Islamic Banking and Finance'" UK: Palgrave Macmillan, First Edition.

Calderón, C. and Servén, L. (2003) "The Output Cost of Latin America's Infrastructure Gap", in Easterly, W., and L. Servén, ed., The Limits of Stabilization: Infrastructure, Public Deficits, and Growth in Latin America, Stanford University Press.

Estache, A. (2006) Infrastructure: A Survey of Recent and Upcoming Issues, World Bank, Washington D.C.

Friedman, M. (1969) "The monetary theory and policy of Henry Simons". In M. Friedman (Ed.), The optimum quantity of money and other essays. Chicago: Aldine.

Hassan, A. (2009) "After the credit crunch: The future of Shari'ah compliant sustainable investing "; Humanomics, Vol. 25(4), pp.285-296, (Emerald Group).

Imady, O. and Seibel, H. D. (2006) "Principles and products of Islamic finance", working paper no 2006-1, Development Research Centre, University of Cologne Germany, 2006.

Khan, F. and Porzio, M. (2010) " Islamic banking and finance in the European Union: A challenge" (pp. 1-7), Cheltenham, UK: Edward Elgar Publishing Limited.

PEI Power Engineering International (2006) Power and desalination – Shuaibah: a model IWPP. Available at www.powerengineeringint.com/articles/mee /print/volume-3/issue-2/features/po accessed on 15th April 2013.

PEI Power Engineering International (2010) Funding power projects with Islamic finance. Available at www.powerengineeringint.com/articles/mee/print/ volume-7/ issue-1/features/fun accessed on 15th April 2013.

Sahoo, P. and Dash, R.K. (2009) "Infrastructure Development and Economic Growth in India", Journal of the Asia Pacific Economy, 14(4), 351-365

Sahoo P. Dash R.K. and Nataraj G. (2010) Infrastructure development and economic growth in china, Institute of Developing Economics.

Sidawi, B. and Meeran, S. (2010) A framework for providing lifelong finance to the owners of affordable dwellings in the Kingdom of Saudi Arabia. Cities, 28(2):138-146.

Simons, H. (1948) Economic policy for a free society. Chicago: University of Chicago Press.

PERCEIVED IMPACT OF THE MARKET ON THE BUSINESS OF REGIONAL CONTRACTORS: A SOUTH AFRICAN CONTEXT

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The economic system is central to the wellbeing of all industrial sectors, especially the construction industry. During economic stability and growth, the construction industry has been observed to thrive in terms of full order books and high levels of profitability. However, in period of limited economic growth, increased competition for works that beget opportunism seems to be rampant in the industry. The principal subject area researched is the impact that economic cycles that leads to sluggish state of the economy has on the competitiveness of the business of regional contractors that are focussed on private sector projects. The methodological approach adopted for the discourse is quantitative in nature as a semi structured questionnaire was distributed among a purposive sample of general contractors (GCs) registered with the East Cape Master Builders Association (ECMBA). Selected findings suggest that in the area of strategic management and transaction cost theory, it would be valuable to assess the factors that would aid regional GCs in South Africa. In addition, there appears to be a need to foster governance structures and strategic thinking attributes that would enable GCs to weather the storm of low order books. The implication is that it is important for GCs to have the ability to deploy strategic management approaches that would ensure the longevity of their firms when outcomes are highly uncertain in the business environment as reputations are difficult to establish and the payoff from opportunism cannot be overlooked in such situations.

Keywords: construction, economic cycle, transaction cost, South Africa.

BACKGROUND

The effects of the recent economic crisis have been widespread and they have resulted in significant asset depreciation, closures of organisations, rising unemployment and a severe slowing down of economic growth in most nations. To a lesser extent, this phenomenon has happened in countries in sub-Sahara Africa of which South Africa is considered to be an economic powerhouse. Until the global financial crisis (GFC) hit South Africa in late 2008, economic growth in the country had been stable. Statistics South Africa (STATS SA, 2009) observes that the gross domestic product (GDP) rose by 2.7% in 2001 to 5.1% in 2007 and then declined to 3.1% in 2008. A consequence

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Emuze F, Sanderson T and Shakantu W (2013) Perceived impact of the market on the business of regional contractors: a South African context *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 201-211.

of this decline is construction tendering activities (especially in the private sector) that have dropped dramatically over the past few years.

For example, STATS SA observed that in the 1st quarter of 2009 activities dropped by 24.8% year on year, with a 21.6% drop reported in non-residential developments. The costs of tendering that tend to be high in the industry (Hughes et al., 2001) worsen the state of the balance sheets of firms that have significant numbers of unsuccessful bids. Thome (2011) observe that during economic upswings in South Africa, the construction industry thrives as order books are full and profit margins are high; whereas in times of economic uncertainties, desperations born out of survival tendencies leads firm to engage in practices that have continually tarnish the image of the industry. Volatility in the industry that fosters fraud and corruption in South African construction (Construction Industry Development Board (CIDB), 2011) thus has the potential to increase transaction costs due to 'opportunism' (Hill, 1990).

Hill (1990) suggests that cooperative behaviour solutions (for example partnering) is unable to deal with opportunism when outcomes are highly uncertain, reputation is difficult to establish, and the payoff from opportunism in a prevailing period outweighs the discounted present value of future cooperation. In the context of transaction cost theory, the argument suggests that there is value in the theory that hierarchical governance has efficiency properties when outcomes are highly uncertain (Hill, 1990). Given that factors that engender opportunism can be said to be prevailing at the time of this study, the formulated problem statement that led to the compilation of this paper proposed that instability in economic cycles negatively affects long term profitability of contractors that are focussed on private sector construction projects. The study was embarked upon in order to explore the perceptions of GCs in terms of the boom and bust cycles in the economy and how this affect the construction industry and the competitiveness of firms operating in the business environment.

REVIEW OF THE RELATED LITERATURE

The literature acknowledge that economic cycles that influence decision makers exist, although the cause (or causes) of such cycles is uncertain and varies with respect to each industry and the prejudice of the observer (Allan, Yin & Scheepbouwer, 2008). Generally it is accepted that a rapid growth phase of the cycle causes inflated prices and reduced competition due to full order books; whilst the downward phase leads to competitive cost cutting, lower margins and short cuts that affect quality, which must be monitored if the industry is to free itself of the most negative aspects of boom and bust cycles (Allan et al., 2008). According to Lewis (2004), the construction sector is generally one of the larger and more important sectors of a nation's economy. The construction sector is also one of the most responsive to economic changes in a country. Construction is usually one of the major sources of employment in an economy, and so regulation of the construction sector not only has an important effect on the performance of the economy but also on levels of employment. For all these reasons, it is important to better understand the way the construction industry relates to other sectors of the economy, and to changes in the national economy itself.

As an illustration, De Valence and Runeson (2011) examined the extent that the building industry has been affected by the GFC and the Euro crisis internationally. They surveyed senior academics and executives in construction businesses in Europe, India, China, Hong Kong, Singapore, Korea, the Middle East, Africa, Australia and South America (No-one responded to the study from North America). The responses to the study show that in developed economies the effect has been a substantial

downturn as finance have taken flight (Spain, Greece and Cyprus may serve as examples), while in developing economies demand has been sustained by population growth induced urbanisation that embrace increased development of residential buildings and infrastructure projects (De Valence & Runeson, 2011). Close to home, De Valence and Runeson noted that the 2010 Soccer World Cup coupled with stringent foreign exchange controls played an important role in protecting the South African construction sector from the GFC. However, the reality in 2013 is not the same as the civil engineering sector that is often buoyed by the public sector is rather sluggish despite repeated announcement of budgetary allocations to the sector (Pillay, 2013). Thus, while the GFC has impacted most developed countries significantly (especially in Europe), the South African economy has not been totally insulated from it.

One of the best ways to avoid cyclical behaviour is to have access to accurate economic current information, and where possible, have lead indicators (Allan et al., 2008). This type of information are essential because the construction industry is vulnerable in a period of high market volatility, where mitigating the related risks has become a challenge for owners and contractors alike (Hibbs, 2007). A major reason for the volatility in the industry is due to the constant changes in prices of material and services. Burns (2008) contends that pricing and cost control now necessitates a proactive approach that requires project partners to frequently attend meetings with contractors, sub-contractors, and suppliers in order to ensure a profitable venture.

The construction industry is deemed to be characterised by increasing fierce competition among and / or between professionals and contractors. Such competitive behaviour could potentially promote opportunism (Hill, 1990) and negate the attempt to reduce transaction costs through collaborative working arrangements by project actors (Pryke, 2012). This can be illustrated through the work of Williamson (see Williamson 1979; 1981; 1985; 1998). Williamson's work combined behavioural assumptions with discussions of the causes of transaction costs and why transactions occur within markets. Pryke (2012) noted that Williamson adopted the concepts of bounded rationality and opportunism in a more strictly economic context related to environmental factors in the form of asset specificity, uncertainty and frequency. According to Williamson (1981: 552), "transactions occurs when a good or service is transferred across a technologically separable interface. One stage of activity terminates and another begins. With a well-working interface, as with a well-working machine, these transfers occur smoothly. In mechanical systems, we look for frictions: do the gears mesh, are the parts lubricated, is there needless slippage or other loss of energy? The economic counterpart of friction is transaction cost: do the parties to the exchange operate harmoniously, or are there frequent breakdowns, and other malfunction?"

With this simple machine metaphor, Williamson (1981) was able to define transaction cost. Although the quantification of transaction has previously proved relatively elusive in construction (Pryke, 2012), one of its inherent premise is that the properties of the transaction determines the governance structure of an undertaking (Williamson, 1985) and influence the governance of contractual relations (Williamson, 1979). Williamson (1979) identifies uncertainty, frequency of exchange, and the degree to which investments are transaction-specific as the principal dimensions for describing transactions. He argued that the efficient organization of economic activity entails matching governance structures with these transactional attributes in a discriminating

way. The propagation of an enabling strategy in a firm will serve the purpose of matching governance structures and transaction attributes.

However, there is limited evidence to show that construction firms have adapted formal processes to develop long-term strategies (McGeorge & Zou, 2013) despite the view that organisations that have implemented strategic management concepts as part of their business cornerstones have shown greater improvements in turnover and profits over the years (Ehlers & Lazenby, 2010). According to Behnam & Rasche (2009), strategy formation represents ethical reflection on a corporate level where one is bound by their own individual standards as well as the political and cultural environment in which the organisation operates. In fact, empirical findings have shown that organisations that implement strategic management competencies generally outperform those that do not (Hunger & Wheelen, 2003). According to Hellrieg et al. (2004), such competencies can be nurtured through:

- Understanding the industry by having a fair idea of the history of the industry as well as staying informed about the actions of competitors and strategic partners, and alertness to changes that will create significant threats and opportunities in the industry.
- Understanding the organisation through the ability to manage the concerns of stakeholders by understanding the strengths and limitations of various business strategies; appropriating the distinct competencies of the firm in conjunction with a clear understanding of the various organisational structures via the advantages and disadvantages of each, and the ability to fit into the unique corporate culture of the organisation.
- Taking strategic actions in the form of executing specific plans that reflect cross-functional and divisional knowledge; assigning priorities and making decisions that are consistent with organisational mission and strategic goals; managing the challenges of alternative strategies by considering the long-term implications of actions, and also establishing tactical and operational goals that facilitate strategy implantation.

METHODOLOGY

The research method chosen for this exploratory study was quantitative in nature since the rigor was limited as the project constitutes a partial requirement for the award of a BSc honours degree in a South African university. The quantitative technique used was the survey method. The literature reviewed provides the platform for the set of questions that were asked in the survey. The questions asked pertain to the ratings of certain aspects of the business of construction that are mostly affected by fluctuations in economic cycles; and the consequences of such fluctuations. The extent to which certain practices observable through the reviewed literature contribute to business profitability was also examined.

Given that construction managers, certainly members of the CIOB in Southern Africa have been noted for spending a limited number of years at operational management level, and more at middle and top management level (Smallwood 2006); the primary data that arose from the study were collected by means of a survey that was conducted among middle and top management employees of Eastern Cape based GCs that are members of ECMBA. According to Smallwood (2006), the most frequently used subject areas in the construction management domain reflects the focus at these respective levels of management: top-the management of business of construction; middle-the management of a number of projects and operational-the management of

specific projects. Thus, the rationale for sampling only middle and top management employee is based on their perceived exposure to the business aspects of construction management in South Africa.

The data were therefore collected through a purposive sampling method. Purposive sampling is a procedure in which the research samples whoever he or she believes to be representative of a given population (Springer, 2010). The difference between purposive sampling and probability sampling approaches is that purposive sampling is based on the researcher's informal ideas about representativeness. Although probability sampling is often preferable to purposive sampling, the latter is often used when population characteristics cannot be precisely determined (Springer, 2010).

Through the ECMBA database, the purposive sampling method led to the selection of 87 GCs. Out of this number, only 37 responded, which equates to a 42.5% response rate. In terms of demographic information, 70.2% of the respondents have been in the industry for over 10 years; 45.9% of the GCs have executed project with average contract value above R10m; 85.7% of them were involved in residential projects; and 83.8% of the respondents occupied either a top management or a middle management position in their respective firms.

FINDINGS - THE SURVEY

When the respondents were asked to tick the phrase that best describe the economic climate of the construction industry among four options, which include stable, volatile, constant, and ever changing, it is notable that almost all the respondents ticked volatile and ever changing. It was observed that 91.7% perceive the industry to be volatile, while 96% perceive it to be ever changing. Based on this response, it can be argued that the respondents were of the opinion that there are fluctuations in economic cycles and these fluctuations affect various aspects of the construction business. As indicated in Table 1, profits and tendering were perceived to be mostly affected by fluctuations. The table indicates the perceptions of respondents related to the effect that fluctuations in economic cycles has on certain aspects of a construction business in terms of response percentages ranging from 1 (minor) to 5 (major) and a mean score (MS) ranging between 1.00 and 5.00. It is notable that 59.5% of the respondents were of the opinion that fluctuations in economic cycles have a major effect on profits, while 48.6% of them perceive that fluctuation have a major effect on tendering. In general, given that the MSs related to profits, tendering and morale were above the midpoint score of 3.00, it can be argued that the respondents perceive the effect of fluctuations in economic cycles on these aspects to be more of a major than a minor effect.

Table 1 Aspects of construction business affected by fluctuations in economic cycles

Aspects	Response (%)						MS	Rank
	Unsure	Minor……..…….….Major						
		1	2	3	4	5		
Profits	0.0	0.0	8.1	5.4	27.0	59.5	4.38	1
Tendering	2.7	0.0	5.4	13.5	29.7	48.6	4.25	2
Morale	0.0	5.4	10.8	40.5	18.9	24.3	3.46	3
Ethics	2.8	16.7	19.4	27.8	27.8	5.6	2.86	4
Quality	0.0	21.6	24.3	32.4	10.8	10.8	2.65	5

In addition, Table 2 indicates respondents perceptions associated with consequences of fluctuating economic cycles in the construction context. The table shows the respondents' perceptions of the consequences of economic instability in terms of response percentages ranging from 1 (strongly disagree) to 5 (strongly agree) and an MS ranging between 1.00 and 5.00. It is notable that all MSs in the table are above the midpoint score of 3.00, which suggest that the respondents agreed as opposed to disagreed with the listed consequences. Specifically, redundancy and liquidation were perceived as the most significant consequences of economic instability in the South African construction industry, while loss of expertise and changing of business are equally important eventualities in such situations.

Table 2 Consequences of fluctuations in economic cycles on construction business

Consequences	Response (%)						MS	Rank
	Unsure	Strongly disagree…Strongly agree						
		1	2	3	4	5		
Redundancy	2.7	2.7	5.4	16.2	29.7	43.2	4.08	1
Liquidation	0.0	5.6	2.8	25.0	36.1	30.6	3.83	2
Loss of expertise	2.7	5.4	13.5	21.6	37.8	18.9	3.53	3
Changing of business	0.0	0.0	21.6	37.8	27.0	13.5	3.32	4

Because of observations such as the ones recorded above and others documented in international construction management research (CMR), the management of the business of construction strategically have being advocated in the literature. To this end, questions related to strategic management were posed to the respondents. With a 'Yes, No, and an Unsure option', the respondents were requested to indicate if their organisations engage in the strategic management of their businesses. It is notable that 65% of the respondents affirm that they engage in one form of strategic management or the other. However, all the respondents concurred that reliable information and astute management expertise are required for making appropriate business decisions. Furthermore, 89.2% of them opine that organisations should have strategic intent / vision in order to make appropriate business decisions. 86.5% of the respondents also contend that greater collaboration between key stakeholders is required for optimum business decision-making processes.

In brief, the respondents were of the opinion that certain practices are central to the ability to make profits in the regional construction business environment in South Africa. As indicated in Table 3, 70.3% of the respondents perceive that integrity is paramount for the ability to engender business profitability in the construction industry. The table also suggests that reliability, strategic management competencies, long-term planning, specialisation and diversification are all important practices for survival and increased profitability in the construction business environment. When asked to make general comments associated with the study, 19 respondents put forward arguments that provided additional insights. Such comments, inter-alia, include:

- "Fluctuating economic cycles affect all aspects of the construction industry, but in particular it decreases the level of skills available in the industry";
- "Economic cycles have a major impact on construction activities, especially in the residential market. Another factor linked to the economy, which influences the construction industry, is the availability of finance", and
- "Due to fluctuating cycles, regular work is not available to the construction companies who have staff that need to be paid. Companies are thus forced to tender on work at next to nothing margins just to retain their workers and keep them happy. This leads companies to 'cut corners' in order to make small profits that results in decreased quality and unhappy clients".

Table 3 Extent to which certain practices contribute to business profitability

Practice	Response (%)						MS	Rank
	Unsure	Minor……..…..….				Major		
		1	2	3	4	5		
Integrity	0.0	0.0	0.0	5.4	24.3	70.3	4.65	1
Reliability	0.0	0.0	0.0	0.0	50.0	50.0	4.50	2
Strategic management competencies	0.0	0.0	2.7	13.5	40.5	43.2	4.24	3
Long term planning	0.0	5.4	2.7	16.2	43.2	32.4	3.95	4
Specialisation	5.4	0.0	5.4	32.4	29.7	27.0	3.83	5
Diversification	2.7	0.0	10.8	32.4	29.7	24.3	3.69	6

Furthermore, some respondent say:

- "Small organisations are constantly in survival mode, while large organisations survive economic cycles by operating outside of South Africa";
- "In bad times you have to take whatever work is available even if it means tendering at cost just to keep your workforce busy";
- "Economic cycles govern the highs and lows of the construction industry. Budget constraints and cost control also contribute";
- "The industry is so volatile, that is makes a mockery of short to medium term planning and the short durations of the cycles make planning for growth and expansion, extremely risky";
- Clients put industry players under major pressure in economic downturns / recessions. Both contractors and consultants have to engage work at very low

margins. Contractors can only do as much as they allowed for in the tender price. Educated clients know this and don't work with lowest set of tenders", and

- "Economic fluctuations have profound effects on the industry as a whole. Economic downturns lead to unethical practices which leaves the industry with a poor public image. It's a horrible cycle that needs fixing. A stabilised economy would go a long way to relieving the industry of many of its problems but the means of stabilise the economy seems unattainable".

DISCUSSION

Although it has been claimed that long-term survival of construction enterprise depends upon effective strategic management based on sound strategic planning, and strategic thinking has become increasingly important to construction organisations as a result of the industry's dramatically changing business environment (McGeorge & Zou, 2013), it appears that the surveyed GCs have not appropriated this management concept. The findings can be further supported by another empirical finding that emanated from the Eastern Cape region in South Africa. The study amplified the need for GCs to manage their firms / or businesses strategically. The qualitative study that was authored by Adendorff, Appels & Botha (2011) revealed that construction SMEs (small and medium size firms) that practise strategic management perform better than their peers, and that there are many advantages for SMEs that adopt strategic management principles at the organisational level. The case study that profiled an Eastern Cape based GC further indicates that the GC was able to grow its business in spite of the tough economic climate because it adopted management strategies that include diversification and specialisation, among others.

A closer look at the general comments noted that the uncertainties in the business environment may be leading to the prevalence of opportunistic behaviours in the regional market. The comments failed to show a particular strategy that the GCs have adopted in this volatile period. Given that opportunism hinders long-term growth of firms (Hill, 1990; Williamson, 1979; 1998), there appears to be a need for the surveyed GCs (and others in the region) to develop an open framework for corporate strategy in construction in terms of technology, human resources, marketing and competition, business, core competencies, knowledge resources, finance, and operations (see McGeorge & Zou, 2013). Doing this should enable the firms to tackle rising transaction costs (for example, costs pertaining to unsuccessful tenders) and low profit margins in the industry. From the data presented by Hughes (2003), there appears to be no relationship between the type of working methods and the costs of tendering in construction. Hughes (2003) noted that while it can be expensive to get into framework deals and partnering arrangements, the expectation of project actors is that this up-front investment results in lower downstream costs; but there is no evidence to support either of these assertions. He however opined that the findings suggest that there are more influences on these costs than the mere presence or absence of collaborative working methods.

The aforesaid have implication for regional contractors that are not exposed to public sector projects in South Africa. The market mechanism dictates the availability of work in the private sector, especially in the residential building sector. Perhaps the argument of Hill (1990) should be considered in this context. Hill (1990) argued that among a population of economic actors that require investment in specialised assets, behaviours that amplify cooperation, trust, and forgiveness of isolated opportunism by

others does have economic value. Furthermore, Hill (1990) suggests that even in cases that are dominated by small numbers and high switching costs, in the long run opportunism does not yield the anticipated benefits.

CONCLUDING REMARKS

The volatility of the economic system has had a profound effect on the construction industry as problems that are synonymous with the sector are often amplified during economic downswings. Economic fluctuations produce ripple effects that affect a number of key construction business areas. This is particularly apparent during a sluggish economic period that the construction industry is so impacted that GCs and other project actors engage in competitive strategies that are not limited to cost cutting, lower margins, and other practices that would secure the lifespan of businesses. The surveyed literature and regional GCs in South Africa indicate that when situations such as the one described above persist, opportunism may escalate transaction costs in the industry. Although behaviours that engenders opportunism would not serve the corporate goals of a firm in the long-term, it appears that interventions that can address it is not been implemented by the surveyed GCs.

This implies that market mechanism (volatility) can have the risk of opportunism even if actors whose behaviours are habitually opportunistic would eventually leave the scene (Hill, 1990). In other words, as markets move towards the state of competitive on-equilibrium, the risk of opportunism will be high. However, the findings of this exploratory study should be viewed in context because of its inherent limitations. In the area of strategic management and transaction cost theory, it would be valuable to assess the factors that would aid regional GCs in South Africa, especially in an unstable economic environment. Governance structures and strategic thinking attributes that would enable GCs to weather the storm of low order books should be made known in a future study. When outcomes are highly uncertain in a business environment, reputations are difficult to establish and the payoff from opportunism cannot be overlooked; it is important for GCs to have strategic management techniques and / or approaches that would ensure the continued existence of their firms.

ACKNOWLEDGEMENT

The authors are grateful to the NMMU-cidb Centre of Excellence, hosted by the Built Environment Research Centre (BERC), for supporting this research project in 2012.

REFERENCES

Adendorff, C, Appels, G and Botha, B (2011) Strategic management: An Eastern Cape construction SME case study. Acta Structilia, 18(2), pp. 40-63.

Allan, A, Yin, Y and Scheepbouwer, E (2008) A study into the cyclical performance of the New Zealand construction industry. New Zealand Centre for Advanced Engineering, Chrishchurch, New Zealand.

Behnam, M and Rasche, A (2009) Are strategies from Mars and ethicists from Venus? Strategizing as ethical reflection. Journal of Business Ethics, 84(1), pp. 80.

Burns, A (2008) 8 ways the economy is affecting construction cost. Boston: The Burns Companies.

Chartered Institute of Building (2010) A report exploring procurement in the construction industry. Oxford: Wiley-Blackwell with the CIOB.

Construction Industry Development Board (cidb) (2011b), Construction Quality in South Africa; a client perspective: a discussion document, cidb, Pretoria, RSA.

De Valence, G and Runeson, G (2011) On the state of the building industry after the GFC and the Euro crisis. Australasian Journal of Construction Economics and Building, 11(4), pp. 102-113.

Ehlers, T and Lazenby, K (2010) Strategic management: Southern African concepts and cases. 3RD ED. Pretoria: van Schaik Publishers.

Hellriegel, D, Jackson, SE, Slocum, J, Staude, G, Amos, T, Klopper, HB, Louw, L and Oosth, T (2004) Management: second South African edition. Cape Town: Oxford University Press.

Hibbs, D (2007) Price fluctuation and market volatility in municipal and treatment plant construction projects. Fort Worth, Texas: Frees and Nichol.

Hill, CWL (1990) Cooperation, opportunism, and the invisible hand: implications for transaction cost theory. Academy of Management Review, 15(3), pp. 500-513.

Hughes, W, Hillebrandt, PM, Lingard, H and Greenwood, DG (2001) The impact of market and supply configurations on the costs of tendering in the construction industry. In: CIB World Building Congress: Performance in Product and Practice, 2-6 April 2001, Wellington, New Zealand.

Hughes, W (2003) Comparative costs of the commercial process in different construction procurement methods. In: Joint International Symposium of CIB Working Commissions W55, W65 and W107, Singapore, October 2003.

Hunger, JD and Wheelen, TL (2003) Essentials of strategic management. 3RD ED. New Jersey: Prentice Hall.

Lewis, MT (2004) The construction industry in the economy of Trinidad and Tobago. Construction Management and Economic, 22(5), pp. 541-549.

McGeorge, D and Zou, P (2013) Construction management: new directions. 3rd edition. Oxford: Wiley-Blackwell.

Pillay, M (2013) From the CEO's Desk: the tortoise and the hare-ngineer. SAICE-Civil Engineering, 21(2), pp. 1.

Pryke, S (2012) Social network analysis in construction. Oxford: Wiley-Blackwell.

Smallwood, JJ (2006) The practice of construction management. "Acta Structilia", 13(2), 62-89.

Springer, K (2010) Educational research: a contextual approach. New Jersey: John Wiley & Sons.

Statistics South Africa (2009) Selected building statistics of the private sector as reported by local government institution [online]. Available from:

http://www.statssa.gov.za/publications [Accessed 3 June 2011]

Thome, J (ed.) (2011) GMBA shocked at collusion allegations. South African Builder, March 2011 (No. 1036).

Williamson, OE (1979) Transaction cost economics: the governance of contractual relations. Journal of Law and Economics, 22(2), pp. 233-261.

Williamson, OE (1981) The economics of organisation: the transaction cost approach. American Journal of Sociology, 87(3), pp. 548-577.

Williamson, OE (1985) The economic institution of capitalism: firms, markets, relational contracting. London: Free Press-Collier Macmillan.

Williamson, OE (1998) Transaction cost economics: how it works: where it is headed. De Economics, 146(1), pp. 25-58.

PERCEPTION TOWARDS COST IMPLICATION OF MECHANISATION AND AUTOMATION APPROACH IN IBS PROJECTS IN MALAYSIA

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Industrialised Building System (IBS) is defined as a construction technique which components are manufactured in a controlled environment (on or off site). These components are then transported, positioned and installed into a structure without too much site works performed by labours. The agenda of IBS has been duly highlighted in the Malaysian Construction Industry Master Plan (2005-2015) as being of significant importance to the Malaysian construction industry. The Malaysian government is also committed not only in addressing the IBS agenda but also meeting its target and adopting innovations in the near future. The aim of the main research is to investigate the cost implication factors of mechanisation and automation approach in IBS projects. The methodologies are based on a thorough literature review, quantitative and qualitative method using semi structured interviews which were conducted among IBS manufacturers, developers and contractors in Malaysia. Capital cost, maintenance cost, operation cost, inadequacy of market size, site arrangement, upgrading, availability of machine locally, site location, training and transportation are among the major cost factors highlighted by the IBS players. These cost factors require considerable attention when the mechanisation and automation approach are to be fully implemented in IBS projects in Malaysia. The findings on the cost implication of the mechanisation and automation approach in IBS will be able to guide the industry players and the government in their quest to reduce the country's over-dependency on foreign workers by encouraging the use of labour saving devices at an optimum cost. Subsequently, the IBS needs mechanisation and automation approach to push their agenda forward to meet the government's transformation policy towards modernising the construction industry in line with other developed countries by the year 2020.

Keywords: costs, industrialised building system , mechanisation, automation.

INTRODUCTION

Malaysia is a dynamic country which is constantly evolving. Being a middle-income country, Malaysia has transformed itself since the 1970s from a producer of raw materials into an emerging multi-sector economy spurred on by high technology, knowledge-based and capital intensive industries. In Malaysia, the government is aware of the importance of developing a capable construction industry driven by technological development in the manufacturing and service industry that can contribute to the economy Azman et al. (2010). In 2008, a circular from the Malaysian Treasury Department, Ministry of Finance denotes full utilisation of IBS for all

Kamaruddin SS, Mohammad MF, Mahbub R. and Yunus RM (2013) Perception towards cost implication of mechanisation and automation approach in IBS projects in Malaysia *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 213-222.

government projects in Malaysia whereby the use of IBS components in government projects must not be less than 70% (Kamar et al. 2009). This is because the IBS has the compensation factors of speed, safety and quality and Malaysia is in a dire need of fast and high quality products for the local construction industry as well as able to complete with the global market. Dealing with the issue on the influx of foreign labour, to stop illegal workers abruptly can be very costly, time consuming and involved a large number of enforcement personnel. The government may need to work hard with the industry to study ways to reduce the country's dependence on foreign workers by encouraging more labour saving devices such as construction methods using IBS and through greater mechanisation and automation approach. Mechanisation and IBS are interrelated to each other. IBS needs mechanisation to fulfil its cycle till the complete erection of those IBS components on site. The automotive industry has moved from craft-based production to mass production and yet people still talk of moving the construction industry from a craft-based to a manufacturing industry (Crowley, 1998). This statement was supported by Azman et al. (2010) in the context of the Malaysian construction industry which is currently in the process of being transformed into a mass manufacturing and production industry in view of developing standardisation of products in line with the demanding local and global markets.

Therefore, the main research aims to investigate the cost implication factors of mechanisation and automation approach in IBS project. However, this paper will attempt to complement precedent studies whilst contributing to IBS research in guiding the industry players and helping the Malaysian government in their quest to reduce the number of foreign workers.

LITERATURE REVIEW

Industrialised Building System (IBS) and the Malaysian Construction Industry

The use of IBS has turned the Malaysian housing industry into one of the mass producers of houses per capita basis than any other countries in the world. It can be defined as an approach or process used in making construction less labour oriented and faster and fulfilling quality concerns (Shaari et al. 2003). The broader view of the IBS is about changing the conventional mind-set, championing human capital development, developing better cooperation and trust, and promoting transparency and integrity (Shaari et al. 2003). The term was invented to shift from the typical paradigm of prefabricated systems. According to the Malaysian Construction Industry Development Board (CIDB) IBS Digest Bulletin Issue 02 2010, IBS is defined as a construction process that utilises components or building systems which involve prefabricated components and on-site installation. From the structural classification, they are divided into six main IBS groups or categories that are popularly used in Malaysia which includes: precast concrete framing; panel and box systems; formwork systems; steel framing systems; prefabricated timber framing systems; and block work systems. Azman et al. (2010) has come up with the table of categorisation of IBS components in the context of Malaysian construction industry as in Table 1.

The term used for IBS may be different from one country and another. Azman et al. (2010) has found out that the term used in the UK is known as the Modern Methods of Construction (MMC) or Off-site Manufacturing. MMC is the term used by UK government to describe a number of innovations in house building, most of which are offsite technologies, moving work from the construction site to the factory. On the other hand, in Australia, the IBS is better known as the Off-Site Manufacture (OSM).

The OSM term has been well known in Australia and internationally as in UK, US, and European countries as well.

Table 1: Categorisation of IBS Components in Malaysia

IBS Introduce in	Categorisation of IBS	IBS Components
Early 60's	Badir et al. (2002)	Frame System
		Panel System
		Box System
Early 90's	Badir and Razali (1998)	Precast concrete framing, panel and box systems
		Load bearing block
		Sandwich panel
		Steel frame
2003	CIDB (2003)	Pre-cast concrete framing, panel and box systems
		Formworks systems
		Steel framing systems
		Prefabricated timber framing systems
		Block work systems
2010	CIDB (2010)	Pre-cast concrete systems
		Formworks systems
		Steel framing systems
		Prefabricated timber framing systems
		Block work systems
		Innovative

The IBS offer benefits to adopters that concerned about cost and time certainty, attaining better construction quality and productivity, reducing risk related to occupational safety and health, alleviating issues skilled workers and dependency on manual foreign labour, and achieving the ultimate goal of reducing the overall cost of construction (Lou et al. 2012). As of February 2009, 320 government projects worth RM9.43 billion have been carried out using the IBS construction approach. The government has also realised that it is also important for the private sector to participate aggressively in the IBS construction approach. Currently there is an exemption in the form of tax levy (0.125% of project cost) for contractors who are using a minimum of 50% of the IBS score in the construction of residential buildings.

According to Hamid et al. (2011) in Finland, IBS (or offsite manufacturing as it is better known in the European Union) represented 70% of total building construction. It offers effective and rapid site assembly and improving the quality and productivity of construction. Japanese house building industry has developed the most advanced manufacturing techniques in construction. Automation and robotics are applied in both manufacturing techniques in construction. Meanwhile, Hamid et al. (2011) adds that offsite manufacturing in German house building industry has improved quality and provided a better value with considerable variety and flexibility in design. It has also helped the developers to overcome strict standard of quality control imposed by local authorities.

According to Thanoon et al. (2003) in the early 60s, the IBS method has been adopted due to the need of accomplishing large quantities of apartments as quickly as possible by The Housing and Development Board (HDB) of Singapore. Furthermore, in Thailand the usage of Precast Large Panel Construction (PLPC) as an example of IBS components has been widely used in Thailand as the government of Thailand planned to build about 600,000 housing units for the low to medium income level population within three years starting the year of 2004 (Thanoon et al. 2003). Meanwhile, Thanoon et al. (2003) the organisation of The Building America Industrialised Housing Partnership (BAIHP), IBS is gaining fast popularity in the USA market in term of both high rise and low rise buildings. According to the researcher Thanoon et al. (2003), the experiences in some developed countries such as United Kingdom and Japan indicate that there is a great potential for IBS to progress as it offers loads of benefits towards the civilization both economically and socially. IBS has already been successfully adopted in Finland, Japan, UK, USA and Singapore where technologies had eventually modernised and improved the industry. However, in Malaysia, according to Kamar, (2009) the percentage of IBS usage is still considered low and deteriorating. This indicates that to be successful, the Malaysian construction industry shall not work in isolation but to benchmark and learn from others.

Therefore, the latest IBS Roadmap from 2011 to 2015 has stated that among the objective is to impose a high-level intended outcome when implementing IBS. The four policies include good on quality, design, components and finished buildings. Aesthetics should be promoted through innovation to ensure that by using IBS the completion time of a building is not only speedier but more predictable and well-managed (Kamar et al. 2012). Concurrently, there is a need to have a ready pool of competent IBS professionals and workers throughout the entire project life-cycle; from design, manufacture, and construction up to maintenance to create a financially sustainable IBS industry that balances users need and affordability as well as manufacturers viability. Apart from this, IBS offers minimal wastage, fewer site materials, a cleaner and neater environment, controlled quality, and lower total construction costs (Pan et al. 2008, Hamid et al. 2008 and Pan et al. 2007).

Mechanisation and Automation in Construction Industry

There are five degrees of industrialisation described by Richard (2005). They are prefabrication, mechanisation, automation, robotic and reproduction (Figure 1). Prefabrication is a manufacturing process that takes place at a specialised facility, in which various materials joined to form a component part of the final installation. Mechanisation comes in whenever machinery employed to ease the workload of the labourer. Automation is a situation when the tooling (machine) completely takes over the tasks performed by the labourer. Robotics comprises the ability of the same tooling which has the multi-axis flexibility to perform diversified tasks by itself. This allows the mass- customisation concept. Reproduction implies that the research and development of innovative processes is truly capable of simplifying the production process. According to Richard, (2005) the first four degrees are still more under the influence of the traditional methods of building. Prefabrication aims rather at the location of the production where the next three degrees (mechanisation, automation and robotics) aim at substituting labour with machineries (Richard, 2005). This range of this research is in between the mechanisation a bit into the earlier stage of automation implementation on site.

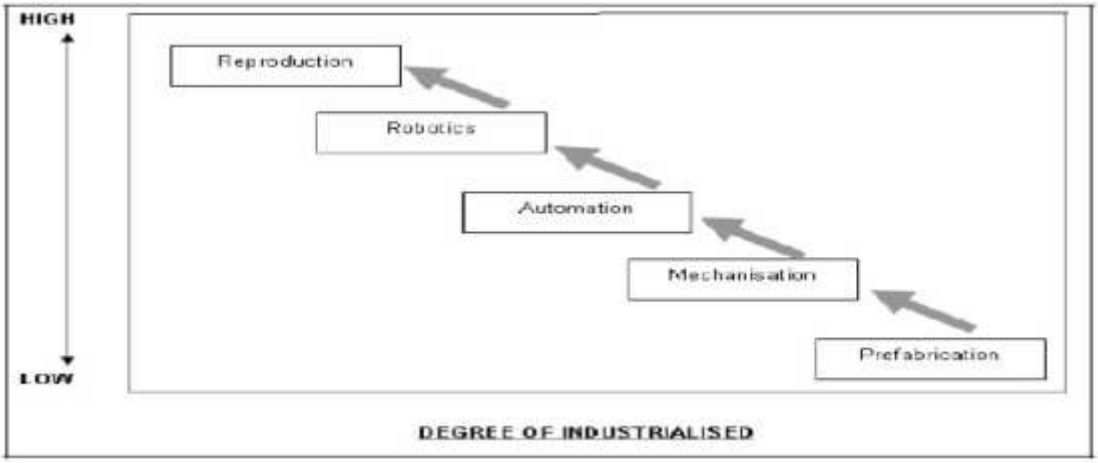

Figure 1: Degree of industrialisation (Richard, 2005)

Mahbub (2012) highlighted that the problems associated with the construction industry such as decreasing quality and productivity, labour shortages, occupational safety and inferior working condition have highlighted the need for an innovative solution within the industry, including the push for further use of industrialisation and construction automation and robotics application on site.

Mechanisation can be described as the process of applying the use of mechanical plants in carrying out a task. The level of mechanisation defined as the number of plants and equipment employed or the number of activities carried out by mechanical plants in an operation (Idoro, 2008).

According to Parker (1989) and Navon (1996) automation is defined as "the replacement of human, labour by machines; or the operation of a machine or device automatically, or remote control". Richard (2005) stated that automation is the tool that is completely taking over the tasks performed by the labour although the "supervisor" is still around. Other than that according to Slaughter (1997) "automated" devices may include other manipulators and equipment that follow a fixed sequence or remote controls.

The Cost Factors on Mechanisation and Automation in IBS Construction Project

Mahbub (2012) have set up the barriers in the implementation of automation and robotic in construction which include high in cost, financial commitments in acquiring and maintaining the technologies. Navon (1996) has listed down that economic analysis is one of the factors that need to be considered in teaching automation as part of the construction curriculum. Results from his survey have shown that the automation system would be economical if it could replace at least one worker. Navon (1996) has also listed ten parameters of the automation system economic analysis which is the initial investment cost, economic life, interest rate, repair and maintenance, operating cost, transfer cost, number of saved workers, labour cost, robot employment time and tax reduction. Warszawski (1985) had come out with an economic feasibility study of robot employment in construction tasks which encompassed development cost: include all expenses associated with labour, materials and facilities used for researching, testing and evaluating of the various alternatives of robotics solutions investment costs: include depreciation and interest on investment. The parameters are the cost of new equipment, it is economic life, the salvage value at disposal and the interest charged on investment. Set up costs: include the installation of the equipment at its work place, the running-in, learning and programming

expenses. Maintenance costs: include the regular upkeep, the inspection and repairs of breakdown. Operation costs: include the electricity consumed for robotic work. CIDB (2012) has also listed down several recommendations to encourage the use of mechanisation and automation in construction. Amongst them are: expanding the machinery for the construction manufacturing industry, developing capacity and capability, strengthening research, development and commercialisation, reduction of construction levy for the contractors, a leasing model for buying the machines, financial assistant and tax exemption from the government, and reduction on import duty and sales tax on heavy machineries.

METHODOLOGY

This paper discusses the questionnaire and semi structured interviews conducted with IBS manufacturers, developers and contractors as a part of an on-going research progress on the implementation of mechanisation and automation in IBS projects in Malaysia. Literature review was the first phase of the research. Secondary data were derived from relevant books, journal articles, theses and dissertations, conference proceedings, and reports. This includes the investigation on the cost implication of mechanisation and automation approach in IBS projects in Malaysia with a variety of IBS key players (manufacturers, developer, and contractors). Therefore, the data presented in this paper are only a portion of those collected, and the conclusions presented here are based on interim findings.

The 5-point scale is used to measure responses on the questionnaires. Items are scored on the following keys: 1- No influence at all, 2- Minor Influence, 3- Moderately Influence, 4- Major Influence and 5- Totally Influence. The data gathered through these questionnaires is compiled and fed into the computer to be analysed. The semi structured interviews were conducted in an open ended manner and recorded using digital voice recorder upon obtaining permission from the participants. The recordings were then transcribed for the purpose of data analysis. Answers from interviewees were compared to previous studies' findings were the condition and types of mechanisation and automation are also taken into consideration during the qualitative analysis.

FINDINGS AND DISCUSSIONS

A total of 24 out of 40 respondents returned the questionnaire within three weeks after being sent out. These represent 60% of total respond to rate which is considered to be quite adequate for analysis. Table 2 and Chart 1 explain the job category of the respondents by percentage. Contractors form the highest number of respondents with 11 respondents (45.8%), followed by developers 9 (37.5%) while the manufacturers 4 (16.7%) form the minority population in this study. The survey data is analyses using IBM SPSS Version 20.

Table 2: Job categories of respondents

	Job Category			
	Frequency	Percent (%)	Valid Percent	Cumulative Percent (%)
Contractors	11	45.8	45.8	45.8
Developers	9	37.5	37.5	83.3
Manufacturers	4	16.7	16.7	100.0
Total	24	100.0	100.0	

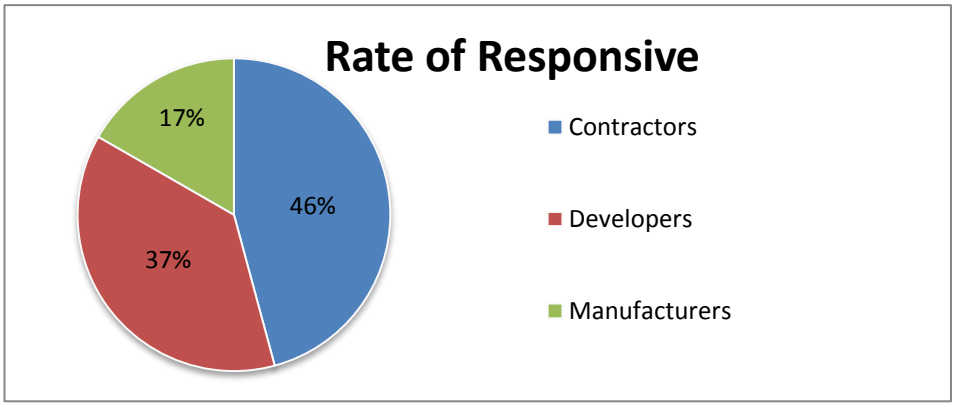

Chart 1: Rate of Responsive

Most of the respondents have good experiences in the industry and IBS construction. According to Table 3, 10 respondents have less than 10 years of experience form the highest percentage (41.7%), 8 (33.3%) of the respondents have experiences between 5 to 10 years and, 6 (25%) of the respondents had 10 years or more experience. Thus, a total of 58.3% of the respondents have been involved in the construction industry for 5 years or more. This represents respondents who had sufficient knowledge on the implementation of mechanisation and automation in IBS. Therefore, the data collected are considered to be reliable and good for an opinion based survey.

Table 3: Respondents experience

	Experience			
	Frequency	Percent (%)	Valid Percent	Cumulative Percent (%)
Less than 5 years	10	41.7	41.7	41.7
5 to 10 years	8	33.3	33.3	75.0
More than 10 years	6	25.0	25.0	100.0
Total	24	100.0	100.0	

Table 4, has shown that the respondents' working experience is sufficient, therefore the results for the Mean, Median and Mode of the data is quite close to each other.

Table 4: Mean, median mode for the working experience

DESCRIPTION		WORKING EXPERIENCE
N	Valid	24
	Missing	0
Mean		1.8333
Median		2.0000
Mode		1.00
Std. Deviation		.81650
Variance		.667
Range		2.00
Minimum		1.00
Maximum		3.00
Percentiles	25	1.0000
	50	2.0000
	75	2.7500

Table 5 illustrates the variables that are rank based on the most influencing factors on the use of mechanisation and automation. It shows that the capital cost is the major factor influencing the cost of mechanisation and automation and that the purchase of plants and machineries will increase the capital cost. This is followed by the maintenance cost, operation cost, and inadequacy of market size, site arrangement, upgrading cost of machines, availability of machine locally, site location, training cost and transportation cost. This finding is in lieu with Navon (1996) and Warszawski (1985) who stated that among the cost of mechanisation and automation are the investment cost, repair and maintenance cost, operating cost as well as labour cost.

Table 5: Factors influencing the mechanisation and automation costs

Item	Description	Rank	Mean
1	Capital cost	1	4.3333
2	Maintenance cost	2	4.2083
3	Operation cost	3	4.0000
4	Inadequacy of market size	4	3.7917
5	Site arrangement	5	3.7500
6	Upgrading cost	6	3.6667
7	Availability of machine locally	7	3.5000
8	Site location	8	3.5000
9	Training cost	9	3.3333
10	Transportation cost	10	3.3333

A combination of literature review and analysis of results was used to arrive at the findings. Based on the results of the interviews, the perceived cost implication factors of mechanisation and automation approach in IBS projects in Malaysia are presented below.

IBS Manufacturers' perception

The mechanisation and automation costs can be very high. The machines can reach up to 1 Million Ringgit Malaysia to 2 Million Ringgit Malaysia per purchase. That is only the initial cost. The machines are all imported because there is no other local technology as yet that can compete with the quality of the imported machines. Even in China, the industry has yet to produce the machineries for construction. Other than that, the wear and tear of the machine components are another aspect that needs to be looked into in the operating cost. All the components such as screws have their time limit whereby when it reaches a certain number of production cycles they need to be replaced. Capital cost will include such thing as purchasing the plants and machineries. Otherwise, the output quality will be affected, and all the components need to be imported from its original manufacturer. The operational and the maintenance cost must also be taken care. Other costs involved are the cost for training or labour cost to train local to use the machines. At the beginning, we had to employ an engineer from Finland to be in charge to train our workers to operate the machines.

Developers' perception

Among the costs that are involved in the mechanisation and automation of IBS are the capital cost to include the purchase of plants and machineries, cost of operation,

maintenance cost, training cost for labour and spare parts cost which are machine wear and tear.

Contractors' perception

The contractor usually rent the machines. They have to provide the cost for running the machine which is the operational cost and machines renting cost. Contractor did not need to provide the machine initial cost and maintenance cost because it is covered with the machines provider.

CONCLUSIONS

All three interviewees in this study were asked about their perception on the cost implication of mechanisation and automation in IBS projects in Malaysia. However, their understanding on the cost implications factors in mechanisation and automation could be enhanced even more. This is also an attempt to address the issues of the country's dependency of foreign labours by encouraging the use of labour saving devices at an optimum cost. Promoting the use of IBS in construction using mechanisation and automation will surely improve the construction productivity and hopefully fulfil the Malaysian government's target of becoming a developed country by the year 2020. This statement is in lieu with Mahbub (2012) that highlighted the problems associated with the construction industry such as decreasing quality and productivity, labour shortages, occupational safety and inferior working conditions. Finally, there is also the need for an innovative solution within the industry, including the push for further use of industrialization, construction automation and robotics application on site in years to come.

ACKNOWLEDGEMENT

The Author wish to extend her appreciation and gratitude to the panel of experts within the research supervisory committee and to industry collaborators for their assistance and constructive comments. A remark of indebtedness is also owed to the Research Intensive Fund (RIF) grant provided by Universiti Teknologi MARA (UiTM) in pursuing this research

REFERENCES

Azman, M.N.A and Ahmad, M.S.S. (2010). Perspective of Malaysian Industrialized Building System on The Modern Method of Construction. The 11th Asia Pacific Industrialized Engineering and Management Systems Conference.

Badir Y.F, Kadir M.R.A., & Hashim, A.H. (2002). Industrialised building systems construction in Malaysia. Journal of Architectural Engineering 8(1):19–23.

CIDB (2003). Industrialised Building Systems (IBS) Roadmap 2005, Construction Industry Development Board (CIDB) Malaysia, Kuala Lumpur.

CIDB (2010). Industrialised Building Systems (IBS) Roadmap 2011-2015, Construction Industry Development Board (CIDB) Malaysia, Kuala Lumpur.

CIDB (2009). Industrialised Building System :Implementation Strategy from R&D Perspective. Construction Industry Development Board Malaysia (CIDB), Kuala Lumpur.

CIDB (2012). Construction Quarterly Statistical Bulletin 2012. Kuala Lumpur, CIDB Malaysia.

Hamid, Z., Kamar, K. A. M., Zain, M., Ghani, K., Rahim, A. H. A. (2008). Industrialized Building System (IBS) in Malaysia: The Current State and R&D Initiatives, Kuala Lumpur.

IBS Roadmap (2011-2015). Kuala Lumpur: Construction Industry Development Board.

IBS Digest, Construction Industry Development Board, Malaysia, Issue 02, 2010, ISBN 983-2724-29-5.

Idoro (2008). Influence of Channels of Recruitment on Performance of Construction Workers in Nigeria. Proceedings of the West Africa Built Environment Research (WABER) Conference 2011 (19-21 July 2011, Accra, Ghana.

Kamar, K,A, M, Hamis, Z,A and Dzulkalnine, N (2012). Industrialised Building System (IBS) Construction: Measuring the perception of Contractors in Malaysia.

Kamar, K. A .M, Hamid, Z., Ghani, M. K., Egbu, C., And Arif, M. (2009). Towards Green And Sustainability through Industrialised Building Systems (IBS) In the Malaysian Construction Industry, Regional Conference On Environmental & Earth Resources (Rcer 09), 7th-8th December, Pahang, Malaysia.

Kamar, K. A. M., & H, A, Z.,(2009). IBS: The Critical Success Factors and Way Forward. 2nd CIDB.CREAM IBS Roundtable Workshop. Kuala Lumpur: CIDB

Mahbub, R. (2012). Readiness of a Developing Nation in Implementing Automation and Robotics Technologies in Construction: A Case Study of Malaysia. Civil Engineering and Architecture, USA Vol 6, Issue 7.

Navon, R. (1996). Teaching Automation as Part of the Construction Curriculum. Elsevier Automation in Construction.

Pan, W., Gibb, A.G. F., and Dainty, A. R. J. (2007). Perspectives of UK house builders on the use of offsite modern methods of construction. Construction Management and Economics, 25, 183–194.

Richard, R. B. (2005). Industrialised Building Systems: Reproduction Before Automation And Robotics, Automation In Construction, 14 (2005), 442– 451.

Shaari, S. N. and Ismail, E. (2003). “Promoting the use of the industrialised building systems (IBS) and modular coordination (MC) in the Malaysia construction industry.” Buletin Bulanan IJM Jurutera, Institute of Engineers, Malaysia, K.Lumpur, Malaysia, 14–16.

Slaughter, E. S. (1997). Chacteristic of Existing Construction Automation and ROBOTICS Technologies. Elsevier Automation in Construction.

Thanoon, W.A., Peng, L.W., Kadir, M.R.A., Jaafar, M.S. and Salit, M.S. (2003). “The experiences of Malaysia and other countries in IBS”, International Conference on IBS, 10-11 September, Kuala Lumpur, Malaysia.

Warszawski, A. (1985). Industrialised and Automated Building Systems. Technion-Israel Institute of Technology, E and FN Spoon.

EDUCATION AND LEARNING

CONSTRUCTION STUDIES IN HIGHER EDUCATION AND THE USE OF DIGITAL TECHNOLOGY

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The construction industry wants graduate employees skilled in relationship building and information technology and communications (ITC). Much of the relationship building at universities has evolved through technology. Government and the ITC industry fund lobby groups to influence both educational establishments and Government to incorporate more ITC in education – and ultimately into the construction industry. This influencing ignores the technoskeptics' concerns about student disengagement through excessive online distractions. Construction studies students (n=64) and lecturers (n=16) at a construction university were surveyed to discover the impact of the use and applications of ITC. Contrary to Government and industry technopositivism, construction students and lecturers preferred hard copy documents to online feedback for assignments and marking, more human interface and less technological substitution and to be on campus for lectures and face-to-face meetings rather than viewing on-screen. ITC also distracted users from tasks which, in the case of students, prevented the development of the concentration and deep thinking which a university education should deliver. The research findings are contrary to the promotions of Government, ITC industry and ITC departments and have implications for construction employers where a renewed focus on human communication should mean less stress, fewer delays and cost overruns.

Keywords: information technology, education, social networking, disengagement

INTRODUCTION

The construction industry is caught between the demands of innovative technologies and the business environment according to Becker, Jaselskis and McDermott (2011) who argue that Information Technology and Communications (ITC) is no longer just the domain of the ITC Department – rather that "All construction professionals … must consider themselves part of the IT department. The daily work of construction professionals is immersed by technology." (*ibid*: 7). Much of the ITC infrastructure in construction universities is absorbed by the informal applications (e.g. email, Facebook, Twitter etc.) which are distractions from academic pursuits. ITC is efficient for routine tasks and skimming information and data. Construction students, however, are required to develop non-routine higher-thinking skills including new literacies, problem solving and face-to-face collaboration. The construction industry believes such people-skills will deliver competitive advantage by reducing conflict

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Ancell D (2013) Construction studies in higher education and the use of digital technology *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 225-235.

and ultimately reducing costs. The challenge therefore is to ensure that the installed ITC meets the development of higher-thinking skills – and that the consumers of such ITC are using it as productively as intended when it was procured.

ITC CHALLENGES

Government-ITC industry influence

There are many influences in ITC procurement including United Kingdom (UK) Government funding of pro-ITC lobbying groups (e.g. Joint Information Service Committee (JISC) and the Higher Education Funding Council for England (HEFCE) which incorporates the Online Learning Task Force (OLTF: 2011)). In Europe there is the European Schoolnet (ES) – another multi-government sponsored technopositivist group of 31 European Ministries of Education specialising in researching ITC development in schools (Balanskat and Balmire, 2007). Njenga and Fourie (2010), promoting dialogue on ITC, examined the higher education e-learning myths espoused by "technopositivists" (*ibid*: 199) with their "compulsive enthusiasm" (*ibid*: 200). Their view is that the technopositivist ideology is "… being created, propagated and channelled repeatedly by the people who stand to gain either economically, socially, politically or otherwise in due disregard of the trade-offs associated with the technology to the target audience." (*ibid:* 200). This group undoubtedly includes the ITC companies and the ITC departments in higher education institutes (HEI's). Dissenting groups of "technoskeptics" have not been provided with Government-funded support.

According to JISC (2008) students welcome ITC fir flexibility over time and location of lectures and for access to class notes and electronic note-taking in lectures and for research (JISC, 2008: 13). This was challenged by Wood *et al* (2012) (using 145 participants to test multi-tasking ability) who found that "attempting to attend lectures and engage digital technologies for off-task activities can have a detrimental impact on learning" (*ibid*: 365). Similarly, the technopositivists' influences and assumptions have also been challenged by Convery (2009). Convery, in his interrogation of the literature espousing the benefits of ITC noted that "…the imperative to learn *about* technology has been allowed to become confused with learning *through* technology…. to establish the myth that computing is inherently beneficial in education." (*ibid*: 27). (This is illustrated by the universities' requirement for students to collaborate on-line to fulfil team-based assignments.) Rowlands *et al* (2008: 300) in their "virtual" longitudinal study to determine the impact of ICT on young students found that they also have a propensity to prefer entertainment to text (*ibid*: 299).

Technology acceptance (usefulness and ease of use)

The construction industry is becoming increasingly ITC-based. The technology acceptance model (TAM) explains the significance of users' perceptions of usefulness (potential enhancement of job performance) and ease of use (free of effort) in the acceptance of new ITC (Davis, 1989; Venkatesh, 2000). The perceived usefulness increases when an individual has focussed immersion and enjoys the interaction.

New literacies and skills are needed (not skim-reading)

However, new skills are needed to encourage self-directed learning which is accurate – and not just easy. These new skills, applied at speed, include the ability to challenge information during on-line reading. Rowlands *et al* (2008: 300) found that the favourable impact of ITC has been overestimated and that comfort with the

technology has meant reliance on search engines, viewing rather than reading and a lack of the ability to critique and analyse information. Visual methods of learning are becoming preferred to verbal. "Society is dumbing down." (*ibid*: 300) "…people exhibit a strong tendency towards shallow, horizontal, "flicking" behaviour in digital libraries." (*ibid*: 300). This has led to claims that students are not fully engaged in learning illustrated by the researched preference for "skimming" when academic sites are only briefly examined for perhaps one or two pages. Rowlands *et al* (2008) also noted that "…around 60% of e-journal users viewed no more than three pages and a majority (up to 65%) never return…" (*ibid*: 294). The frequent switching from one task to another also raises the challenge of how to manage the vast quantity of information now instantly available.

Head and Eisenberg (2010) examined how students (n=8,353) used and evaluated information in the digital age. Few respondents used Web 2.0 applications for collaboration on assignments often preferring instead to evaluate information using friends and/or family and instructors for academic work. The students' favoured researching strategies were driven by efficiency and predictability in order to manage the quantity of information available through digital sources. Lower order thinking skills (such as "…procedural memorized routines, techniques and rules for conducting research and finding information…" (*ibid*: 37) as well as higher order thinking skills ("…interpreting, synthesizing and creatively manipulating abstract concepts to generate new constructs, meanings, interpretations and knowledge...") (*ibid*: 37) are both necessary for information literacy and lifelong learning. The students in the sample considered themselves adept at lower order thinking skills in research but felt they were disadvantaged for applying the higher-order thinking skills (possibly because they felt swamped with the amount of digitally-available information). Rowlands *et al* (2008) also speculate that (based on previous research) social networking sites produced by the HEI may have only limited support – implying that students prefer social networking for social purposes only (*ibid*: 298).

ITC DISTRACTIONS

Easy attainment

Ferneley and Sobreperez (2006) discuss the different facets of user engagement where users can comply, workaround or resist – the latter being two means by which users can undermine the planned use of (expensive) ITC systems. Commercial tools such as Googlescholar which encroach on academic search domains (but which are easy) are also seen as a threat to the traditional institutions such as libraries (Rowlands *et al*, 2008: 296). "Young scholars are using tools that require little skill: they appear satisfied with a very simple or basic form of searching..." (Rowlands *et al* (2008: 297) supporting Davis' (1989) TAM theory).

Memory, multi-tasking and disengagement

ITC is designed to support and integrate multiple tasks. However, multitasking, interruptions and lack of concentration can all lead to disengagement from task as discovered by many researchers. Bennett *et al* (2008:779) found that "…multi tasking may not be as beneficial as it appears and can result in a loss of concentration and cognitive "overload" as the brain shifts between competing stimuli…". Rowlands *et al* (2008: 300) found that the impact of ICT has been overestimated and that comfort with the technology has meant reliance on search engines, horizontal "flicking" behaviour, skimming rather than reading – all resulting in lack of the "critical and

analytical skills to assess the information" (*ibid*: 290). "Society is dumbing down." (*ibid*: 300). Ophir, Nass and Wagner (2009) found that heavy media multi-taskers (n=49) had poor results when tested on task-switching ability possibly due to reduced ability to filter interference in tasks. Similarly Greenfield (2009) recognised that cognitive skills are changing to adapt to a background of interference from informal learning environments (television, video games, internet). She also decided that weaknesses were developing in higher-order cognitive processing skills (including problem solving, critical thinking and imagination) previously developed through stimulation from reading hard copy and listening to radio (*ibid*: 69). Nicholas, Rowlands, Clark and Williams (2011) also concluded that the Google Generation have poorer working memories.

Similarly, the impact of ITC on memory was the subject of four studies by Sparrow, Liu and Wegner (2011) which showed that "…when faced with difficult questions, people are primed to think about computers…" and instead of recalling the information they recall where to access it. In this way, the internet has become a form of "…external or transactive memory where information is stored collectively outside ourselves…". (*ibid*: 1) (this is also known as the "Google effect"). In a multi-tasking environment the opportunity for interruptions fractures the periods of reflection needed for thinking. By making it "easy" (i.e. dumbing down) for students with internet keyword searches and journal abstracts as substitutes for in-depth searching, reading and absorption, there is a possibility that students are not really participating in the learning experience. The continual distractions and interruptions available through ITC applications prevent brains from forging the neural connections that give depth to thinking thereby weakening memories and preventing joined-up thinking. Kirschner and Karpinski (2010) in their research (n=219) into the use of social-networking site Facebook and its relationship to academic performance found that students who admitted to being avid Facebook users had lower grades than non-users (also supported by Rosen, Carrier and Cheever, (2013) in their study of 263 students' on-task behaviours).

RESEARCH

The foregoing raises many beliefs surrounding the use of ITC in a construction faculty and whether it will prepare employees who can concentrate on task, collaborate and problem-solve. An attitudinal survey was compiled to test key findings from the literature. The applications choices comprised emails, podcasts, blogs, wiki, filesharing, Facebook, Twitter, YouTube, music, news streams (e.g. newspapers, BBC), iplayers (t.v. replays), Skype, Wikipedia, Excel, Word, Photoshop, AutoCad, Googlesearch, Wikipedia and "other". Following an investigatory pilot survey and subsequent amendments to the instructions and content, the one month availability of the on-line voluntary, anonymous Google-documents questionnaire was notified to 263 students and 33 lecturers in the same construction studies faculty in a UK construction university. The return rate was 24% (n=64) for students and 54% (n=18) for lecturers.

RESULTS

The students' sample comprised 50 males, 12 females and two transgenders with a mode of 20-25 years. The lecturers were 11 male and seven female with a mode of 46-55 years. While self-reporting surveys should be treated with caution, the results nonetheless support many of the findings of researchers examined in the literature search.

Ease of searching techniques

The non-academic search engines were preferred by 73% of students for academic research (vs 22% for lecturers) and only 32% of students agreed or strongly agreed that university search engines are easy to navigate.

Flexibility over lecture time and location

A clear majority of lecturers (89%) had a distinct preference for on-campus lecture delivery rather than off-campus delivery over the internet. Of student respondents, 75% claimed to attend all lectures and 22% "sometimes".

Skimming

As a test of in-depth document reading vs skimming 13% of students noted they only ever read the journal abstract 37% read the abstract and some of the journal pages, and 20% said they read the whole article.

Face-to-face vs on-screen contact

Table 1: preference for contact for feedback, marking and tutoring

Preference	Scale	Students receiving feedback %	Lecturers giving feedback %
I prefer face-to-face feedback for assignments	always	69	50
	sometimes	22	44
	never	9	6
I prefer to receive/read feedback on hard copy	always	76	78
	sometimes	19	22
	never	5	0
I prefer to receive/give feedback on screen	always	33	6
	sometimes	45	44
	never	22	50
I prefer marks returned/marking student assignments on-screen	always	33	0
	sometimes	45	33
	never	22	67
I want more time with lecturers and tutors	strongly agree	44	N/A
	agree	31	
	neither	20	
	disagree	3	
	strongly disagree	2	

Contrary to the exhortations of ITC departments and the ITC industry, the results above (Table 1) show a preference for human contact and hard copy feedback.

Most used functions

Table 2: top five most used and most popular functions

Usefulness	Students when studying %	Lecturers when working %
top five most used functions	98= email, Word 89 Youtube 86= Excel, music, Wikipedia 73= Facebook, news stream 70 iPlayer	100 email 89 Word 78= Excel, YouTube 72= iPlayer, music 67 news stream (e.g. BBC)
top five most popular open functions when studying/ working	81 email 80 Word 38 Excel 36 music 28 Facebook	89= email, Word 56 Excel 39 news streams (e.g. BBC) 28 other (e.g. Powerpoint) 17= Skype, Wikipedia
top five most popular open functions when **NOT** studying/working	86 email 55 Facebook 50 music 48 Word 44 YouTube	89 email 44 Word 28 news streams (e.g. BBC) 17= iplayer, Skype, Excel 11= Wikipedia, music, YouTube

Switching from task to task

Table 3: switching ease

Switching ease	Scale	Students %	Lecturers %
I find it easy to switch from one task to another when working on my ITC tasks	always	65	56
	sometimes	17	44
	never	18	0
		100	100

Distractions: source and frequency

Table 4: applications open and interruptions per hour

Open applications/ source of interruptions	Frequency of interruptions per hour	Students when studying %	Lecturers when working %
open applications when studying/working	0-2	47	39
	3-5	41	61
	6-8	7	0
	9-12	3	0
	12+	2	0
self-interruptions e.g. to initiate or answer emails/Facebook© per hour	0-2	58	89
	3-4	27	11
	5-6	9	0
	7-10	0	0
	11+	6	0
externally-generated interruptions by social media per hour	0-2	36	100
	3-4	23	0
	5-6	30	0
	7-10	3	0
	11+	8	0

Interruptions and impact on anticipated degree success

Table 5: self interruptions and anticipated degree classification

Students self-interruptions per hour e.g. to initiate or answer emails, Facebook, Twitter etc.		Anticipated degree classification				
		First	2:1	2:2	TOTAL	
	0-2	16	15	7	38	59%
	3-4	5	10	2	17	27%
	5-6	1	3	2	6	9%
	7-10	0	0	0	0	0
	11+	2	1	0	3	5%
	TOTAL	24	29	11	64	100%

DISCUSSION

The findings indicate that many ITC-installation decisions have not taken full account of users' behaviours. The finding that non-academic search engines were preferred to academic search engines confirmed Ferneley and Sobreperez (2006). In other words, the computerising of existing systems rather using than the "Google approach" to start afresh does not make university search engines easy or useful and if search engines are not perceived as useful or easy they will be unused – an example of waste. Student skimming of journals was also a concern with 50% only reading the abstract and possibly some additional pages. However, this fits with Rowlands *et al* (2008) who noted that 60% of users read no more than three pages of journals. Effectively, this means that one third of the students did not engage with the formal research base. The findings that lower order thinking skills are more frequent (Head and Eisenberg, 2010) would appear to support this result as well.

The finding of students' high attendance at lectures (totalling 97%) could be because students who participate in voluntary questionnaires are possibly more motivated generally and therefore more likely to care about their studies and attend classes (which may bias these results). The availability of on-line lectures was to give flexibility to the students and save space costs at the university – but the research findings would appear to undermine both ideals. The lecturers' preference for on-campus delivery rather than on-line lecturing also indicates a different need for physical space. Research (JISC, 2008:13) claimed flexibility over location was an important factor in student university choice and a justification for more ITC – but in

fact it would not appear to be a major factor in students choosing the university construction courses.

The option for face-to-face contact with hard copy feedback (Table 1) (rather than on-line, electronic feedback) showed to be a clear preference for students – which is unexpected in an age of instant communication. In fact, students actually wanted more face-to-face time with lecturers and tutors. The majority of lecturers (72%) preferred reading and marking student assignments on paper (rather than on-screen). This possibly implies that the more established methods of teaching are more comfortable which could be a generational issue within the lecturing community (mode age 46-56 years) or that lecturers feel more in control of their work if they can physically touch the paperwork. Importantly for the construction industry, more face-to-face interaction was preferred by students and lecturers (confirming Njenga and Fourie (2010: 209)).

The most useful application for both students and lecturers (Table 2) was email for respondents when not studying (students) or not working (lecturers) followed by more frivolous student applications (Facebook, music, Word, YouTube) and more serious applications for lecturers (Word, news streams, Excel, Wikipedia). What was noticeable however was the importance of Facebook for students (second most popular) compared to Word (which was second) for lecturers – which may also be indicative of maturity (lecturers being older and perhaps not as technically savvy) or that lecturers have more self-regulation than students with regard to open non-academic applications. This supports the views of Bennett *et al* (2008) of perceived usefulness increasing when individuals are immersed and enjoy the interaction. Students enjoy Facebook (but not academic search engines). Although Twitter was offered as an option it never featured in the top five most used applications which may indicate that students and lecturers were not as involved in social media as the technopositives propose.

The potential for distraction is obvious with students finding it easy to switch from task to task when working (Table 3) possibly because they need to do it more often and is therefore practised – or because they have fewer formal applications open than lecturers. Since students generally have more distractions and more applications open than lecturers they are more likely to be superficial skimmers rather than deep thinkers concentrating on a single task (Head and Eisenberg, 2010) and this could be one of the root causes of any student disengagement (Convery, 2009). Some students admitted to more than 12 applications open (Table 4) when studying and two admitted to 11+ self interruptions per hour which equates to one interruption approximately every five minutes. If (in the most extreme example) these same students are also those interrupted 11+ times/hour from external sources then they will be entertaining around 22 interruptions per hour i.e. approximately one every three minutes. This makes them time-poor students with insufficient productive time forcing them to skim websites to gather information for their studies. It also sets a pattern of bad work habits for when they become employees and has implications for future construction employers with their need for increasing productivity – and increased use of ITC. It would appear that students are not self-regulating when working because they have so many applications open. Frequent interruptions minimise concentration. In contrast, lecturers had far fewer applications open simultaneously and fewer interruptions (both self-generated and from external sources).

Finally, Table 5 connects the potential impact of the number of self-interruptions and anticipated degree classification. For those with higher levels of self interruption (11+) there is a certain level of optimism (two Firsts; one 2:1) which conflict with Ophir *et al* (2009). However, realistically, these respondents could have been indulging in some flippant behaviour. The 16 Firsts and the 15 2:1's anticipated by those with 0-2 interruptions per hour would indicate engagement and concentration and support Kirschner and Karpinski (2010) and Bennett *et al* (2008).

CONCLUSION

The findings challenge the relationship between Government and the ITC industry to employ more ITC in education for the supposed benefits of the students and educators. Not all ITC is beneficial. The technoskeptics who could have provided the challenge have inexplicably been excluded from the debate.

Students and lecturers value human interaction more than on-line connections as shown by a preference for attending class and face-to-face meetings. This contradicts much of the technopositivists' argument. Similarly, students' prefer technologies which are easy and require little deep thinking indicated by shallow searching on commercial search engines when studying and a disposition for viewing rather than reading and absorbing information. This will not prepare them for the world of construction employment. The acceptance of the new applications of ITC in general (Table 2) among students and lecturers was lower than might have been predicted implying that perhaps the level of ITC literacy and speed of adoption for both groups may not be as high as was assumed by the ITC Department. The reason for this could be economic (e.g. cost of devices in an economic recession) or lack of interest – or even, perversely, lack of time.

ITC also provides distractions – particularly for students. Flexible switching between tasks, multi-tasking on a wide spread of tasks while entertaining multiple interruptions and (more worryingly) lacking the concentration time needed to develop critical and analytical information skills have an effect on students' anticipated degree classification. Furthermore, the increased availability of ITC-supported leisure applications has an impact on the time available for student concentration, in-depth evaluation, output, engagement and self-regulation. In order to achieve the deeper thinking required in higher-level education and in the construction industry, students need to use ITC more selectively and to be aware of its powers of distraction. Similarly, lecturers need to be consulted on just which of the vast range of ITC tools available they will actually use.

The ITC industry will continue to upgrade its products which in turn will require ongoing spending from user departments in order to retain technical support. The push to integrate ITC further into construction education for diminishing returns is almost inevitable unless the technoskeptics' voices have equal volume to match the Government and ITC-industry funded technopositives' promotions. Unintentionally, construction university ITC may actually be contributing to the "dumbing down" of construction education – and ultimately the construction industry.

FURTHER RESEARCH

Greater validity to the results may be derived from a similar study in another institution. In addition, follow up research as to the final degree classification matched to the number of interruptions would also yield some interesting data.

REFERENCES

Balanskat, A., Balmire, R. (2007), ITC in schools: trends, innovations and issues in 2006-2007, European School network available from http://resources.eun.org/insight/ITC_%20in%20_schools_2006-7_final4.pdf accessed 20 February 2011

Becker, T., Jaselskis, E. and McDermott, C. (2011) *Implications of Construction Industry Trends on the Educational Requirements for Future Construction Professionals* in 47th ASC Annual International Conference Proceedings, Associated Schools of Construction available from http://ascpro.ascweb.org/chair/paper/CEGT329002011.pdf accessed on 3 April 2013

Bennett, S., Maton, K. and Kervin, L. (2008), *The "digital natives" debate: a critical review of the evidence*, British Journal of Educational Technology **39**(5) 775-786

Convery, A. (2009), *The pedagogy of the impressed: how teachers become victims of technological vision*, Teachers and Teaching **15**(1) 25-41

Davis, F. D. (1989), *Perceived usefulness, perceived ease of use, and user acceptance of information technology*, MIS Quarterly **13** (3) 319–340

Ferneley, E.H. and Sobreperez, P. (2006), *Resist, comply or workaround? An examination of different facets of user engagement with information systems*, European Journal of Information Systems **15** (345-356)

Greenfield, P. (2009), *Technology and informal education: what is taught, what is learned,* Science **323,** 5910 69-71

Head A. and Eisenberg, M. (2010) *Truth be told: how college students evaluate and use information in the digital age*, Project Information Literacy Progress Report, 1 November 2010 published by Information School, University of Washington available from http://projectinfolit.org/pdfs/PIL_Fall2010_Survey_FullReport1.pdf accessed 15 April 2012

Joint Information Systems Committee (JISC) (2008), *Exploring tangible benefits of e-learning: does investment yield interest?* Northumbria University, available from http://www.jisc.ac.uk/publications/briefingpapers/2008/bptangiblebenefitsv1.aspx accessed 01 April 2011

Kirschner, P. and Karpinski, A. (2010), *Facebook© academic performance*, Computers in Human Behavior, **26** 1237-1245

Nicholas, D., Rowlands, I., Clark, D. and Williams, P. (2011), *Google Generation II: web behaviour experiments with the BBC*, Aslib Proceedings, New Information Perspectives **63**(1)

Njenga, J.K. and Fourie, L.C.H. (2010), *The myths about e-learning in higher education*, British Journal of Educational Technology, **41**(2)199-212

On Line Learning Task Force (OLTF) (2011), *Collaborate to compete: seizing the opportunity of online learning for UK higher education*, available from http://www.hefce.ac.uk/pubs/year/2011/201101/name,63891,en.html accessed 27 April 2012

Ophir, E., Nass, C. and Wagner, A. (2009) *Cognitive control in media multi-taskers*, Proceedings of the National Academy of Sciences of the United States of America, **106**(37), 15583-15587

Rosen, L. D., Carrier, L. Mark, Cheever, N.A. (2013), *Facebook and texting made me do it: media-induced task switching while studying*, Computers in Human Behavior **29** 948-958

Rowlands, I., Nicholas, D., Williams, P., Huntington, P., Fieldhouse, M., Gunter, B., Withey, R., Jamali, H., Dobrowlski, T. and Tenopir, C. (2008), *The Google generation: the information behaviour of the researcher of the future,* Aslib Proceedings: New Information perspectives **60**(4) 290-310

Sparrow, B., Liu, J. and Wegner, D. (2011), *Google effects on memory; cognitive consequences of having information at our fingertips*, Science **333** issue 6043

Venkatesh, V. (2000), *Determinants of perceived ease of use: integrating control, intrinsic motivation and emotion into the technology acceptance model,* Information Systems Research, **11**(4) 342-366

Wood, E., Zivcakova, L., Gentile, P., Archer, K., de Pasquale, D. and Nosko, A. (2012), *Examining the impact of off-task multi-tasking with technology on real-time classroom learning,* Computers & Education, **58** 365-374

DO EDUCATIONAL MISMATCHES INFLUENCE JOB SATISFACTION? THE CASE OF SPANISH BUILDING ENGINEERING GRADUATES WORKING AS SITE MANAGERS

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It is important that higher education provide students with competences that enable them to maintain their employability in the professional environment. On the other hand, research has confirmed the existence of a positive relationship between education and job satisfaction by means of wages. Education-job mismatches are also reported to have serious effects on a number of labour market outcomes. But the consequences of educational mismatches (overeducation and undereducation) on employees working as construction site managers and the defects of their higher education have not been explored yet. This paper presents an exploratory study which seeks to examine the educational mismatch experienced by building engineers working as site managers, and analyses the relationship with job satisfaction. Using an interpretive approach within the qualitative paradigm, semi-structured in-depth interviews were carried out with a total of 34 Spanish building engineers. All were asked about their higher education and about their first professional experiences managing construction sites. More than half of participants confirm that the perceived negative educational mismatch (undereducation) has a negative influence in their job satisfaction, while the rest declare there is no effect. Undereducation also generates additional negative effects such as insecurity, uncertainty, embarrassment, frustration, work overload and waste of time. In order to overcome this situation, these professionals have developed different strategies such as delegating tasks, subcontracting and participating in training courses. Early conclusions are that educational mismatches due to undereducation are an important cause of job dissatisfaction for graduates in Building Engineering. Consequently, they may negatively impact construction companies through productivity decreases of these employees.

Keywords: building engineering, educational mismatch, job satisfaction, site manager, qualitative research

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Fuentes-del-Burgo J and Navarro-Astor E (2013) Do educational mismatches influence job satisfaction? *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 237-247.

INTRODUCTION

During the last decades research on education-job mismatch has grown to a considerable size (Kucel and Vilalta-Bufí 2012), focusing its attention on developed countries (Allen and van der Velden 2001, Kucel and Vilalta-Bufí 2011, Mavromaras and McGuinness 2007). Evidence has shown that education-job mismatch is a common phenomenon in different countries (Allen and van der Velden 2001) and that it causes undesirable effects in the labor market (Kucel and Vilalta-Bufí 2012).

Through education, individuals acquire knowledge, aptitudes and skills, and may therefore increase their productive capacity, with monetary returns (Allen and van der Velden 2001). In fact, there is a relationship between education and earnings that has become a fundamental tool in the research on monetary returns such as wages and income (Allen and van der Velden 2001; Verhaest and Omey 2006).

A literature review reveals a number of recently published studies in Spain focused on the relationship between the education-job mismatch and job satisfaction (Badillo Amador *et al.* 2012; Fabra and Camisón 2009; Kucel and Vilalta-Bufí 2013; Peiró *et al.* 2010). The study by Mora *et al.* (2007), centered on job satisfaction among young European higher education graduates, has highlighted that Engineering graduates (in general) tend to be more satisfied in their jobs than graduates in Humanities, Social Sciences, and Law.

In Spain, in the labour market for the construction industry, the Law 38/1999 of "Ordenación de la Edificación" (Town planning and development Act, Boletín Oficial del Estado 1999), stipulates contractor's responsibilities among which the appointment of the "jefe de obra" (site manager). This professional takes charge of the technical representation of the contractor on site and, due to his/her educational degree level or site trade experience, must have the necessary training according to the characteristics and complexity of the construction project. This implies that depending on the judgement of the contractor, Spanish site managers will have different educational backgrounds.

No official statistics informing on the qualifications of Spanish site managers have been found in the literature review. However, according to Portales (2007, p. 8) "building engineers are the most demanded professionals for working as site managers" and Spanish site managers have a high level of University training (Asociación Española para la Calidad 2007, p.42). In other words, there has been a positive evolution in the training of Spanish site managers and, nowadays, most of them have a graduate background in Building Engineering.

In relation to the Spanish term "jefe de obra", it might be considered synonymous with that of the site manager used in the UK and construction project manager used in Australia (Haynes and Love 2004).

This paper aims at clarifying the role of educational factors in explaining job satisfaction for building engineers working as site managers. Specific objectives are to explore the educational mismatch experienced by them, to analyse its relationship with job satisfaction and to describe the strategies used by building engineers to face it. The research has been carried out in the Autonomous Community of Castilla-La Mancha, using a qualitative methodology with semi-structured interviews that took place between July 2010 and May 2011.

VARIABLES OF STUDY

The study of job satisfaction has been approached from manifold viewpoints, which have enriched its definition with different nuances. Thus, some authors state that there is not a universal and agreed-upon definition as such for the term (Navarro-Astor *et al.* 2010). Here we use Locke's definition: it is the result of a subjective evaluation of the existing discrepancy between what people want from their job and what they perceive they get from it (cited by Kucel and Vilalta-Bufí 2013, p. 1).

Although there exists a variety of factors affecting job satisfaction (Pajo *et al.* 2010), which implies that it can be examined from different viewpoints by using different categories (Schmidt 2007), in this research only education-job mismatch will be considered with a one-dimensional approach to job satisfaction.

In relation to the second variable of study, educational mismatch, "a plethora of definitions and conceptualisations have been developed, with a lack of consistency in the terminology used. As a result, terms such as "overeducation", "overqualification", "underutilisation" and "underemployment" are used variably and interchangeably" (Scurry and Blenkinsopp 2011, p. 644). Educational mismatch may refer both to over- and undereducation (Verhaest and Omey 2006). Workers are overeducated if the skills they bring to their jobs exceed the skills required for that job (Groot and van den Brink 2000) or when their formal qualification is higher than that required for carrying out the job (Peiró *et al.* 2010). Symmetrically, an individual working in a job where the required level of education is higher than his actual education is defined as undereducated (Mavromaras and McGuinness 2007).

Allen and van der Velden (2001) are of the opinion that the terms educational mismatch and skill mismatch are connected, since the first implies the second. Education-labor mismatch refers to the level of discord between the job performed by an individual and his/her education and skills (Kucel and Vilalta-Bufí, 2012). Furthermore, other authors use another related term, "competence mismatches" (Badillo *et al.* 2008). The level of professional competence is determined by the abilities, skills, attitudes and knowledge possessed by workers, which may be lower or higher than those required in their jobs. When this happens, there is a competence mismatch in the job-worker pairing.

In this research, since interviewees did not differentiate between educational, skill or competence mismatches, we use the general term education-job mismatch.

Research has shown contradictory results regarding the relationship between education and job satisfaction. Some have found both positive or negative links (Kucel and Vilalta-Bufí 2011), others indicate that the link is not conclusive (Albert and Davia 2005), that "results are ambiguous in most cases" (Mavromaras and Mc Guinness 2007, p. 281) or outline the existence of mixed results (Kampelmann and Rycx 2012).

RESEARCH APPROACH

The sample is composed of 34 building engineers, who were recruited through snowball sampling. Interviews have an average duration of 60 minutes.

Participants were 27 males and 7 females, within a 23-63 age span. 15% of respondents were under 29 years of age, 23% between 30 and 33, 47% between 34 and 37, 12% between 38 and 40 and 3% were over 60. As regards their occupation 9% were working as liberal professionals in construction project management teams, 6%

had their own construction company, and 85% were working as site/construction project managers or as team directors. The provinces where they were working at the time were Cuenca (53%), Albacete (26%), Ciudad Real (12%), Toledo (6%), and Guadalajara (3%).

In terms of educational background all of them had a degree in Building Engineering, but had studied in various universities: 67% in Universidad de Castilla-La Mancha, 12% in Universitat Politècnica de Valencia, 12% in Universidad Politécnica de Madrid, 6% in Burgos and 3% in Granada. As regards professional experience as site managers, 21% had less than 3 years, 26% from 3 to 5, 35% from 5 to 10, 15% from 10 to 16 and 3% more than 25 years of experience. For identification throughout transcriptions, participants are assigned a number.

Due to the qualitative nature of this research, we decided to use the method of worker self-assessment (Hartog 2000) in an indirect way, by asking participants to describe whether, compared to their education in Building Engineering, a higher, a lower or a different education was needed for carrying out their job. They were also asked to identify the strategies followed in order to solve potential education-job mismatches and to think about the consequences of these gaps on their job satisfaction.

Interviews were recorded and transcribed. The ATLAS-ti software programme was used for the analysis of the transcribed material. The exploratory analysis allowed the finding of regularities, which in turn made easier the generation of codes and categories. Relations between data and categories have been established by means of an interpretative analysis, trying to describe the phenomena studied, with the aim of developing a future theoretical model (Charmaz 2006).

RESEARCH FINDINGS

Identifying the educational-job mismatch

Few participants declare that the Building Engineering degree had properly trained them for carrying out the duties of the construction manager. The majority report that education had been partial or that it had not been useful. University studies do not seem to prepare building engineers to play the role of the site manager right after their degree. For some this is not a gap, they believe that universities cannot meet this employability demand. "*The Technical School offers you general training and you, listening to professionals on site, they are the ones who teach you, especially if you have little experience*" (Nº 33).

According to participants, undereducation was found in the following topics: business management, labour management, financial management, construction management, construction process development and site planning and organization. Some of these results accord with Smallwood and Emuze (2012) who concluded that in South Africa diplomats and graduates skills in planning and organizing should be improved. More than half of the interviewees also mentioned having little skills regarding the use and application of computer tools, and as a consequence felt under-skilled. *"I wish they had taught us, because we did not work at all with the tools that we used afterwards at work*" (Nº 17).

Considering the study programmes published in the web pages of the Universities where participants had studied, we have carried out an analysis of the credit distribution assigned to different basic subjects established in the White Book of Building Engineering Degree (ANECA 2004). Results are shown in Table 1. Indeed, it clearly illustrates that the percentage of credits assigned to subjects related to

Construction Management is below that assigned to Scientific Fundamentals and Graphic Expression.

Marzo-Navarro *et al*. (2008) in their research about competencies of Spanish graduates, concluded that university education shows weak points regarding scarce practical training and a lack of basic professional knowledge and capacities. Building engineers working as site managers would agree with this result, since they ask for an increase in practical training on site and for providing a more applied content to most subjects. Even though they have in mind the fact that the degree also entitles them to develop different professional careers.

Confronting the educational-job mismatch

When talking about strategies or actions followed to solve the perceived lack of knowledge, skill or competence at work, many participants used the following expressions: “sort myself out”, “do anything”, “find the way”, “make it through”, “do what you have to do”. These words involve a mixture of actions, strategies or, at times, shortcuts to solve the problems and succeed when facing difficult situations. Respondents described these behaviors as a positive trait of the building engineer linked to a good decisive capacity and to life-long learning skills.

Table 1: % credit distribution in Building Engineering degrees in different Spanish Universities (Source: Personal compilation)

Topic	Subjects	UCLM[1]	UPM[2]	UPV[3]	UGR[4]	UBU[5]	Mean
Scientific Fundamentals	Mathematics; Physics	10.0%	9.9%	12.0%	15.4%	15.0%	12.5%
Graphic Expression	Descriptive geometry; Graphic Expression Topography	12.3%	16.5%	15.3%	18.5%	18.0%	16.1%
Building Techniques & Technologies	Materials; Construction; Pathology; Site equipment; Construction History	26.4%	26.9%	27.3%	24.6%	26.0%	26.3%
Building structures & facilities	Structures; Facilities	11.7%	11.5%	12.0%	10.3%	13.0%	11.7%
Process Management	Safety & risk prevention; Quality; Organization, planning & control	5.9%	8.2%	9.0%	5.1%	5.0%	6.7%
Applied Law & Economics	Applied Economics; Measurements; Legal aspects; Valuation	8.8%	8.2%	9.7%	11.3%	11.0%	9.8%
Optional		19.2%	13.2%	10.7%	8.2%	4.0%	11.1%
Technical projects and Final Undergraduate Project	Technical projects; Final Undergraduate Project	5.8%	5.5%	4.0%	6.6%	8.0%	6.0%

[1] Universidad de Castilla-La Mancha; [2]Universidad Politécnica de Madrid; [3]Universidad Politécnica de Valencia; [4]Universidad de Granada; [5]Universidad de Burgos.

The strategies pointed out can be grouped in the following categories: use of internet, asking colleagues and/or friends, bibliography research, queries to material suppliers or subcontractors, gaining experience on site, training, studying notes, asking the professional association of building engineers and subcontracting. As site manager Nº 21 recalls, many participants face their lack of preparation for the practical aspects of

work on site by carrying out a mixture of actions: *"Trying to talk to colleagues, reading documentation, books, internet, nowadays any of these".*

Internet has become a fundamental source for sorting out educational mismatches and for fulfilling the lack of information and vagueness of architectural projects. Through its use, construction managers can have fast access to technical and commercial information, improving and making the task of document and record management much easier. As interviewee Nº 8 explains: *"It makes your life happier"*, or according to another: *"Internet which is a very useful tool, it has everything in it, lately I've been using it, you look it up in the internet and you find anything*" (Nº 10).

Not many interviewees refer to the hours invested in filtering the information obtained from internet search engines, or in checking its veracity or applicability. But for some, time devoted to research implies a productivity decrease or a waste of time: *"In the process of searching information many hours go by*" (Nº17). According to their opinions, having a source of information seems to be more important than side effects derived from processing, filtering and corroborating it.

Looking for advice from colleagues and friends is the second most quoted strategy and it is clearly related to the social capital of the building engineer. Participants accord a high value to this resource, as well as Spanish architects do (Navarro-Astor and Caven 2012). Colleagues can be workmates from the same company or not, and friends are usually classmates from University.

Advice required by site managers might be related to doubts due to the lack of information in projects or to technical or bureaucratic problems raised during project execution. Other matters have to do with information regarding subcontractors, material manufacturers or construction systems. Finally, they also need to have an initial guide where they can look for information. Promptness of the reply to the enquiry is the fundamental aspect of this resource.

Spanish Building Engineering university degrees authorize graduates to the professional practice of building engineering. Therefore, subjects' programmes aim to provide a general knowledge. On the other hand, construction projects tend to be innovative and learning generated by on site problem solving remains with the individuals and the tasks concerned (Winch 2010). It can be argued then that when building engineers ask colleagues for help in problem solving, an informal knowledge transfer actually takes place (Raidén *et al.* 2009).

None of the Spanish participants come from a site trade background and yet, they are managing construction sites. It seems natural then that site work experience is considered another essential element for overcoming the lack of practical preparation. They use words such as determination, self-improvement, progressing, learning, studying, asking, taking in, gathering information or being trained in their daily working routines as site managers. They refer to the time and effort devoted to develop professionally. In fact, the less professional experience they have, the more education-job mismatches they perceive. When engineers enter the labour market, right after graduation, they experience more education-job mismatches: *"When you start working you have no idea about anything, at the end you have to study everything and well,.., at times you make mistakes, you get it right, you learn from errors*" (Nº 10). These words accord with the argument that "mismatches are temporary phenomena that appear at the start of a career and typically become less frequent with age and labour market experience" (Mavromaras and McGuinnes 2007, p. 281).

These temporary mismatches could be cut down if construction companies used mentorship programs with new graduates. These programs consist of pairing new employees with senior staff on similar career paths, for providing professional guidance and for checking appropriate on-the job training (Loosemore *et al.* 2003). Furthermore, mentors facilitate knowledge transfer of job specific skills (Raidén *et al.* 2009; Winch 2010), and of values, beliefs and ways of working (Fellows *et al.* 2002).

Regarding training, respondents participate in courses, study from books and notes and browse the web looking for useful information. The common theme in all their responses is the effort, the cost when paying for courses, the additional work and the waste of productive time involved. Apart from the perceived lack of preparation during their undergraduate studies, continuous technological improvements in the construction industry and their will to develop professionally, have also pressed them to follow this course of action.

When referring to all these strategies, some building engineers use words reflecting a high level of individualism and a search for life-long learning. After all, the process of studying and integrating new concepts is an individual and internal process, which belongs to each person: *"Doing training on my account, being self-sufficient and self-taught… When I´ve had an education gap I´ve trained myself and I´ve looked for training in that matter" (Nº 24).*

At times, when participants admit being ignorant, not being trained enough for the matter, not having time for training, a lack of necessary computer tools or a mixture of all these, the fastest alternative to solve the education-job mismatch is subcontracting: "*It is not worth it. How much are they going to charge me for making the calculations or for recalculating the framework? 200€? How long will it take to do it myself? 3 days? It isn´t interesting for the company, it does not interest anyone" (Nº 1).*

In any case, the perceived mismatch, regarding both knowledge and skills, implies a waste of time, work overload and/or a decrease in the performance of the engineer. This research confirms other authors´ results showing that a lack of preparation negatively influences site managers´ performance (Kucel and Vilalta-Bufí 2012).

Effects of educational-job mismatch on job satisfaction

For around one third of the interviewees these mismatches do not influence their job satisfaction. Because they consider that university offers general training, not specifically applied to the professional role of the site manager, educational gaps do not affect them. It is a question of what they expect from the undergraduate curriculum and what they get.

But more than half of the participants report that their job satisfaction is negatively affected: *"Mismatches affect badly,… not being well trained you have to invest in more education in order to balance out*" (Nº 8). This result accords with previous researches (Allen and de Weert 2007; Kucel and Vilalta-Bufí 2012).

This negative consequence is increased when graduate site managers have to give commands and supervise the work of experienced construction workers with site trade background. The situation implies that the building engineer does not know whether the task is being executed well enough, how it must be done or even if the final result is correct. At times, feeling ashamed, they try to hide their lack of knowledge when talking to either subordinates on site or to subcontractors: "*In some matters you are completely lost, and all you do is pretending. In front of the subcontractor you try not to show that you don´t know a thing"* (Nº 22).

Ignoring how to apply knowledge acquired at undergraduate education was an important motive for dissatisfaction, due to the lack of preparation for the practical aspects of construction works execution. *"You´ve studied a university degree, but when you get to the site you feel that you don´t know anything… But at the technical school they don´t explain many basic things, basic such as "you have to place the terrazzo, place the skirting board and then spread the plaster"… nobody tells you the basic ideas that could help when entering a site, you feel completely lost" (Nº 31).*

Now and then, respondents used the metaphor of being "thrown in the deep end" when describing their transition into industry. Lack of knowledge becomes overwhelming and causes traumatic experiences such as the one described by a female participant when recalling her first job as site manager: *"In those days my heart really sank, because I said to myself: "Oh my God! I´ve been studying for 8 years and now I am not going to apply anything because, honestly, this is really unsatisfactory and disappointing. On site I felt like being punched up from all directions, the truth is I had no clue where the blows might come from"* (Nº 30).

Other negative effects can be inferred from the following expressions: "*feeling like an ignorant*" (Nº 4), "*frustration*" (Nº 31), "*seeing oneself as inexperienced*" (Nº 12), "*uncertainty*" (Nº 5), "*feeling completely useless*" (Nº 17), "*being lost*" (Nº 5, Nº 31), "*feeling uncomfortable*" (Nº 32) or "*finding one self out of the game*" (Nº 32).

Additionally, some respondents point out that when having the adequate education for carrying out the required tasks, they feel both job satisfaction (Badillo *et al.* 2008) and personal satisfaction. Furthermore they feel confident about how to do things correctly, being a positive feeling that could be transmitted to subordinates, colleagues and company leaders.

Finally, in disagreement with previous results (Allen and van der Velden 2001), overeducation of building engineers does not negatively affect their job satisfaction. As an example, for a participant "*education is never in excess*" (Nº 7).

CONCLUSIONS

Despite the limited size of the sample and qualitative approach applied to the research, this study confirms the existence of educational-job mismatches in building engineering, in relevant subjects for the work of the site manager such as site planning and organization, construction methods and financial management. These may be due to the difficulty of transferring the real construction site environment to university classrooms. Nevertheless, the curriculum of Building Engineering degree programmes deserves to assign more credits to subjects related to construction management.

The implication for curriculum development is twofold. On the one hand, practical stages in construction companies during the last years of the undergraduate program are encouraged. On the other, knowledge and skills should be taught with more application to daily practices on site, following the procedures and using the computer tools commonly used by construction companies.

In accord with results from previous researches, more than half of participants identify a negative link between undereducation and job satisfaction. Nonetheless, a few point out that overeducation does not affect them negatively. On the contrary, they feel more confident, more productive and competent at work.

Furthermore, undereducation generates additional negative consequences such as insecurity, uncertainty, embarrassment, frustration, work overload and waste of time;

negatively affecting the productivity of building engineers. In order to confront this situation, these professionals have developed different strategies such as delegating tasks, subcontracting, making use of their social capital and practicing their life-long learning skills by further studying and/or participating in training courses.

One of the limitations of this work is that it has not compared participants' responses with the curriculum of each of the Building Engineering degree programmes under study. The number of universities involved, several study programme changes occurred over the past twenty years as well as differences in subject approach, length and requirements, due not only to teachers' view but also to the number of credits assigned, are some of the reasons for this limitation. This raises a research question of interest for future works.

REFERENCES

Albert, C and Davia, M A (2005) Education, wages and job satisfaction. *In:EPUNET-2005 Conference,*Essex. University of Essex, Vol. 1-34.

Allen, J and van der Velden, R (2001) Educational mismatches versus skill mismatches: effects on wages, job satisfaction, and on-the-job search. *Oxford Economic Papers* 3), 434-452.

ANECA (2004) "Libro blanco del título de grado en Ingeniería de Edificación". Agencia Nacional de Evaluación de la Calidad y Acreditación (ANECA).

Asociación Española para la Calidad (2007) "Claves de la construcción española para el siglo XXI". Madrid: Cyan, Proyectos y Producciones Editoriales.

Badillo Amador, L, López Nicolás, A and Vila, L E (2012) The consequences on job satisfaction of job-worker educational and skill mismatches in the Spanish labour market: A panel analysis. *Applied Economics Letters* 19(4), 319-324.

Badillo, L, López Nicolás, A, and Vila, L E (2008) Education and competence mismatches: job satisfaction consequences for workers. *In:XVI Jornadas ASEPUMA - IV Encuentro Internacional de Profesores Universitarios de Matemáticas para la Economía y la Empresa,*Cartagena (España). Asociación Española de Profesores Universitarios de Matemáticas para la Economía y la Empresa, Vol. 1-12.

Boletín Oficial del Estado (1999) Ley 38/1999, de 5 de noviembre, de Ordenación de la Edificación. 38925-38934.

Charmaz, K (2006) "Constructing Grounded Theory. A practical guide through qualitative analysis". London: SAGE.

Fabra, M E and Camisón, C (2009) Direct and indirect effects of education on job satisfaction: A structural equation model for the Spanish case. *Economics of Education Review* 28(5), 600-610.

Fellows, R F, Langford, D, Newcombe, R and Urry, S (2002) "Construction management in practice". Oxford: Blackwell Science Ltd.

Groot, W and van den Brink, H M (2000) Overeducation in the labor market: a meta-analysis. *Economics of Education Review* 19), 149-158.

Hartog, J (2000) Over-education and earnings: Where are we, where should we go? *Economics of Education Review* 19), 131-147.

Haynes, N S and Love, P E D (2004) Psychological adjustment and coping among construction proyect managers. *Construction Management and Economics* 22(2), 129-140.

Kampelmann, S and Rycx, F (2012) The impact of educational mismatch on firm productivity: Evidence from linked panel data. *Economics of Education Review* 31(6), 918-931.

Kucel, A and Vilalta-Bufí, M (2011) Graduate job satisfaction: comparing Spain, the Netherlands and Norway. *In:*Essex. Universtity of Essex, Vol. 1-36.

Kucel, A and Vilalta-Bufí, M (2012) Graduate labor mismatch in Poland. *Polish Sociological Review* 3(179), 413-429.

Kucel, A and Vilalta-Bufí, M (2013) Job satisfaction of university graduates. *Revista de Economía Aplicada* 3(179), 1-27.

Loosemore, M, Dainty, A and Lingard, H (2003) "Human resource management in construction projects. Strategic and operational approaches". London: Spon Press.

Marzo-Navarro, M, Pedraja-Iglesias, M and Rivera-Torres, P (2008) Determinants of the satisfaction of firms with the competencies of university students: a Spanish case study. *International Journal of Training and Development* 12(4), 282-292.

Mavromaras, K and McGuinness, S (2007) Education and skill mismatches in the labour market: Editors' Introduction. *The Australian Economic Review* 40(3), 279-285.

Mora, J G, García-Aracil, A and Vila, L E (2007) Job satisfaction among young European higher education graduates. *Higher Education* 53), 29-59.

Navarro-Astor, E and Caven, V (2012) The professional career of Spanish Arquitects: Obstacles and facilitators. *In:2nd International Conference on Construction and Building Research, 14-16th Nov.,*Valencia, Spain. ETSI, Universitat Politècnica de València, Vol.

Navarro-Astor, E, Llinares, C and Montañana, A (2010) Factores de satisfacción laboral evocados por los profesionales de la construcción en la Comunidad Valenciana (España). *Revista de la Construccion* 9(1), 4-16.

Pajo, K, Coetzer, A and Guenole, N (2010) Formal development opportunities and withdrawal behaviors by employees in Small and Medium-Sized Enterprises. *Journal of Small business Management* 48(3), 281-301.

Peiró, J M, Agut, S and Grau, R (2010) The relationship between overeducation and job satisfaction among young Spanish workers: The role of salary, contract of employment, and work experience. *Journal of Applied Social Psychology* 40(3), 666-689.

Portales, A (2007) "El oficio de jefe de obra: las bases de su correcto ejercicio". Barcelona: Ediciones Universidad Politécnica de Cataluña.

Raidén, A, Dainty, A and Neale, R (2009) "Employee resourcing in the construction industry. Strategic considerations and operational practice". Oxon: Spon Press.

Schmidt, S W (2007) The relationship beween satisfaction with workplace training and overall job satisfaction. *Human Resource Development International* 18(4), 481-498.

Scurry, T and Blenkinsopp, J (2011) Under-employment among recent graduates: a review of the literature. *Personnel Review* 40(5), 643-659.

Smallwood, J and Emuze, F A (2012) The integration of diplomats and graduates into the construction industry: A pilot South African study. *In:*Smith, S. D. (Ed.), *Procs 28th Annual ARCOM Conference,*Edinburgh, UK. Association of Researchers in Construction Management, Vol. 1, 189-199.

Verhaest, D and Omey, E (2006) The impact of overeducation and its measurement. *Social Indicators Researchs* 77), 419-448.

Winch, G M (2010) "Managing construction projects". West Sussex: Wiley-Blackwell.

ASSESSING LEARNING AND TEACHING STRATEGIES OF A POST-GRADUATE CAPSTONE COURSE: STUDENTS' PERSPECTIVE

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Quality enhancement and quality assurance are the means by which higher education institutions are monitoring to ensure the standards are maintained worldwide. The views of students are in integral component in this process: as such extensive studies have been conducted in this regard. The students' perspective, over a three year span (2010 to 2012), on the design and delivery of a post-graduate capstone course that has undergone a recent restructuring is presented in this paper. The research utilised an anonymously e-assessed questionnaire: thirteen (13) closed-ended and two (2) open-ended questions. The instrument was administered a week after the delivery of the course. The results indicate a generally significant positive reception to the learning and teaching strategies employed. However, the negative feedback also indicates the level of dissatisfaction and lack of understanding of the intentions of the course structure. The research can be used to guide others engaged in the development of capstone courses to ensure quality is achieved from the perspective of the key stakeholder - the students.

Keywords: quality, education, capstone course, e-assessment, student perception, accreditation.

INTRODUCTION

Quality enhancement and quality assurance are the means by which higher education institutions are monitoring to ensure the standards are maintained worldwide (Harvey 2001; Jones 2003; Lomas 2007; Blackmore 2009). The views of students are an integral component in this process; as such, extensive studies have been conducted in this regard (Harvey 2001; Edström 2008; Denson et al 2010; Fluckiger et al 2010; Yueh et al 2012).

The Quality Assurance Agency for Higher Education (HE) is the body responsible for safeguarding the standards of UK higher education and also assists universities and other providers improve the quality of the learning experience (QAA 2012). The Institution of Civil Engineers (ICE) along with three other professional engineering institutes have joined together to form the Joint Board of Moderators (JBM) with the intention of strengthening the links between HEI and industry (JBM 2009). One such thrust would include a merger between the QAA and the JBM to establish guidelines

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Ellis L, Petersen A and Lewis T (2013) Assessing learning and teaching strategies of a post-graduate capstone course: students' perspective *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 249-258.

for checking output standards of degree programs (JBM 2010). The JBM adopted the QAA's "Framework for Higher Education Qualifications in England, Wales and Northern Ireland" (QAA 2009).

The Department of Civil & Environmental Engineering at the University of the West Indies (UWI), St Augustine Campus, Trinidad & Tobago has a long standing relationship with the JBM in accrediting its degree programs at the undergraduate and postgraduate levels. Based on a previous visit to the University, the department was asked to revise its programs to maintain its accreditation. Concurrently, a new Strategic Plan 2007-2012 was put forward by the Vice Chancellor of the UWI that required a number of desired attributes to be developed in the graduates (UWI 2007). These recent events led to the restructuring process to redesign the learning outcomes for its MSc programs of the Department as follows:

- Lead and work within teams to identify and solve technical, business, social, cultural and ethical issues in Civil Engineering both systematically and creatively, make sound judgments in the absence of complete data, and communicate their conclusions clearly to specialist and non-specialist audiences;
- Demonstrate self-direction, critical thinking and originality in tackling and solving problems, and act autonomously in planning and implementing tasks using Information Technology.
- Continue to advance their knowledge and understanding, and to develop their new skills to a higher level. Candidates will have the competencies, qualities and transferable skills necessary for employment requiring: the exercise of initiative and personal responsibility; decision-making in complex and unpredictable situations; and the independent learning ability required for continuing professional development as a practicing Civil Engineer.

The program learning outcomes were weaved in to the courses of the various programs. This study focuses on a capstone course known as COEM 6025 - Practical Team Project, hereafter referred to as the Course, with specific learning outcomes to:

- Lead and work within teams.
- Identify technical, business, social, cultural, and ethical issues for a given Project.
- Solve technical, business, social, cultural, and ethical issues for a given Project both systematically and creatively, make sound judgments in the absence of complete data.
- Communicate conclusions clearly to specialist and non-specialist audiences.

Teaching & Learning Strategies

To measure the fore-mentioned learning outcomes industry techniques were introduced as best practice into the Course developing five (5) innovative forms of assessment: a bespoke 360-degree feedback questionnaire; Zero Tolerance; Institution of Civil Engineers (ICE) Development Objectives (D.O.); an Interview and a Written test (Essay) based on the Professional Review stage of the ICE (Ellis et al. 2011; Ellis & Petersen 2011).

The teaching and learning strategy involved the students being placed in teams of five members with each student role playing as leader for a weekly objective based on the nine Knowledge Areas of the Project Management Body of Knowledge (PMI 2008). Each student was given an opportunity to lead their team twice throughout the

semester based on rotation of the roles of leader and team player. The teams were assigned a client: an industry liaison or a staff member with industry experience. The projects were hypothetical "real world" scenarios that required the students to address learning outcomes 2 and 3 to produce a Project Plan. A marking criteria and rubric was created for each form of assessment that allowed for quality control throughout the process and to reduce the level of subjectivity in the evaluation. The interview session was conducted by a pair of panellist that assigned the Essay question to each student individually based on their contribution to the Project Plan and their personal ICE Development Objectives.

The Course was delivered in the final semester over the 15 week duration. The first week was used to introduce the students and assisting industry liaison, role playing as clients on the project, to the teaching and learning strategies of the course. The following ten weeks had weekly assessment conducted based on the bespoke 360-Degree Feedback (learning outcome 1) and Zero Tolerance (learning outcomes 2 & 3). The ICE Development Objectives (Learning outcomes 2 & 3) were submitted on week 13, while the remaining forms of assessment, Interview and Essay (learning outcome 4) were conducted in week 14 based on all components previously covered in the Course. These forms of assessment are described in detail in Ellis et al (2011) and Ellis & Petersen (2011).

The students were invited to complete an anonymous questionnaire (Post Evaluation), via an e-learning platform, following the completion of the Course (week 15) to determine their level of satisfaction with its design and delivery as well as its ability to advance their professional development. This study focuses on the Quality of the teaching and learning strategies used in the Course in meeting the needs of the students as a key stakeholder in the educational process over the period of three academic years spanning (2010 to 2012). Quality is defined as "the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs" (BSI 1991). Green and Harvey (1993) in their study identified five different approaches to defining quality; however this study focuses on one: as fitness for purpose (meaning the product or service meets the stated purpose, customer specifications and satisfaction).

LITERATURE REVIEW

Quality enhancement and quality assurance are the means by which higher education institutions are monitoring to ensure the standards are maintained worldwide (Harvey 2001; Jones 2003; Lomas 2007; Blackmore 2009). In the study of Harvey (2001), it was found that in the 1980s feedback from students concerning their experience in higher education (HE) was a rare event. However, due to the expansion of tertiary education and the greater concern with quality, the need arose for such practices. The common practice is to collect the students' views in the form of 'satisfaction' feedback. The feedback from students has two main functions: Internal information to guide improvement and external information for potential students and other stakeholders. Our research focuses on the former, but also looks at their reflection on learning.

Harvey (2001) separated 'satisfaction' surveys in HE into five forms: (a) institution-level satisfaction with a total student experience or a specified sub-set; (b) faculty-level satisfaction with provision; (c) program-level satisfaction with the learning and teaching and related aspects of a particular program of study; (d) module-level feedback on the operation of a specific module or unit of study; (e) and teacher-

appraisal by students. At the University of the West Indies, we are engaged in the latter three forms of feedback, but this research is focused at only the module-level feedback based on the Course. The University conducts a generic course evaluation; however this study focuses on a course evaluation design to highlight specific aspects of the Course.

Module-level feedback tends to focus on specific learning and teaching associated with the module and is generally collected with the aid of a questionnaire as in this research. One challenge with this form of feedback is the fact that the information collected has little benefit to the students who provided the same (Harvey 2001). While this is true, this research is also geared towards reflective learning for the students thereby creating a benefit to both parties involved in the process.

It is said that there are a few common characteristics that are shared by student evaluations of teaching (SET) regardless of their application (Sproule 2000; Algozzine et al., 2004): (1) a mixture of open-ended and closed questions; (2) a single item which addresses overall teaching satisfaction/effectiveness; (3) written comments about the course or instructor; (4) anonymity; (5) responses are obtained at the end of the term, in the absence of the instructor; and (6) responses are analysed.

Open-ended questions can be utilized in this process which provides a wider pool of information and allows for more reflection on learning. In addition to the "what" questions, the "why" and "how" questions can drive students to think deeper and wider in their evaluation of their own learning (SEDL 2000). Due to difficulty in analysing and the time consumed in arranging them, open-ended questions are infrequently used (Harvey 2001).

Learning is not just a process of accumulation of information. It could be considered as a network of co-existing ideas (Moon 1999) or it is about how the new knowledge that the learner encounters is integrated with his existing schemata of prior knowledge (Ong 2000). This new knowledge is a combination of experiences (action) and thought (reflection) (SEDL 2000).

In the extant literature on the subject of reflection many of the authors promote a diverse range of constructivist approaches in defining and explaining the construct, drawing theory into practice (Donaghy and Morss 2000; Fisher 2003; Jones 2004; McCollum 2002; Moore 2004; Price 2004; Rodgers 2002; Spalding and Wilson 2002). Based on a review of the literature "Questioning" is seen as a practical inquiry that requires critical incident analysis and develops higher order skills, such as analysing and evaluating (University of Sydney n.d.).

When considering learning from the students' perspective it requires us to: (1) appreciate how students perceive our intentions as teachers and assessors; (2) understand the institution's intentions towards us in terms of evaluation; (3) design and use methods of assessment that will contribute to deeper student learning; and (4) choose evaluation methods which contribute to the development and improvement of learning and teaching (University of Sydney n.d.).

One constraint that may exist with the feedback process and reflecting is the student's inability to critically reflect on their learning over the period of time (University of Sydney n.d.). Some students may be better reflectors than others, however, throughout the Course the students' were given weekly opportunities to reflect on their leadership abilities and the abilities of their teammates which would prepare them for this form of feedback.

Another important barrier to the effective implementation of this form of feedback is the atmosphere in which the feedback is solicited. For students to feel open and honest about their views, they must feel that they will not be penalized for their unfavourable opinions (SEDL 2000). This issue is addressed by the anonymity of the data collection in this research.

METHODOLOGY

A questionnaire comprising 15 questions was administered to the students in the final week of the semester. The questionnaire was divided between closed-ended and open-ended questions. Questions 1 – 10 were closed-ended and focused on the delivery of the course and its relevance to the career goals of the students. These were measured with the aid of a 5-point Likert scales, ranging from strongly agree to strongly disagree. Question 11 sought to determine how the course could be improved from the students' perspective with an open-ended question. Questions 12 and 13 were focused on the students' leadership and the contribution the course may have made to its improvement. Question 12 required a "yes" or "no" response, while question 13 was open-ended. Questions 14 and 15 were geared towards to students' rating of themselves on a scale of 1 to 5, based on their perception of their Professionalism, Sustainability, HSE Management, Risk Management, and Design before and after the course. These five areas were integrated into the design of the course as common threads throughout the weekly objectives, forming their Project Plans, based on the nine Knowledge Areas of the PMBoK.

The questionnaire was administered via the e-learning open-sourced platform, Moodle (Heap et al 2004), termed MyElearning at the UWI. The students were asked to log into the course online and complete the anonymous questionnaire to allow for openness and honesty. The data was collected and analysed over a period of three academic years (2009/10, 10/11, and 11/12) with a total of 69 of the 95 students enrolled in the course over the period responding to the questionnaire.

The data was statistically analysed using One-Sample t-test and Paired-Sample t-test in SPSS. The results have been presented in the following section.

RESULTS

In Table 1, the results indicate the levels of significance (P value) that have been ascribed to questions 1 through 10. The level of significance used in this study was $p>0.01$. The results in Table 1 indicate an overall agreement that teaching and learning strategies used in the Course were effective. The students' indicated that the material covered in the course was easily understood and original when compared with the other courses. The students' were in agreement that overall structure and objectives of the Course were clear; however they had a few suggestions as to how the Course could be improved as indicated in their responses to Question 11. Attempts have been made to improve the course. The system of feedback has been improved with an increased use of MyElearning for submission of coursework and feedback outside of the allotted class time. The "best" projects from each cohort are used as examples to the incoming group to give a general idea as to the quality standard expected. This has resulted in a consistent level of improvement in the quality coursework submissions.

Table 1: Showing the results of Questions 1-10 using a One-Sample t-Test

Questions	N	Mean	SD	T	df	P
1. The material covered in the course was easy to understand	69	3.29	0.91	2.648	68	0.01
2. There was too great an overlap with other courses in the Department	69	2.81	1.13	-1.387	68	0.17
3. The overall structure of the course was clear	69	3.23	1.15	1.672	68	0.099
4. The objectives of the course were clear	69	3.35	1.16	2.489	68	0.015
5. The course load for this course was comparable to that of other courses in the Department, taking the credit into account	69	3.25	1.17	1.752	68	0.084
6. The feedback on the marked coursework was relevant to my career objectives	69	3.22	1.07	1.689	68	0.096
7. The material covered in the course was relevant to my career objectives	69	3.42	1.29	2.711	68	0.008
8. I am glad I decided to take this course	69	3.48	1.22	3.256	68	0.002
9. This course should be compulsary for all M.Sc. students in the Department	69	3.48	1.23	3.225	68	0.002
10. This course needs much improvement	69	3.04	0.86	0.418	68	0.678

NB. Test Value = 3

The respondents also indicated that the feedback received from coursework and the materials covered in the Course were relevant to their career objectives. As construction managers and engineers, the educational curriculum should have a direct impact on the professional development of the students. The Course focuses on leadership and team working on 'real world' problems that allow the students to role play making critical decisions that could have long term effect on projects. The Zero Tolerance approach to errors and omissions give the students' the opportunity to change a culture of mediocrity for professional excellence. The 360-Degree feedback allows the students to be aware of their leadership and its impact on the quality of the project. As a result we have seen significant improvements over the 10 week period (Ellis & Petersen 2011).

Question 11- In a few words, how could this course be improved?

The students' responses to this question were varied, however most were in agreement with their viewpoints. Ten of the most frequent responses are: clarity of objectives; increased time; understanding of course; removal of ICE Development Objectives; marks weighting of ICE Development Objectives; speed of feedback by clients;

knowledge of other projects; becoming a member of ICE at the end of course; deeper focus on PMBoK areas; and greater correlation between marking scheme and work load.

The responses indicated a greater concern for one of the assessment strategies used in the course: ICE Development Objectives. Greater focus has been placed in the introduction week as well as continuously throughout the course to ensure clarity and to give guidance to the completion of the document. The responses also indicated a revision in the weighting ascribed to the various forms of assessment, which had 20% assigned for each of the five forms. For greater satisfaction in these areas further revision would be needed. However, it must be noted that this aspect of the course has received favourable reviews from the successful JBM accreditation visit in 2011, and was mentioned in their Annual Report as good practice (JBM 2012: 21):

"The Construction Management programme that actively encourages students to aim for chartered status by using the format of the ICE Personal Development Objectives in the assessment criteria."

As such, this aspect of the course will remain, with a greater level of importance being expressed to the students for their understanding of its overall purpose to their professional development.

Question 12- Do you think you are a better leader as a result of this course?

Of the 50 respondents to this question, 90% indicated “yes” while the remaining 10% indicated “no.” This reveals that the course, based on its project-based learning design, was able to develop the leadership of the Postgraduate students. It is said that purpose of construction education is to enhance leadership development while preparing construction professionals to manage and lead project teams that extend the organisations of owners, construction professionals, prime contractors, subcontractors, suppliers and others (Chowdhury 2013). This course has taken a direct approach to this topic of leadership.

Question 13 - If YES to question 12, how? If NO, why not?

A total of 50 students responded to this question. Based on the responses, 10 of the most frequently used phrases are presented. The students indicated that the course aided in their: self awareness; increased knowledge; conflict resolution; communication skills; management skills; level of confidence; ability to delegate effectively; understanding of different personalities; and people skills. The students responding negatively said: the team was strong; the lack of feedback; straying from intended process.

The responses would indicated that most students experienced positive improvements within themselves, while others did not see a marked improvement owing to various reason outside of the control of the course.

Question 14 - How would you rate yourself prior to this course on a scale of 1 to 5 (with 5 being the highest) on the various categories mentioned below?

Question 15 - How would you rate yourself after going through this course?

Table 2: Showing the results of Questions 14 and 15 using a Paired-Sample t-Test

	N	Mean	SD	T	df	P
14a. Professionalism (Before)	50	3.54	0.76	-9.333	49	0.000
15b. Professionalism (After)		4.34	0.52			
14b. Sustainability (Before)	50	2.98	0.80	-11.513	49	0.000
15b. Sustainability (After)		4.12	0.56			
14c. HSE Management (Before)	50	3.16	0.84	-8.359	49	0.000
15c. HSE Management (After)		4.08	0.60			
14d. Risk Management (Before)	50	2.88	0.75	-11.002	49	0.000
15d. Risk Management (After)		4.12	0.59			
14e. Design (Before)	50	2.64	0.90	-8.359	49	0.000
15e. Design (After)		3.56	0.99			

The results in Table 2 have indicated high levels of significant differences between the students' pre and post assessment of the respondents. These significant differences indicate that the course has been very effective in incorporating the five aspects throughout the course. Professionalism has been integrated with the aid of Zero Tolerance to errors and omissions. The ICE Development Objectives has also assisted in this area by giving the students the opportunity to systematically document their professional development to date while highlighting the existing gaps. The students were required to incorporate sustainable concepts focusing in the social, economic and environmental aspects of their projects. This also required the development of a HSE management plan for the respective projects. Risk Management being one of the nine knowledge areas of the PMBoK was a direct requirement for the Project Plan. The teams assigned were an integration of students from the various MSc programmes which comprised construction management and civil engineering students. This allowed for a greater development in Designs given the fact that the key personnel needed for the overall project success through the various phases (initiating to close out) of the project were involved from the project inception.

CONCLUSIONS

The authors developed the Course to meet the needs of the stakeholders of the MSc programs in the Department of Civil & Environmental Engineering at the University of the West Indies. The literature review highlighted the need for feedback in academia at various levels. A module-level feedback assessment was conducted for the course based on the experience of the students. The results of the feedback indicated that the Course was successful at improving the leadership and professional development amongst other key features from the students' personal viewpoint. The results also indicate that the course design and delivery had significantly contributed to this improvement. The accuracy of the results can be improved if the Likert scale was changed from a 5-point to 4-point with the removal of the “neutral” option from

questions 1 -10. This would have allowed for either positive or negative responses only.

REFERENCES

Algozzine, B, Beattie, J, Brau, M, Flowers, C, Gretes, J, Howley, L, et al (2004) Student evaluation of college teaching: A practice in search of priniciples. "College Teaching" 52(4), 134-141.

Blackmore, J (2009) Academic pedagogies, quality logics and performative universities: evaluating teaching and what students want. "Studies in Higher Education" 34(8), 857–872.

BSI (1991) "Quality Vocabulary Part 2: Quality Concepts and Related Definitions". London:BSI.

Chowdhury, T (2013) Impact of senior design project for the development of leadership and management skills in construction management. "European Journal of Engineering Education", 38(1), 1-16.

Denson, N, Loveday, T and Dalton, H (2010) Student evaluation of courses: what predicts satisfaction? "Higher Education Research & Development" 29(4), 339–356.

Donaghy, M E and Morss, K (2000) Guided reflection: a framework to facilitate and assess reflective practice within the discipline of physiotherapy. "Physiotherapy Theory and Practice" 16, 3-14.

Edström, K (2008). Doing course evaluation as if learning matters most. "Higher Education Research & Development" 27(2), 95–106.

Ellis L A, Petersen, A K and Nicholls S (2011) Bridging the gap: improving the professional development of post graduate engineers through the educational system. In: Cheung, S O, Yazdani, S, Ghafoori, N, and Singh, A (eds), "Modern Methods and Advances in Structural Engineering and Construction, ISEC-6", June 21 - 26, 2011, Research Publishing, .Zürich, Switzerland.

Ellis, L A and Petersen, A K (2011) A way forward: assessing the demonstrated leadership of graduate civil engineering and construction management student. "Leadership Management Engineering", 11(2), 88–96.

Fisher, K (2003) Demystifying critical reflection: defining criteria for assessment. "Higher Education, Research and Development", 22(3), 313-323.

Fluckiger, J, Tixier y Vigil, Y, Pasco, R, and Danielson, K (2010) Formative feedback: involving students as partners in assessment to enhance learning. "College Teaching", 58, 136–140.

Harvey, L (2001) Student feedback – a report to the higher education funding council for England. "Centre for Research into Quality". The University of Central England in Birmingham: Perry Barr, Birmingham.

Harvey, L and Green, D (1993) Defining 'Quality'. "Assessment and Evaluation in Higher Education", 18(1), 9-34.

Heap, N W, Kear, K L and Bissell, C C (2004) An overview of ICT-based assessment for engineering education. "European Journal of Engineering Education", 29(2), 241–250.

JBM (2009) "Guidelines for checking output standards of degree programmes". (http://www.jbm.org.uk/uploads/JBM114_OutputStandards.pdf) [Feb 4, 2013].

JBM (2010) "Welcome to JBM". (http://www.jbm.org.uk/) [March 9, 2010].

Jones, A (2004) Teaching critical thinking an investigation of a task in introductory macroeconomics. "Higher Education, Research and Development", 23(2), 167-181.

Jones, S (2003) Measuring the quality of higher education: linking teaching quality measures at the delivery level to administrative measures at the university level. "Quality in Higher Education", 9 (3), 223–229.

Lomas, L (2007) Zen, motorcycle maintenance and quality in higher education. "Quality Assurance in Education", 15 (4), 402–412.

McCollum, S (2002) The reflective framework for teaching in physical education: A pedagogical tool. "Journal of Physical Education, Recreation and Dance", 73(6), 39-42.

Moon, J A (1999) "Reflection in Learning and Professional Development: Theory and Practice". London: Kogan Page.

Moore, T (2004) The critical thinking debate: how general are thinking skills? "Higher Education, Research and Development", 23(1), 4-8.

Ong, R (2000) "The role of reflection in student learning: a study of its effectiveness in complementing problem-based learning environments". (http://www.myrp.sg/ced/research/papers/role_of_reflection_in_student_learning.pdf) (Sept. 29, 2012).

Project Management Institute (PMI) (2004) "A Guide to the Project Management Book of Knowledge: PMBoK Guide." 3ed., Pennsylvania: Project Management Institute Inc.

Price, A (2004) Encouraging reflection and critical thinking in practice. "Nursing Standard", 18(4), 46-52.

QAA (2009) "The framework for higher education qualifications in England, Wales and Northern Ireland - January 2001". (http://www.qaa.ac.uk/academicinfrastructure/fheq/EWNI/default.asp#framework) [June 17, 2009]

QAA (2012) "About us" (http://www.qaa.ac.uk/AboutUs/Pages/default.aspx) [Nov 12, 2012].

Rodgers, C (2002) Defining reflection: another look at John Dewey and reflective thinking. "Teachers College Record", 104(4), 842-866.

Spalding, E and Wilson, A (2002) Demystifying reflection: a study of pedagogical strategies that encourage reflective journal writing. "Teachers College Record", 104(7), 1393-1421.

Sproule, R (2000) Student evaluations of teaching: A methodological critique of conventional practices. "Education Policy Analysis Archives", 8(50), 125–142.

SEDL (2000) Action + Reflection = Learning. "TAP into Learning", 3(2), 1-12.

University of Sydney (n.d.) “Reflection – The University of Sydney.” (http://sydney.edu.au/education_social_work/groupwork/docs/Reflection.pdf) [Oct. 1, 2012].

University of the West Indies (2007) UWI strategic Plan 2007-2012. Office of Planning and Development. (http://www.uwi.edu/StrategicPlan/strategicplan20072012.aspx) [July 20, 2009].

Yueh, H, Chen, T, Chiu, L, Lee, S, and Wang, A (2012) Student Evaluation of Teaching Effectiveness of a Nationwide Innovative Education Program on Image Display Technology. "IEEE Transactions on Education", 55(3), 365-369.

EQUALITY AND DIVERSITY

OLDER CONSTRUCTION WORKERS: NEEDS AND ABILITIES

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Construction presents specific problems for vulnerable workers, be they younger, older or migrant workers (Dainty et al, 2007). This paper concentrates on the needs and abilities of older workers. In addition to the health problems associated with normal ageing, heavy physical workloads have been shown to exacerbate this physical decline. Construction is recognised as having higher rates of fatality, injury and illness than most other industries. Many workers in industries with a heavy physical workload are forced into early retirement due to injury and ill-health. Although there is data available to show age-related relationships with a range of occupational ill-health conditions in construction, little has been done to explore workers' personal perceptions of ageing. The SPARC (Strategic Promotion of Ageing Research Capacity) initiative funded a project at Loughborough University to explore the needs and abilities of older construction workers (Leaviss et al, 2008). The pilot research used qualitative methodology to attempt to gain a rich understanding of some of the issues that are perceived to impact upon the health and career paths of older workers. In-depth semi-structured interviews and focus groups were held with participants from several areas of the industry. A range of issues have emerged that are considered to affect older workers in construction have emerged from the project and are wide ranging, acting at both a macro and micro level within the industry. Client demands, construction company employment policy and design considerations act alongside specific work processes, employee uptake of safe practice, and availability of tools and equipment to create an environment which can be hostile to the older worker. The contribution of this work was as the foundation of Loughborough's older construction worker research that is continuing with the development of occupational ill-health simulators as training aids for younger workers and empathy aids for designers (Cook et al, 2009 & 2012 and Nyateka et al, 2012) and workplace design (Williams et al, 2011).

Keywords: ageing workers, health, safety

INTRODUCTION

An ageing population

Worldwide demographic trends show an ageing population (United Nations 2005). Ilmarinen (2006) states that "longer life expectancies and low birth rates together impact on the demographics of the workforce. The proportion of 50 to 64 year-olds in the workforce will be double in size compared to workers younger than 25 years (35% versus 17%) in the EU15 (the first 15 European countries to join the union) by the year 2025.

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Gibb A, Leaviss J and Bust P (2013) Older construction workers: needs and abilities *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 261-271.

Retaining the older worker in the workforce will not only become a necessity, but it is also beneficial to industry. Older workers accumulate invaluable job-related knowledge and experience, and it should be desirable for employers to retain this skill base."

Physical ageing

Normal ageing produces declines in physiological fitness in gross and fine motor performance, cognitive abilities (reaction time, memory, decision making), sensory perception (auditory and visual), and aerobic capacity (Kowlaski-Trakofler et al, 2005). These age-related declines result in difficulties for the older worker, particularly in tasks requiring joint mobility, manual dexterity, muscular strength and endurance. These effects are more apparent for tasks with a heavy physical nature, with ability to perform such activities reducing with age. "Muscular strength tends to peak between the second and third decades and remains the same until about 45-50 years of age in men" (Evans & Hurley, 1995), it then "starts to decline from about the fifth decade at a rate of 12% to 15% per decade until the eighth decade."

Similarly, aerobic capacity declines to 70% of peak by age 65. Ageing also produces postural limitations, with older adults experiencing difficulty stooping, crouching, bending and reaching. Herberts et al (1980) showed shoulder muscle fatigue to be a specific concern for older workers engaged in tasks requiring elevated arm activities.

Ageing in the construction industry

The construction sector is one of the largest employers in the EU. Eurostat data (Eurostat, 2009) showed that "construction activities in the EU-27 provided employment to an estimated 14.8 million persons in 2007 (some 11.5 % of the non-financial business economy workforce)". In addition to these official figures, the true number of employees in construction work may be far higher, as many workers are believed to go undeclared (Mateman & Rencoy, 2001).

The HSE's advisory group CONIAC (2009) states that "over a nine year period from 1996/7 to 2004/5 in UK construction the average proportion of fatal injuries suffered by 60+ workers, for those cases where age is known, is 11.6%. Over the same period the proportion of all workers in the 60+ age group averages 5.7%. This raw data suggests that the potential for fatal injury amongst the 60+ age group is twice that for construction workforce overall."

It is well-documented that construction workers are at greater risk of a range of work-related health disorders than many other industries and the population as a whole (see Kines et al, 2007, & Arndt et al, 2007 for reviews). Common conditions include musculoskeletal disorders, lung disease, hearing difficulties, and fractures and sprains.

The nature of construction work presents specific problems for the older worker. In addition to the health problems associated with normal ageing, heavy physical workloads have been shown to exacerbate this physical decline. Whilst a low level of physical exertion can have positive training effects on physical capacity (Schibye et al, 2001), heavy occupational physical activity over many years causes this capacity to deteriorate (Nygard et al, 1991). The most common form of work-related health complaints are musculoskeletal disorders (MSDs) (HSE, 2002). Physically strenuous work and the moving, lifting and carrying of heavy weights are associated with a significantly higher risk of back pain and MSDs (Schneider, 2006).

Construction has high levels of early retirement due to permanent disability or ill-health: Guberan and Usel (1998) studied early retirement rates in a range of occupations in

Geneva. Of all the occupations studied, construction had the lowest rate of survival in work without permanent incapacity at aged 65, at only 57%. This compared with an average across all industries of 75%. A study of early retirement in construction workers in Ireland (Brenner and Ahern, 2000) showed the most common disabilities leading to early retirement on health grounds were cardiovascular disease (31%), hypertension (16%) and musculoskeletal disorders (30%). These studies suggest that the construction sector is not a hospitable environment for the older worker.

The current recession in the UK and across much of the world is causing a significant downturn in activity. This has eased the labour shortage in the short term; however, there is anecdotal evidence that many older experienced workers have willingly or unwillingly left the industry, thus storing up a future skills shortage when the upturn finally comes.

Easing the workload

Problems caused by a heavy physical workload are being addressed through the design and use of specialised equipment (e.g. power or hand tools, access equipment such as ladders and scaffold) and the redesign of work processes. The effective interaction of process and equipment should optimise work posture and reduce physical stress (Vedder & Carey, 2005). Williams et al (2011) have developed a web-based tool to aid workplace design to facilitate inclusion and a better working environment for all ages.

Three main solutions to MSDs include: reducing extreme joint movement (keeping motion within acceptable range); reducing excessive force (using mechanical aides); and reducing highly repetitive tasks (use of power tools) (McMahon & Philips, 1999). Effective implementation of these strategies can lead to the reduction of work related injury and ill-health and may lead to a reduced likelihood of early retirement.

There are financial benefits to reducing work-related ill-health in construction. HSE (2011) estimate the cost of work-related accidents and ill-health in the UK construction industry is £1216 million. A previous study (HSE, 1997) estimated that they accounted for 8.5% of project costs. This included the costs of delays, absenteeism and health and insurance charges. It is estimated that occupational ill-health and injury may be costing the EU construction industry nearly €75billion a year (OSHA, 2004). Early retirement may add to these costs, and the cost of retirement may often be borne by the State.

The SPARC research

The aim of the SPARC study was to gain a richer understanding of the specific needs and abilities of older workers in construction, as perceived by those in the industry. It was beyond the scope of the project to examine in detail the risk factors for older workers in all trades and tasks and devise solutions accordingly. This preliminary research used qualitative methodology to make an initial exploration of the research questions. It explored the personal perceptions of a broad range of industry participants, in order to examine in more depth the issues surrounding growing old in construction. It also sought to identify potential solutions to some of the problems experienced specifically by older workers. This work is now being taken forward in a project funded by AGE-UK.

METHODS

Interview structure and data collection

Data were collected via in-depth semi-structured interviews and focus groups to explore perceptions of the needs and abilities of the older construction workers, based on:

- What health problems are associated with older workers?
- What workplace equipment and materials are relevant to the older worker?

- What are the barriers to uptake of safe practice in the older worker?
- What other issues are of concern to older workers in construction?

Participants were encouraged to expand on issues that were of particular interest. Interviews were conducted in the workplace; some in site offices, others incorporated into site walkabouts. It was therefore not possible to record all interviews – where recording was possible, all material was fully transcribed, verbatim.

Participants

Participants were drawn from a wide range of industry backgrounds (Table 1). Access to older workers was gained through H&S managers of large construction companies.

Table 1: List of participants

Job description	Number (Total n=55)
Health and safety managers/consultants	8 (private sector 6, public sector 2)
Site managers	5
Older workers	23 (of which 4 retired)
Union Representatives	2
Younger workers	4
Equipment/materials hire/design	6
Other	7 (inc. company owner, ageing expert, surveyors, training and health bodies)

Age of older workers: The literature generally has that the age of an 'older' worker as 40+, but it was felt by many of the health and safety managers that this was too young. The study therefore aimed to sample those workers aged 50+, although 3 workers were in fact in their 40s. The average age of the older workers in the study was 56.5 years (range 41-64). In addition to these 4 retired workers were interviewed, average age 74.5 (range 72-79). All interviewees had 10 years or more construction experience.

Analysis

Qualitative data was examined and a thematic analysis was conducted to identify emerging issues. Data was reduced by coding around main themes corresponding with interview questions, then searching for emerging themes within these categories.

RESULTS

A range of issues that are perceived to affect older workers in construction have emerged from the project and are being investigated further through on-going work. We have found these issues to be wide ranging, acting at both a macro and micro level within the industry. Key issues to emerge are summarised as follows.

> "You get to our age – 50 odd – nobody would want us…" (Older worker)

Positive Value

The value placed on older workers should not be underestimated. Both management and workers recognised the value of retaining older workers within the industry.

Table 2 Value: Older workers in construction

Positive Value	Negative Value
Trade skills and knowledge	Lack of fitness
Experience	Lack of safety behaviours
Work ethic	Resistance to change
Workmanship	Cost to project

"The strength of any organisation whether it's a multi-million pound company, the Royal Family, a football team…the strength of that organisation is that if you were to remove the top layer for one reason or another, how competent are those lower down able to move up and fill their places?" (Clerk of the Works)

Skills – Older, experienced workers bring with them invaluable knowledge and skills of their trades. A significant decline in apprenticeships in the construction trades has caused an erosion in the skill base. Younger workers are not being attracted into the industry. As older workers retire, they are not being replaced by similarly skilled workers.

"Its not the best trade to be in. I can see why the younger ones don't want to come in. They just lose heart, just lose heart in it. I mean its hard graft." (Site manager)

Table 3 Perceived reasons for lack of young workers entering construction

Younger workers are idle
Construction work is demeaning to them
Doesn't occur to them that construction is a viable option
Younger people want easy money
Younger people don't want to be told what to do
Only see construction work as stop gap to something else

"People…they're retiring and skills are not getting passed on anyway so they just make the job as simple as they can to suit the ability of the person that's doing it. Rather than bring the person up to the standard they're lowering the standard to the person." (Older worker)

Work ethic: Older workers are perceived by both management and workers as having a better 'work ethic'/mentality. For example they will present for work even when sick where a younger worker would not.

"Never had a day off sick. My time keeping is ace." (Older worker)

Workmanship: Older workers are perceived to take greater pride in their work and to produce work of a higher quality.

"You get an older guy on the job – he may take longer but you get the quality. The younger guy he just wants his money." (Small construction company owner)

Negative Value

The nature of construction work has changed. An increased reliance on pre-fabricated materials e.g. staircases, roof trusses and ever-tight profit margins have created a working environment that is hostile to the older worker.

"It's hard work, yeah, and the older you get, the harder it is." (Older worker)

Lack of fitness: Older workers are perceived to be slower and unable to keep up the pace set by the younger workers. The ability to hit targets is crucial for construction companies/site managers who need to complete jobs on schedule or suffer financial consequences. This negative is perceived to outweigh the positive attributes offered by the older worker.

"He's not mobile for starters. I don't mean getting in his car but he's not as physically fit as he would have been as a younger person. And that brings on its own problems whether its mental agility or physical ability - and the ability as well under the mental side of it to assimilate information correctly." (H&S manager)

Macro-level Issues

The organisation of the construction industry as a whole is perceived to have implications for creating a hospitable working environment for older workers.

"It's an industry that's insecure…it's an industry where you have got every single different employment status you can think of, so it's a minefield out there." (H&S Consultant)

Direct versus indirect labour – The employment tenure of older workers was thought to have a direct effect on their experience of work in construction. Many construction firms employ workers through sub-contractors and many workers are therefore self-employed. Employers who do employ direct labour are perceived to 'look after' their older workers, to find them less physically demanding tasks when necessary, and are obliged to provide 'sick pay' when a worker is unable to present for work through ill-health/injury. Conversely, being self-employed and finding work through sub-contractors is perceived to have a negative effect on the experience of older workers. Workers are chosen on the basis of being fit and able to complete the job quickly. Allowances are not necessarily made for the slower pace of the older worker. If a self-employed worker is unable to work through ill-health, they do not get paid, and must rely on private insurance or state benefits. Many older participants reported that they would prefer to be 'on the books'.

"If there was somebody there that had been there donkey's years then they would probably find him a lighter job. I mean I know bricklayers that have had a heart attack and they've finished up in the joiner's shop as a labourer." (Older worker)

Client responsibilities: The construction industry is highly competitive. This financial pressure results in extremely tight margins. There was a perception amongst some participants that these small margins make it financially impossible to make allowances for the physical 'slowness' of the older worker. A slow worker was perceived to cost more money than a fast worker, and some participants felt that the competitive tendering process creates a reluctance by the main contractors to bear this cost. It was suggested by several participants that the only way to address this issue would be for the client to bear the cost.

"I'm not saying clients are the whole answer but they really are a big part of it." (H&S manager)

"It depends on the people with the money. If you've got money then you can have the job done as you want it." (Older worker)

Pay structure: - Participants reported that much of the construction industry relies on 'bonus/price work'. This type of payment system may appeal to younger, physically fit workers as there are financial rewards for speed. There was a perception amongst some participants that the quality of the work suffers through this type of payment system. Many older workers reported that they would prefer a 'day rate' because the focus becomes on quality rather than speed.

"If a guy is paid by productivity and he's going up and down that roof ladder like a fiddlers elbow – If he's an old guy and he's immobile he's not going to earn a crust." (H&S manager)

Employment flexibility: - Many of the older workers who participated in this study want to stay in the industry. However, as they get older many prefer to work more flexibly, either working part-time or on day rates due to the high pressure of price-work.

"They don't want you on day rates. We couldn't come here and get a job on day work, laying bricks or blocks or whatever – they won't have us." (Older worker)

Micro-level Issues

Preventing chronic ill-health and injury in construction workers is vital to reducing early retirement from the industry.

Attitudes to Health and Safety: - Workers accept ill-health and injury as part of the work.

"It's just the job." (Older worker)

Many participants reported that early retirement is currently an accepted part of the industry. Participants reported 'expiry dates' for older workers in construction – i.e. the age at which the average worker in a specific trade would have to retire from the industry through ill-health. Many workers felt that the health and safety regulations are 'over-the-top', and prevent workers from doing their job fluently. There was an attitude amongst workers that nothing could be done to make the job less physically strenuous, and that the job is inherently hard. However, when encouraged to talk more about their specific job tasks, older workers were able to think of improvements to their own job tasks that could otherwise cause or exacerbate physical injury or ill-health. Management sometimes perceived older workers to be less likely to follow safe practice for self-protective behaviours, e.g. wearing PPE and it is possible that these issues are linked.

"We've invented some of the most fantastic things in the world and they've all come from this country but there's still a reluctance on behalf of some people to make life easier for themselves." (Clerk of Works)

Health problems and potential interventions are trade specific. For example:

- **Joiners** perform tasks that require repetitive motion e.g. hammering, use of screwdrivers. These tasks can cause problems in the joints e.g. tennis elbow. These tasks can often be made easier with power tools. Battery drills can be used instead of pump screwdrivers. Nail guns can be used instead of hammers.
- **Bricklayers** are constantly manual handling heavy materials. This results in musculoskeletal disorders. Manual handling aides and lifting devices can make some of this work easier. However, older workers would prefer lighter materials rather than to use lifting devices which are regarded as a hindrance to fluency of work. Forklifts and other mechanical handling devices are now more readily available to assist with lifting tasks. However this only eliminates the need for a labourer to carry materials to the bricklayer. This gives the bricklayer the additional job of loading/unloading, creating an extra physical burden.
- **Plasterers** perform wet work that can result in rheumatic problems. Repetitive motion results in aches and pains. Newer materials are available that reduce the amount of wet work that is required for the job, e.g. dry lining. Plasterers are reported to have the earliest 'expiry date' as the work is so physically demanding.

Barriers to intervention

"If you can cut a corner you will do – it's as simple as that." (Older worker)

There are many perceived barriers to the effective employment of interventions designed to alleviate the physical nature of the work. Personal responsibility: Some workers are reluctant to wear PPE or use appropriate equipment as they felt this affects how they do the job. In addition, it was perceived that many work processes or pieces of equipment that help with the physical side of the job do not help with the financial side.

"It saved a lot of lugging but you've got two men working it and while you're working it you're not laying…and you're not earning, you're not earning while you're getting your stuff up." (Older worker)

Financial responsibility: Because of the way the industry is organised, it was reported that financial responsibility for PPE and equipment was sometimes unclear. Often self-employed workers must provide their own tools, but the contractor provides the materials. If the appropriate materials are expensive e.g. nails and gas for nail guns, they may not always be provided.

Role of site managers

"When the physical standard has gone, look at the mental." (Regional H&S advisor)

It was reported that site managers can play a role in easing the workload for the older worker. This may be dependent on budgetary and time restrictions for individual projects, however many participants reported that individual differences in site managers play a role in making the working environment more hospitable for the older worker. For example, site managers can make use of older workers skills e.g. as a safety scaffolder, putting them on (more skilled yet less labour intensive) corners when laying bricks etc. If older workers have aptitude they may be employed as supervisors or to train young workers.

"I'm talking about different site agents – they're all different, temperamental…I don't mind telling you. (Current site manager) treats you as a person, sometimes they'll just treat you as a straight labourer." (Older worker).

Tools and Equipment Design Issues

Design of construction tools and equipment should be inclusive. Designers and manufacturers reported a reluctance to design specifically for older workers, as there were no financial gains due to a lack of demand. Particularly for PPE, design and promotion of new equipment was reactive to whatever ill-health condition was prominent at the time. Some participants reported there was little market for construction tools designed to be used for older workers, but if there was a demand they would react to this. Architects could be more aware of physical limitations when designing buildings e.g. access.

Solutions

Participants reported many ways in which the working environment could be made more amenable to the older worker. Table 4 shows different types of equipment and materials that have been suggested may be particularly relevant to the older worker. Table 5 shows participants' reported solutions other than equipment and materials that they felt would create a more hospitable working environment for the older worker. Finally, there was a perception by some of the older workers that the industry simply did not care for them.

"The construction industry is cut-throat. It's dog-eat-dog." (Older worker)

Table 4 Other solutions perceived to be relevant to older workers

More labourers	Reorganise the way the work is done
More direct labour	Use work rotation system to avoid repetitive exposure
Pay by day rate	Loading out gangs
Shorter working hours	Self-selection
Flexible working patterns	Provision of medical care e.g. osteopaths
Improved sick pay	Company partnering

Table 5: Equipment and materials perceived to be relevant to older workers

Low-vibration tools	Pre-mix mortar
Pre-fabricated units	Fall arrest equipment
Kerb-lifting equipment	Reduction in weights/lifting

Scissor-lifts	Power hand tools
MEWPS (mobile elevated work platforms)	Mechanical handlers
Ladder assists	PPE (personal protective equipment)
Electrical hoists	Forklifts
Access equipment	Plant operatives equipment
e.g. stair access on scaffolding	*e.g. noise reduction*
Facilities	Block splitters
e.g. toilets and catering	
Conveyor belts	Long-handle shovels
Vacuum lifters for glass	Mini-diggers

CONCLUSIONS

Construction work is arduous and physically challenging. It is well-documented that workers in the industry are at increased risk of work-related ill-health and injury. Less work has been conducted on the increased risk of occupational illness to the older construction worker; however the existing research indicates a pattern of increased ill-health with age (Arndt et al, 2005; Brenner & Ahern, 2000). The main aim of the SPARC study was to explore the perceptions of those within construction of the specific needs and abilities of older workers, and to identify ways in which the working environment could be made more hospitable for them (cf. Williams et al, 2011). Discussions with construction employees offered a valuable preliminary insight into these issues. Findings suggested that intervention can be made at all levels of the construction industry to reduce current unacceptably high levels of work-related ill-health and to reduce early retirement.

In summary, this pilot study has gained, through qualitative methodology, a broad perspective on key issues perceived by those in the industry as having implications for the working life of older workers in construction. These are thought to act at both macro and micro levels of the industry. Client demands and employment policy act alongside specific work processes, personal responsibility for safe work practice and availability of tools and equipment in creating an environment which can be hostile for the older worker as argued by Ilmarinen (2006). Further quantitative work is continuing to validate these findings, in order that effective interventions can be designed to enable older workers to take an active healthy role in the industry until retirement age, and that they may enjoy their retirement unhindered by long-term chronic health conditions caused by their work.

REFERENCES

Arndt, V., Rothenbacher, U., Daniel, U., Zscshenderlein, B., Schuberth, S., Brenner, H. (2005) Construction work and risk of occupational disability: a ten year follow-up of 14 474 male workers. *Occupational and Environmental Medicine*, **62**, 559-566.

Brenner, H., Ahern, W. (2000) Sickness absence and early retirement on health grounds in the construction industry in Ireland *Occupational and Environmental Medicine*, **57**, 615-620.

Bureau of Labor Statistics, (2003) *Current Population Survey.*

Cook, S., Richardson, J, Gibb, A.G.F. & Bust, P.D. (2009) Raising awareness of the occupational health of older construction workers, cib W099 international conference, Melbourne, Australia

Cook, S; Gibb, A.G.F.; Richardson, J.; Walmsley, K. & Bullock, D. (2012) Loughborough University SKInS: wearable simulations of occupational health – defining specifications and product development, cib W099 international conference, Singapore, NUS, 358-367.

CONIAC (2009) Ageing Workers in the Construction Industry – their vulnerability and management, CONIAC Vulnerable Workers Working Group Information Paper, pp.1-10

Dainty, A.R.J., Gibb, A.G.F., Bust, P.D. & Goodier, C.I. (2007) Health, safety and welfare of migrant construction workers in the south east of England, Inst of Civil Eng, London, 54 pp

Eurostat (2009) Construction Sector Statistics, (accessed 01/05/13)

http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Construction_sector_statistics

Evans, W.J. and Hurley, B.F. (1995) Age, Gender and Muscular Strength, Journal of Gerontology, A (50A), 41-44, doi: 10.1093/gerona/50A.Special_Issue

FIEC website http://www.fiec.org/main.html Construction in Europe – key figures.

Guberan, E. And Usel, M. (1998) Permanent work incapacity, mortality and survival without work incapacity among occupations and social classes: a cohort study of ageing men in Geneva. *International Journal of Epidemiology*, **27**, 1026-1032.

Herberts, P., Kadefors, R., Broman., H., (1980) Arm positioning in manual tasks. *Ergonomics* **23** (7), 655-665

Health and Safety Executive (1997) Great Britain, The costs of accidents at work, HSG96, ISBN 0 7176 1343 7.

Health and Safety Executive (2002) Upper limb disorders in the workplace. *HSE Books*, Sudbury.

Health and Safety Executive (2011) Costs to Britain of workplace injuries and work-related ill health, 26 pp. http://www.hse.gov.uk/statistics/pdf/cost-to-britain.pdf (accessed 01/05/13)

Ilmarinen J. (2006) The ageing workforce – challenges for occupational health, Occupational Medicine, (Lond) 56 (6): 362-364. doi: 10.1093/occmed/kql046

Kines, P., Spangenberg, S., Dyreborg, J. (2007) Prioritizing occupational injury prevention in the construction industry: Injury severity or absence? *Journal of Safety Research*, **38**, 53-58.

Leaviss, J., Gibb, A.G.F. & Bust, P.D. (2008) Understanding the older worker in construction – meeting the challenges of an ageing society, SPARC – Strategic promotion of ageing research capacity, EPSRC/BBSRC SPARC initiative, 8pp

Mateman, S. & Rencoy, P.H. (2001) Undeclared Labour in Europe – Towards an integrated approach of combating undeclared labour, Amsterdam.

Nyateka, N, Dainty, A.R.J., Gibb, A.G.F. and Bust, P.D. (2012) Evaluating the role and effectiveness of training interventions in improving the occupational health and safety of younger construction workers: A literature review *In:* Smith, S.D (Ed.), *Proceedings 28th Annual ARCOM Conference*, 3-5 Sept 2012, Edinburgh, Association of Researchers in Construction Management, 455–64.

Nygard, C-H., Luopajarvi, T., Ilmarinen, J. (1991) Musculoskeletal capacity and its changes among aging municipal employees in different work categories. *Scandinavian Journal of Work, Environment and Health.* **17** (Suppl. 1) 110-117.

OSHA (2004) Website: http://ew2004.osha.europa.eu/static/whyconstruction

Schiybe, B., Hansen, A.F., Sogaard, K., Christensen, H. (2001) Aerobic power and muscle strength among young and elderly workers with and without physically demanding work tasks. *Applied Ergonomics*, **32**, 425-431.

Schneider, S., Lipinski., S., Schilternwolf. (2006) Occupations associated with a high risk of self-reported back pain: representative outcomes of a back pain prevalence study in the Federal Republic of Germany, *European Spine Journal*, **15**, 821-833

Vedder, J., Carey, E. (2005) A multi-level systems approach for the development of tools, equipment and work processes for the construction industry, *Applied Ergonomics*, **36**, 471-480.

Williams, E.Y; Gibb, A.G.F; Gyi, D.E; Haslam, R.A. (2011) Constructive Ageing: A Survey of Workers in the Construction Industry, cib W099 international conference, August, Washington DC, Virginia Tech publishing, CD, 14pp, www.workinglate-owl.org/

MAINSTREAMING EQUALITY IN CONSTRUCTION: THE CASE FOR ORGANISATIONAL JUSTICE

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Despite over 20 years of initiatives, research, and agendas the UK construction sector has failed to embed equality into business priorities and approaches; with both women and minority groups remaining under represented and unfairly treated in construction trades and the professions. Literature in this area shows low levels of retention amongst minority groups, high levels of discrimination and key talent from across the population finding the sector unappealing due to its macho image and the lack of diversity. We posit that, before equality can be realised in organisations, the majority of employees must perceive a base level of fairness. To understand how this can be achieved, a review of Organisational Justice is presented; a theoretical perspective which can explain how to encourage co-operation across the workforce. In exploring this we consider how the perceived focus on equality with respect to pre-existing out-groups works against group differential theory and, therefore, question whether the co-operation from the in-group must be necessary for any initiative to be successful.

Keywords: ethics, equality, diversity, fairness, inclusion, organisational justice.

INTRODUCTION

Over the last 20 years research has found that the construction industry faces on-going challenges around equality. There is a lack of representation of both women (Greed 2006; De Graft Johnson et al. 2009) and minority groups (Holloway 2005; EHRC 2009) with 13% and 7% current representation respectively (Office for National Statistics, 2012). At 13.9% the proportional numbers are slightly more encouraging regarding the number of people with disabilities working in the sector, however this stems from the industry's high accident rate rather than equal recruitment practices (Newton & Ormerod 2005). Information on other groups is currently lacking (De Graft Johnson et al. 2009). Although recruitment is an issue, retention of under-represented groups in the sector could be argued to be a bigger problem which has stemmed from lack of support, barriers to progression and discriminatory treatment (Bagilhole et al. 2002; Dainty et al. 2010; Holloway 2005; EHRC 2009). Efforts such as Respect for People (McCabe 2003) and Working Group 8 (Greed, 2000) have, in the same timeframe, failed to yield significant impact and the industry is seeking fresh

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McCarthy C, Thomson D and Dainty A (2013) Mainstreaming equality in construction *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 273-282.

ideas on how to progress the equality agenda. This is driven by a number of factors including legislation, procurement, business improvement and ethics (Caplan et al. 2009).

Historically, work to improve equality has focused on minority group or groups, presenting a case that the industry must change to meet their needs. In contrast, this paper posits that, on its own, such work could actually increase the challenges for minority groups by further reinforcing their out-group status. It further proposes that, in order for mainstreaming to be successful, the traditionally recognised requirements of leadership, training, resources and clear roles (Howard 2010) must be accompanied by a positive perception of organisational justice amongst organisational members. This can be achieved by 'mainstreaming' equality into collective organisational consciousness to the point where it is recognised as routine, and essential, aspects of work.

Mainstreaming

Equality literature establishes three main phases in the development of the concept of mainstreaming: 'equal treatment,' which gives support to individuals but does not seek to address past wrongs, much like equality of context (Scott & Marshall 2009); 'positive action,' which includes diversity management and puts measures in place to overcome historic obstacles such as stereotyping and bias given that these measures have been criticised for isolating equality and misconstruing or misrepresenting the message (Liff 2006); and 'mainstreaming,' which recognises organisational institutions as predisposed to able-bodied, straight, white males and finds that other groups struggle to gain the same access to employment, promotions and board appointments (Rees 1998). Greed (2005) defines this with regard to gender as “the systematic integration of gender into all systems and structures of governance, policies, programmes, processes and projects into ways of seeing and doing, into cultures and organisations.”

Policy and practice have moved away from diversity management and towards mainstreaming so, whilst it is still yet to be proven as a system of embedding equality, it is where current academic and practical interest is focusing and therefore where this paper is positioned.

The minimum requirements for gender mainstreaming (Howard 2010) to be recognised as a valid approach in organisations are generally agreed to be:

Leadership - positive policy commitment, with management support;

Strategy - incorporation of gender objectives into planning and implementation procedures;

Resources - experts acting as focal points with a catalytic role;

Training - awareness and skills-raising for all relevant personnel; and

Clear roles - clear identification of who has responsibility for implementation and a system of accountability.

Rees (2005) named three key principles to mainstreaming: treating the individual as a whole person; democracy and fairness; and justice and equity. Rees identified that many of the mainstreaming tools are the same as would be used in the diversity management agenda but, where diversity management is centred on the business case, mainstreaming arose from a social case due to its roots in fairness, justice and respect

(Rees 1998). In the work environment, employees will usually divide into "in" and "out" groups. In westernised societies in-groups can normally be defined as Male, White, Anglo-Saxon, Protestant (MWASP) whilst out-groups are typically those who do not fit this group (female, gay, ethnic minority, disabled, and so forth) (Stone-Romero & Stone 2005). Past efforts at equality in the workplace have focused on the perspective of the out-groups ensuring that their needs are recognised. Consideration has not been given to the perceptions of fairness as seen by the in-group, which could create a barrier to progress.

Critics of mainstreaming argue that it fails to manifest distinct leadership, encounters resistance among staff and is often ownerless (Brouwers 2013) meaning it can be hard to prove or disprove which organisations are substantively addressing the equality agenda and which are simply paying it lip service (Beveridge & Nott 2002). Much of this criticism cites a lack of co-operation amongst employees and leaders. Some organisations fail to “buy in” to the equality agenda simply using the terminology to appear current, with others only taking it up to access procurement frameworks (James et al. 2009). This suggests that the benefits of equality are not being realised and, whilst the business model has put forward the case for the organisation as a whole, the impact on the average individual worker has not been established. For mainstreaming to be successful it must do more than overcoming the employee resistance to new equality measures (which, Brouwers (2013) observes, is often exhibited as apathy and low prioritisation (Brouwers 2013)). Mainstreaming must also establish co-operation from employees as a majority. Howard (2010) notes that, in the case of gender mainstreaming, there is a tendency to see non-experts (which most employees are) as passive recipients rather than active resisters. She argues that, to move forward this agenda, employees' position must be better understood to create co-operation. It is here that the principles of organisational justice - the idea that people’s feelings of how fairly they have been treated are assessed in comparison to others - can be introduced to foster cooperation using group identity to establish a collective environment. Organisational justice can also explain why resistance to the mainstreaming of the equality agenda might emerge.

Organisational Justice

The central tenet of organisational justice is the idea that people’s feelings of how fairly they have been treated are assessed in comparison to others (Leopald 2002). Its literature has developed in four distinct waves (Colquitt et al. 2005): distributive, procedural, interactional and integrative.

Distributive justice, first coined by (Homans 1961), is based upon outputs such as pay, job status and status symbols, and inputs such as education, training and intelligence and effort extended on the job (Adams 1965). It finds that outputs and inputs must be equal to achieve employee satisfaction. Adams (1965) established that, when individuals perceived a situation as inequitable, they responded with either guilt (about whether output should exceed input), which caused them to increase input, or anger (if input exceeded output), which caused them to decrease input. Adams compared these findings to earlier studies of relative deprivation (Stouffer et al. 1949) and found that perceptions of fairness were linked to comparisons with others.

Procedural justice (Thibaut & Walker 1975; Leventhal 1980) advanced this theory by establishing that, if the process around the distribution of outcomes was determined as fair, negative emotions and reactions could be overridden. Procedural justice was, therefore, more concerned with the process followed when deciding on the resources

to be allocated than the allocation itself. Interactional justice (Bies & Moag 1986) was concerned with the interpersonal nature of procedures such as treating people with respect and sometimes also embraced the sometimes-distinguished informational justice (Jerald Greenberg 1993), which attempts to provide individuals with reasons for the decisions that are made. Some researchers consider interactional and informational justice to be part of procedural justice and are at pains to point out that the original studies never considered them to be separate (Stone-Romero & Stone 2005).

In the final wave, integrative justice, theorists attempted to integrate the previous three waves by working on models which allowed the consideration of all justice dimensions (Colquitt et al. 2005): it is within this area that this paper is positioned. Two such models - the group-based differential justice model and the group engagement model - are considered particularly insightful.

In and Out Groups: The group-based differential justice model

To understand why there might be resistance to a equality agenda the group-based differential model shows how members of the in-group react to the allocation of resources to out-groups. Organisational justice had failed to give any real consideration to discrimination towards out-group members until Stone-Romero and Stone (2005) proposed the group-based differential justice model which examined how those who allocated resources (allocators) behave with regard to the usually dominant in-group in comparison with out-group members. They found that, when allocating outputs, the measurement of inputs was influenced by the allocator's pre-existing beliefs. They also found that success by a member of an in-group was seen as ability, whereas failure was seen as being unlucky. Conversely, allocators saw out-group member success as luck whereas failure was seen as lack of ability. An example of this is seen in Dainty et al. (2000) where women were consistently given lower appraisal scores by their managers than their male counterparts. These findings have clear implications for the career progression of individuals in out-groups, but there are also implications regarding how this affects group dynamics. From a distributive justice position, even where outputs have been justly allocated, members of the in-group may perceive them to be unjust. This may result in a reactive reduction in input from the in-group or an attempt to make the out-group increase their input (Adams 1965; Bagilhole et al. 2002). If this approach fails then the in-group may display deviant behaviours (Aquino et al. 1999) either towards the organisation such as arriving late, ignoring instruction or theft (organisational deviance) or towards the individual such as teasing, gossiping, harassment, ethical or racial slurs (interpersonal deviance) in an attempt to restore perceived equilibrium. An example of deviant behaviour in construction can be seen in Dainty et al. (2000) where women were both overtly and covertly discriminated against by men. An additional factor that must be considered is the use of procedures to reinforce norms that favour the in-group (Stone-Romero & Stone 2005) such as promoting those who have strong peer support (Holloway, 2005).

Where the out-group individual perceives that there is a discrepancy in output or procedure, the out-group individual's response can be cognitive, attitudinal or behavioural. Cognitive reactions from the out-group can be balanced by either down-playing their own input to create psychological equilibrium or failing to recognise the variance in input from the in-group (Greenberg & McCarty, 1990). For example, female students may pass off sexist remarks from their lecturers as unintentional

(Powell et al. 2006). Attitudinal reactions can result in increased anger, decreased satisfaction, decreased organisational commitment and the intention to quit the job (Bagilhole et al. 2002). Behavioural reactions might comprise either increasing inputs or attempting to make the group decrease outputs, or organisational or interpersonal deviance action. All of the responses are likely to put additional strain on the out-group, affecting their productivity, happiness and identity in the workplace. Stone-Romero & Stone (2005) encourage further work in this area and acknowledge that there is currently not a strong enough body of work to support their theories substantially. Despite this call, little study of group based differential justice has occurred. Although there is some work from (Steiner & Bertolino 2006) which continues the discussion, it does not provide significant developments. Understanding of in-group and out-group behaviours needs to be considered alongside models of co-operation. Without this, efforts to mainstream equality risk being perceived by the in-group as an additional output of the out-group resulting in, at best, loss of productivity and, at worst, deviant behaviour from the in-group.

Organisational Justice and Co-operation: The group engagement model

Moving on to understanding how organisational justice can encourage co-operation, we consider the group engagement model. Since the powerful effect of perceived justice on the workplace had previously been established (Adams 1965; Greenberg 1990; Alexander & Ruderman 1987), Blader and Tyler (2005) felt that organisational justice could further explain how fairness in the workplace could encourage co-operation between employees. They identified relatively little work in this area and encouraged more; considering the next step to be understanding how to harness organisational justice to achieve a co-operative workforce. They identified a number of models of justice - particularly relational and identity models - as avenues for research into employee co-operation. The group engagement model (Tyler & Blader 2003), which does not differentiate between in-group and out-group members, argues that employees are not motivated by the resources given to them (Adam's (1965) distributive justice) or the way resources are allocated (Thibaut and Walker's (1975) procedural justice) but rather by how these actions inform group identity. Tyler and Blader (2003) proposed that perceived fair allocation of resources received by the group leads to pride and respect, which in turn creates a positive identity and leads to co-operation of the group members.

The group engagement model suggests that there are two stages to forming group identities: the first stage (first stage identity) involves social categorisation, where categories that define the group such as interests, tasks, gender, and so forth are used by the group to construct its own identity. In construction, these categories may encompass a tough working environment which can be expressed by enduring weather conditions, discomfort, as well as drinking and horse play. Combined with macho stereotypes and rejection of health and safety (Ness 2011), this provides a strong first stage identity. Employees perceive they must adopt this stance in order to be part of the group and thereby create an even more dangerous and challenging working environment (Caplan et al. 2009; EHRC, 2009; Greed, 2000).

The second stage (Figure. 1) involves linking views of self-worth to group membership through organisational justice. Where group identity is informed in the absence of organisational justice, the group works against the organisation displaying unproductive and disruptive behaviours (Aquino et al. 1999). Where the group perceives fair process and distribution, however, it works with the organisation and is

more likely to co-operate (Blader & Tyler 2009). In the construction sector, the second scenario is associated with low distributive and procedural justice; itself characterised by the long working hours, poor facilities, high health and safety risks and low pay often revealed as false self-employment (Harvey & Behling 2008; Ness 2011; Latham 1994; Constructing Excellence 2009). In the main, distributive and procedural justice is poorly applied with an adversarial culture remaining in the sector (Latham 1994; Constructing Excellence 2009).

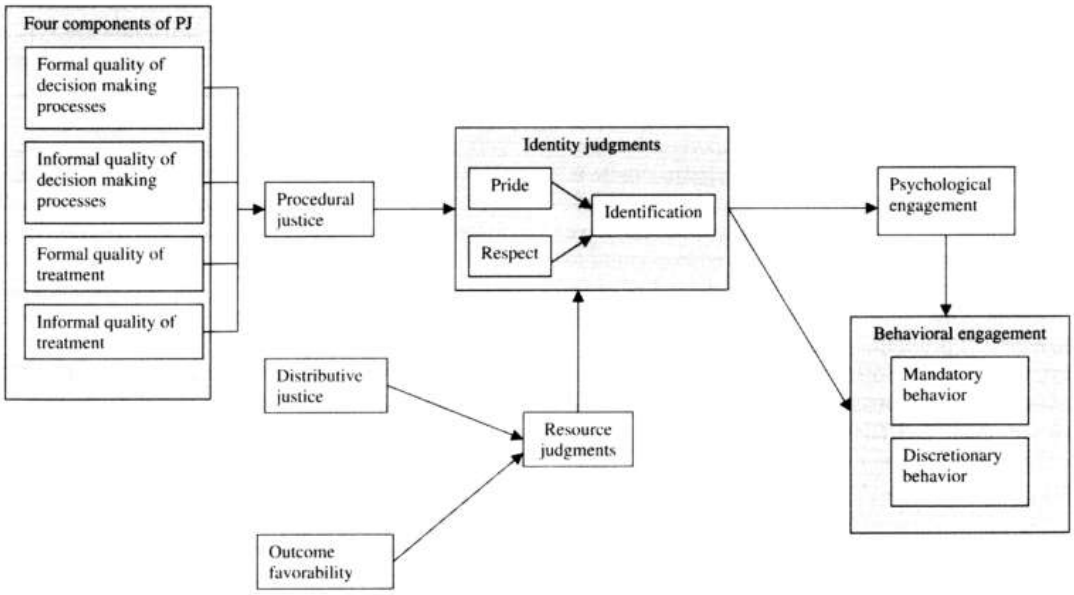

Figure 1. The Group Engagement Model (T. Tyler & S. Blader 2003)

Based upon the group-based differential model (Stone-Romero & Stone 2005) it would seem that an uncooperative group (i.e. a group perceiving low distributive and procedural justice) will lead to organisationally disruptive behaviour and interpersonally disruptive behaviour that will affect out-group members disproportionately. Where this deviant behaviour is directed at the organisation it will affect the return on investment of diversity initiatives (Kochan et al. 2003; Jehn et al. 1999). Where it is interpersonal, it will affect the attitudinal and behavioural response of out-group members, contributing to their low retention rate and high levels of discrimination. Any attempt to mainstream equality where these organisational traits are present will result in not only a negative response, but an amplified one.

Therefore, any attempt to mainstream equality must consider perceptions of organisational justice within the organisation or risk exacerbating the situation. It is proposed that in order to mainstream equality into any organisation the original requirements of leadership, training, resources, clear roles, strategy and management must be accompanied by perceived organisational justice. Figure 2 shows that that this model can be heavily influenced both positively and negatively by forces external to the organisation such as politics, procurement and the economy.

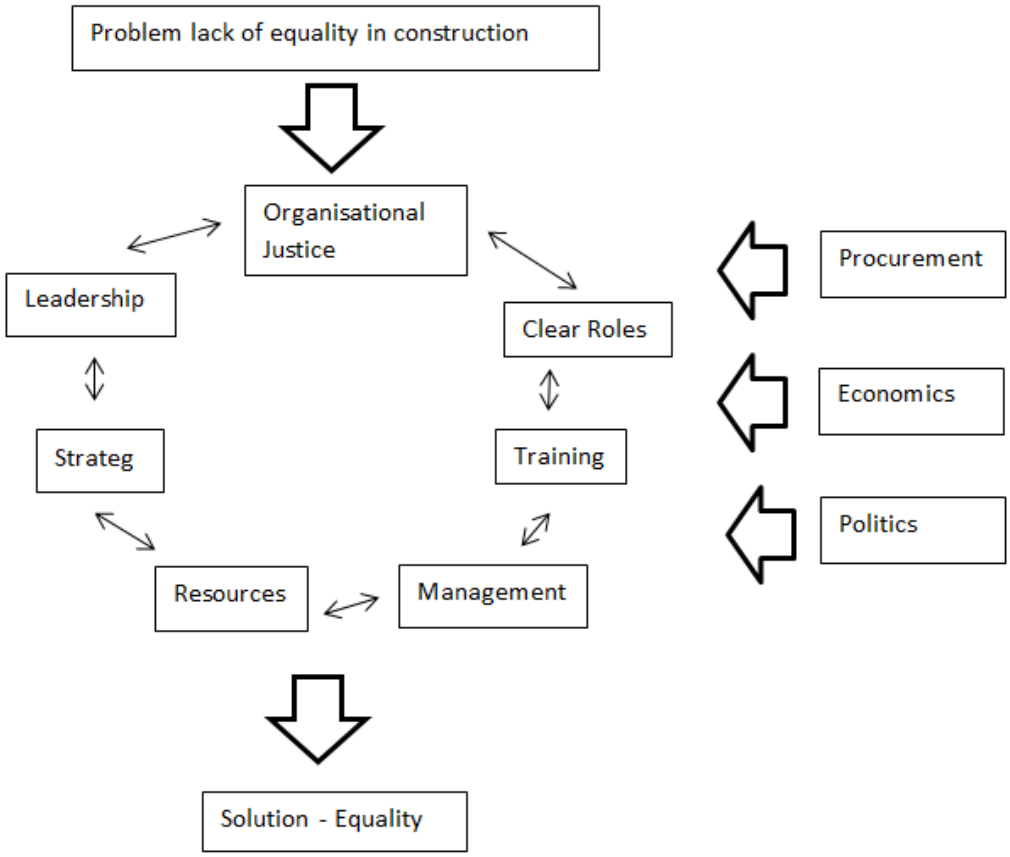

Figure 2. Requirements of mainstreaming

CONCLUSIONS

Whilst prior work on both discrimination and co-operation within the field of organisational justice remains limited, this initial review suggests that its principles can help explain some of the challenges faced by the construction industry when attempting to mainstream equality. Further work is now required to test the proposition that, in order to mainstream equality, construction organisations must consider organisational justice in the creation of a co-operative environment by building positive group identity through the use of the group engagement model and the group-based differential model to balance and thus dissipate in-groups and out-groups.

It is further proposed that achieving a co-operative environment through the use of organisational justice will allow equality mainstreaming practices a greater chance of success. This is attributed to an increased sense of pride and respect felt by the in-group as explained in the group engagement model. This theory could be tested in organisations undertaking mainstreaming initiatives by regular employee surveys that measure how employees responded to integrated justice perceptions of their and organisation. Survey results could be measured against social return on investment within the organisation to see if there is a link between perception of fairness and success of on-going mainstreaming.

REFERENCES

Adams, J., 1965. Inequity in social exchange. Advances in experimental and social psychology., 2, pp.267–299.

Alexander, S. & Ruderman, M., 1987. The role of procedural and distributive justice in organizational behavior. Social Justice Research, 1(1), p.177.

Aquino, K., Lewis, M.U. & Bradfield, M., 1999. Justice constructs, negative affectivity, and employee deviance: a proposed model and empirical test. Journal of Organizational Behavior, 20(7), pp.1073–1091.

Bagilhole, B.M., Dainty, Andrew R J & Neale, R.H., 2002. A Woman Engineer ' s Experiences of Working on British Construction Sites *. Int. J. Engng Ed., 18(4), pp.422–429.

Beveridge, F. & Nott, S., 2002. Mainstreaming: A case for optimism and cynicism. Feminist Legal Studies, 10(3), pp.299–311.

Bies, R.J. & Moag, J.S., 1986. Interactional justice: Communication criteria of fairness. In Research on Negotiation in Organizations. JAI Press.

Blader, S.L. & Tyler, T.R., 2005. How can theories of organizational justice explain the effects of fairness. In Handbook of Organisational Justice. Mahwah New Jersey: lawrence Erlbaum Associates, pp. 329–354.

Blader, S.L. & Tyler, T.R., 2009. Testing and extending the group engagement model: linkages between social identity, procedural justice, economic outcomes, and extrarole behavior. The Journal of applied psychology, 94(2), pp.445–64. Brouwers, R., 2013. Revisiting gender mainstreaming in international development. Goodbye to an illusionary strategy. ISS Working Paper Series/General Series, (556). Caplan, A. et al., 2009. Race Discrimination in the Construction Industry : A Thematic Review.

Colquitt, J.A., Greenberg, J. & Zapata-Phelan, C.P., 2005. What is Organizational Justice? A historical Overview. In J. Greenberg & J. a. Colquitt, eds. Handbook of Organisational Justice. Mahwah: Psychology Press, pp. 3–58.

Constructing Excellence, 2009. Never waste a good crisis,

Dainty, Andrew R J, Bagilhole, B.M. & Neale, R.H., 2000. A grounded theory of women ' s career under- achievement in large UK construction companies. Construction Management and Economics, (October 2012), pp.37–41.

EHRC, 2009. Race Discrimination in the Construction Industry Inquiry.

Graft-johnson, A. De et al., 2009. Gathering and Reviewing Data on Diversity within the Construction Professions.

Greed, C, 2006. Social exclusion; women in construction. In A. Gale & M. Davidson, eds. Managing Diversity and Equality in Construction: Initiatives and Practice. Oxon: Taylor and Francis, pp. 71–97.

Greed, Clara, 2005. Overcoming the factors inhibiting the mainstreaming of gender into spatial planning policy in the United Kingdom. Urban Studies, 42(4), pp.719–749.

Greed, Clara, 2000. Women in the Construction Professions: Achieving Critical Mass. Gender, Work and Organization, 7(3), pp.181–196. Greenberg, J & McCarty, C., 1990. Comparable worth: A matter of justice. Research in personnel and human resources management., 8, pp.265–301.

Greenberg, J., 1990. Organizational Justice: Yesterday, Today, and Tomorrow. Journal of Management, 16(2), pp.399–432. Greenberg, Jerald, 1993. The Social Side of Fairness: Interpersonal and Informational Classes of Organisational Justice. In Justice in the workplace; approaching fairness in human resources management. Hillsdale NJ: lawrence Erlbaum Associates, pp. 79–103.

Harvey, M. & Behling, F., 2008. The evasion economy: false self-employment in the UK construction industry. A UCATT Report. Holloway, R., 2005. Black & Minority Ethnic Representation in the Built Environment Professions. CABE, (June).

Homans, G.C., 1961. Social Behavior: Its Elementary Forms, London: Routledge and Kegan Paul.

Howard, P.L., 2010. Beyond the " grim resisters ": towards more effective gender mainstreaming through stakeholder participation. Development in practice, 12(2), pp.164–176.

James, J., Williams, M. & James, P.D., 2009. Towards Measures of Equality,

Jehn, K. a., Northcraft, G.B. & Neale, M. a., 1999. Why Differences Make a Difference: A Field Study of Diversity, Conflict, and Performance in Workgroups. Administrative Science Quarterly, 44(4), p.741. Kochan, T. et al., 2003. The effects of diversity on business performance: Report of the diversity research network. Human Resource Management, 42(1), pp.3–21. Latham, M., 1994. Constructing the team: final report: joint review of procurement and contractual arrangements in the United Kingdom construction industry, London.

Leopald, J., 2002. Human Resources in Organisations,

Leventhal, G., 1980. What should be done with equity theory? In Social Exchange. New York: Plenum Press.

Liff, S., 2006. Diversity and equal opportunities: room for a constructive compromise? Human Resource Management Journal, 9(1), pp.65–75.

McCabe, S., 2003. The "respect for people initiative" - mere rhetoric or a new epoch in British construction? In People & Culture in Construction:

Ness, K., 2011. Constructing Masculinity in the Building Trades: "Most Jobs in the Construction Industry Can Be Done by Women". Gender, Work & Organization, doi: 10.11(j.1468-0432.2010.00551.x), p.no–no.

Newton, R. & Ormerod, M., 2005. Do disabled people have a place in the UK construction industry? Construction Management and Economics, 23(10), pp.1071–1081.

Office for National Statistics., 2012. Labour Force Survey,

Powell, A., Bagilhole, B.M. & Dainty, Andrew R.J., 2006. The problem of women's assimilation into UK engineering cultures: can critical mass work? Equal Opportunities International, 25(8), pp.688–699.

Rees, T., 1998. Mainstreaming equality into the european union First., London: Routledge.

Rees, T., 2005. Reflections on the uneven development of gender mainstreaming in Europe. International Feminist Journal of Politics, 7(4), pp.555–574.

Scott, J. & Marshall, G., 2009. A Dictionary of Sociology Third., Oxford: Oxford University Press.

Steiner, D. & Bertolino, M., 2006. The contributions of organizational justice theory to combating discrimination. Cahiers de l'Urmis, 11(2006). Stone-Romero, E.F. & Stone, D.L., 2005. How do organiszational justice concepts relate to discrimination and practice? In Handbook of Organisational Justice. Mahwah New Jersey: lawrence Erlbaum Associates, pp. 439–467.

Stouffer, S.A. et al., 1949. The American Soldier: Combat and Its Aftermath. 1st ed., New jersey: Princeton University Press. Available at:

Thibaut, J.W. & Walker, L., 1975. Procedural justice: A psychological analysis, Hillsdale NJ: L. Erlbaum Associates.

Tyler, T. & Blader, S., 2003. The group engagement model: Procedural justice, social identity, and cooperative behavior. Personality and social psychology review, 7(4), pp.349–361.

RE-THINKING THE APPROACHES TO MASS HOUSING DELIVERY IN NIGERIA: LESSONS FROM PAST HOUSING PROGRAMME IMPLEMENTATION

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Nigerian cities are experiencing increasing population and rising urbanisation rates which are inconsistent with the provision of adequate housing and urban infrastructure. This contradictory trend arises mostly from the failures of past efforts by the government and the private sector. In recent times, public-private partnerships have evolved at different urban centres to produce houses which are inaccessible to the low-income households. Consequently, a substantial population of the low-income households residing in the urban areas are accessing their housing through informal arrangements which are synonymous to the sprawling of substandard housing. This problem is evidenced by the deficiency of infrastructure, shortage of good housing, unplanned urban expansion, poor living condition, high residential rentals and deprivation. To examine these issues, a review of government's mass housing schemes is undertaken. Official policy papers, reports and academic literature covering the period from 1960 to 2010 were used to explicate the mass housing schemes. The findings indicates a consistent use of top-down approach to design and implement mass housing programmes, from the Federal to State and Local government levels. This approach failed to achieve desired results due to non engagement of relevant stakeholders (governmental actors, private institutions, land owners and end-users) in the funding, design and implementation of housing projects. Similarly, roles were over-centralised in Federal Government line agencies which gave undue advantage to few individuals to monopolise the implementation processes. Furthermore, there was a lack of appropriate procurement regulations to address probity, accountability and efficiency concerns. In view of these findings, a bottom-up approach, the decentralisation of roles and partnership of multiple actors are recommended. These have potentials for solving the problems identified; therefore, further research could empirically verify this claim.

Keywords: housing, bottom-up approach, top-down approach, national policy

INTRODUCTION

The post independence arrangement of housing provision in Nigeria can be split into two eras; state-led approach and market friendly system. In approximate terms, the state-led era began from 1960 to 1990 and the market friendly system was introduced in 1991 and remains operational till date. These two eras are marked by contrasting

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Jambol DD, Molwus JJ and Daniel MM (2013) Re-thinking the approaches to mass housing delivery in Nigeria *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 285-295

ideological stance, policy framework, strategies, and actions (FGN-Housing Policy, 1991, 2006). Studies however, documented that the two eras share similarities of worrisome and awful inefficiencies and ineffective arrangements for the supply of housing to meet growing demand ((Ikejiofor, 1999).

Since independence in 1960, the population of Nigeria has been on the rise. In 1963, the population estimate was put at 55.6 million (Metz, 1992 p.94), it rose to 88,992,220 in 1991, 140,431,790 in 2006 (FGN-National Population Commission, 2010) and 162.47 million in 2011 (World Bank, 2010). This population growth rate makes Nigeria one of the most populous countries in Sub-Saharan African region (World Bank, 2009). There has been a rapid occurrence of urbanisation in Nigeria and it is estimated that 48 percent of the population resides in urban areas (World Bank, 2009 p. 119). By this estimate, Nigeria has become one of the most urbanising countries in the Sub-Sahara African region (Hitimana, Heinrigs, and Trémolières, 2011; Akinbamijo, 2012). The growing population of Nigeria is causing a demand pressure for adequate and affordable housing in urban and rural areas but the supply is not keeping pace with this rising demand. For instance, as of 2006, the official government records put the total number of houses at 28,197,085 (FGN-Housing Census, 2006) and this stock is made up of houses of varying standards such as: houses on separate stand (50.6 percent), traditional hut structures made of traditional materials (13.9 percent), flat in block of flats (9.7 percent), semi-detached houses (9.7 percent), rooms/let-in houses (13.6 percent), improvised dwellings (0.5 percent) and others (1.9 percent) FGN-Housing Census, 2006). Based on the combination of sub-standard housing stock and new demand, a prevailing deficit of between 12 - 16 million housing units has been estimated (FGN-Housing Sector Reforms, 2006). This overwhelming shortage is rising regardless of the policies, strategies, and actions which the government has pursued since independence.

In view of the present housing situation in Nigeria, it is necessary to provide answers to a number of questions: what are the key variables that influence the outcomes of past housing programmes? On what basis could a case for a rethink on present housing approach be made?

RESEARCH METHODOLOGY AND CONTEXT

The methodological approach adopted for this study is premised on the idea that housing is a complex commodity and its provision require multiple components such as finance, land, infrastructure, labour and building materials. These components are organised and shaped by legal, regulatory and institutional frameworks within which they operate. The forces that would often operate within any housing sector are policies, strategies, instruments and actions (UN-HABITAT, 2004 p. 4; 2010 p. 13). Conducting a study in such a complex context requires the selection of method that respect contingency (Jessop, 2008).

The sources of information used for this study include official policy papers, reports and peer review articles. The official policy papers and reports were obtained from the relevant authorities (the Federal Ministry of Housing and Urban Development, the Federal Mortgage Bank of Nigeria and the Federal Housing Authority) during a field visit and some were accessed from the websites of international agencies (such as the World Bank, the UNDP, and the UN-HABITAT). The academic literature (journal articles and conference papers) were mostly retrieved from the internet. As not all the archival records were accessible during the field visit, the review, therefore, is limited to the extent of resource availability at the time of writing this paper.

Four key interactive macro level processes of housing provision were reviewed, these include: policy framework and institutional arrangement, funding mechanism, housing project implementation and allocation process. The review is limited to this scope, bearing in mind that all knowledge is partial, provisional, and incomplete-able (Jessop, 2008).

THE STATE-LED HOUSING PROVISION ATTEMPTS

This section reviews the attempts by government to provide housing and factors that influence outcomes which can be summarised into four key aspects: housing policy framework and institutional concerns; funding mechanisms; project implementation; and allocation process.

Inappropriate Policy Framework and Institutional Concerns

Starting from 1960 till early 80s, Nigeria's national development programme was based on a socialist political ideology and the Keynesian central command type of economic planning. On the basis of this ideology, five yearly National Development Planning (NDP) systems were introduced and the chronology of the Plans is presented in Table 1. It is important to note that, the idea of NDPs was later replaced with three-year overlapping National Rolling Plans (NRPs) in 1990 and as of 2001, about six of such Plans have been implemented (Mongabay, 2010). Furthermore, the institutional arrangement for housing provision in Nigeria developed within the overall process of national development and the key interactive variables that affected housing provision are summarised in figure 1. Previous studies (for example, Achuenu and Achuenu, 2008; Olotua and Babadoy, 2009; Ademiluyi, 2010) concluded that housing provision was neglected in the first and second NDPs, this review has clearly shown that with the prevailing developmental circumstances at that time such neglect was expedient.

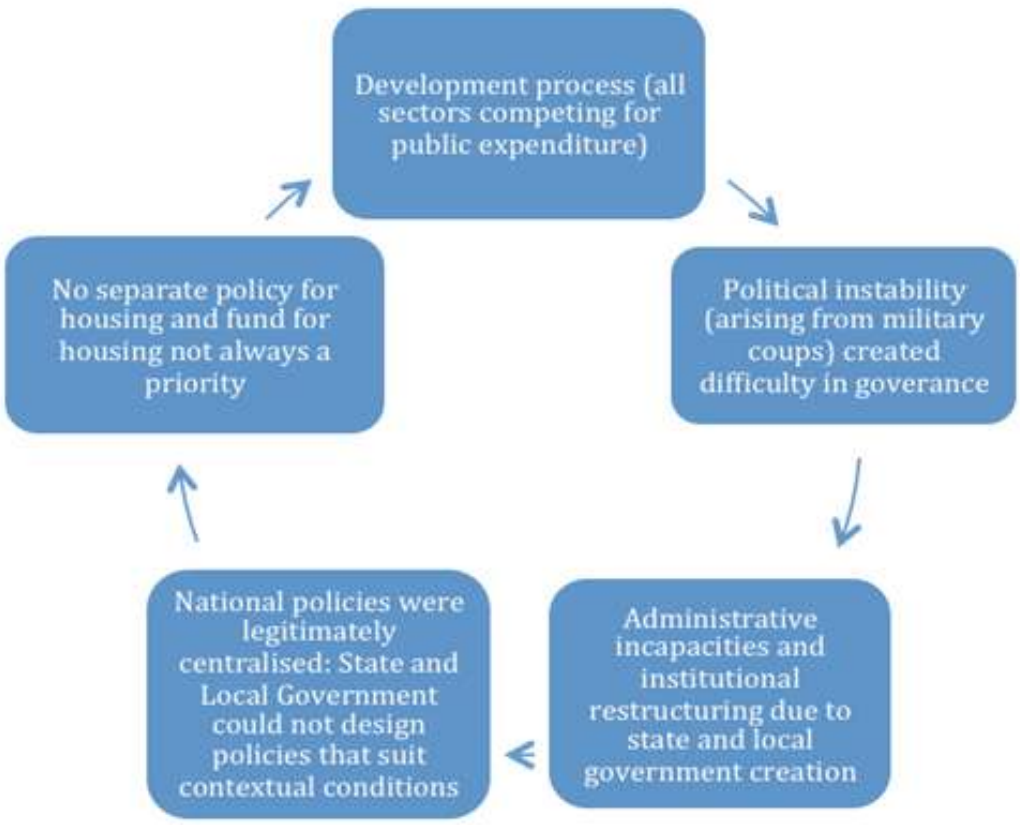

Figure 1: Interactive issues influencing the supply of housing

Unsustainable Funding Mechanisms

Public expenditure for housing first appeared in official government records in early 70s and this was in the period when the second NDP was being implemented. Prior to this time, other welfare items such as health, education, cooperative social welfare, water supply had received budget priority but this was not the case with housing. When housing first received budget attention, it was only the federal government that provided funding while state and local governments did not (Ekundare, 1971). Similarly, the capital expenditure schedule shows that housing was not initially included but an afterthought allocation of ₦2.634 million was later made (Awotona, 1990). In the third and fourth NDPs and the fourth NRP, budget estimates (in Nigerian Naira) of ₦1.830 billion, ₦2.686 billion and ₦2.0 billion were respectively provided by the federal government. The values of these amounts of monies were good in the periods at which the budgets were made because the exchange rate of Nigerian currency (₦) to US dollar ($) was almost at par and the inflation rate was at a single digit in some of the periods. For instance, the exchange rate of ₦0.66 to 1US$ was recorded in 1973 and the inflation rate was put at 5.4 percent (Metz, 1992). In 1982 the exchange rate of ₦0.67 and inflation rate of 5.6 percent were recorded and similarly in 1991, the exchange rate of ₦9.91 and inflation of 12.7 percent were recorded (Imimole and Enoma, 2011 p. 12; Onwioduokit (1999 p.3). The budgetary provisions, number of houses projected to be provided and number of houses actually provided during these periods are presented in Table 1.

Table 1: Federal Government housing budget and milestone

Period		Budget amount	Number of houses projected	Outcome
1st NDP	1962-68	-	24,000	About 500 units completed (*)
2nd NDP	1970-74	₦2.634 million	54,000	- (**)
3rd NDP	1975-80	₦1.830 billion	66,000	About 23.3 % success rate (***)
4th NDP	1982-86	₦2.686 billion	440,000	About 13.3 % success rate (****)
5th NDP	1987-89	Projects were suspended due to economic recession and government's focus turned to implementation of Structural Adjustment Programme (SAP) (******)		
1st NRP	1990-92			
2nd NRP	1991-93	Consolidating on SAP and dealing with macroeconomic issues (******)		
3rd NRP	1993-95			
4th NRP	1994-96	₦2.0billion	121,000	About 2000 units completed (******)
5th NRP	1997-99	-	-	- (******)
6th NRP	1999-01	-	-	- (******)

***Sources**: (*) FGN (1962); (**)Ekundare, (1971); (***)Lewis (1977); (****)UNDP (1982); Awotona, (1990); Ikejiofor (1999); (******)Ademiluyi (2010); Onwe et al (2013).*

Other arrangements for the financing of housing in Nigeria were also not adequate. For instance, the FMBN housing loan arrangement scheme started in 1977 after the federal government, through the Indigenisation Policy transformed Nigerian Building Society (NBS) into FMBN (Ademiluyi, 2010). The bank was lacking robust resources to finance mortgages such that from 1979 to 1983, it received 2,798 applications but only granted loan to 538 applicants (UN-HABITAT, 2001 p. 25). Another arrangement through which public housing was funded is the Employers' Housing Loan Scheme. This scheme started in the 70s but the amount of loan provided to workers is not well documented in public records and academic literature. It is also clear from the evidences presented in Table 1 that the federal government was not consistent in providing funding for housing through the NDPs and NRPs.

The participation of state governments in funding public housing started during the second NDP but like the federal government, they were not consistent in providing the funding. Awotona (1990) confirmed this evidence and also revealed that housing received less priority in state governments' budget compared to other welfare services. During the second NDP for instance, the aggregate expenditure of 11 states on health care services was ₦87.362 million, the expenditure on education was ₦179.542million and town and country planning including housing provision received an expenditure of ₦27.576 million. The situation was similar in subsequent NDPs and NRPs and more worrisome was the non participation of LGCs in the funding of housing (Ikejiofor, 1998 & 1999; Ademiluyi, 2010).

Poor Administration of Project implementation

The evidences presented in Table 1 clearly show the failure rates that occurred from the efforts at provision of housing by the federal government through NDPs and NRPs. Identifying the reasons for the failure of these efforts will guide future efforts

at housing provision. There are multiple variables that accounted for the poor performances as summarised in Table 2.

Table 2: Key variables influencing housing project implementation

Key variables	Manifestation of problems	Effects
Poor organisational framework	Use of top-down model of design and implementation of projects Monopoly over the administration of project implementation by Federal Government agencies Small group of individuals became too powerful and exerted considerable influences over the implementation process Volume of projects to implement at certain time outweigh the administrative capacity of implementation agencies Local Government Agencies, Community Based Organisation and Non-Governmental Organisations were left out	Over-centralisation of roles in few agencies, lack of probity, accountability, transparency and failures (+)
Inadequate procurement regulation	A lack of a uniform procurement regulation and permanent arrangement for control and surveillance Proliferation of Tender Boards which have limited mandate and power to decide contract *de facto* resting with politicians and bureaucrats Procurement process was handled by officers that lacked relevant skills and knowledge	Bribery, corruption, contract collusion, 'ghost contracts', 'ghost contractors', inflations of contract cost and kickbacks (++)
Land acquisition issues	The land tenure try to take away land ownership from individuals and kinship groups The land tenure gave too much power to Governors to grant statutory rights on land to give consent transfer of landed properties Land ownership tussles between kinship groups and governments causes delay in land acquisition for housing development Seeking consent from Governor before carrying transaction creature delay for investors.	Delays over land acquisition process, inadequate compensation payment to dispossessed land owners and reluctance (of kinship groups and individuals) to sell land to government and private investors. (+++)

Sources: (+) Ikejiorfor, 1999, 1998,1999; Ademiluyi, 2010; (++)Oguonu, 2005; World Bank, 2010; (+++) Otubo,2012; Awotona, 1978, 1989

Faulty Allocation process

The arrangement for allocation of housing by government agencies to beneficiaries in Nigeria was faulty during the state-led approaches and this created some major concerns which are summarised in figure 2.

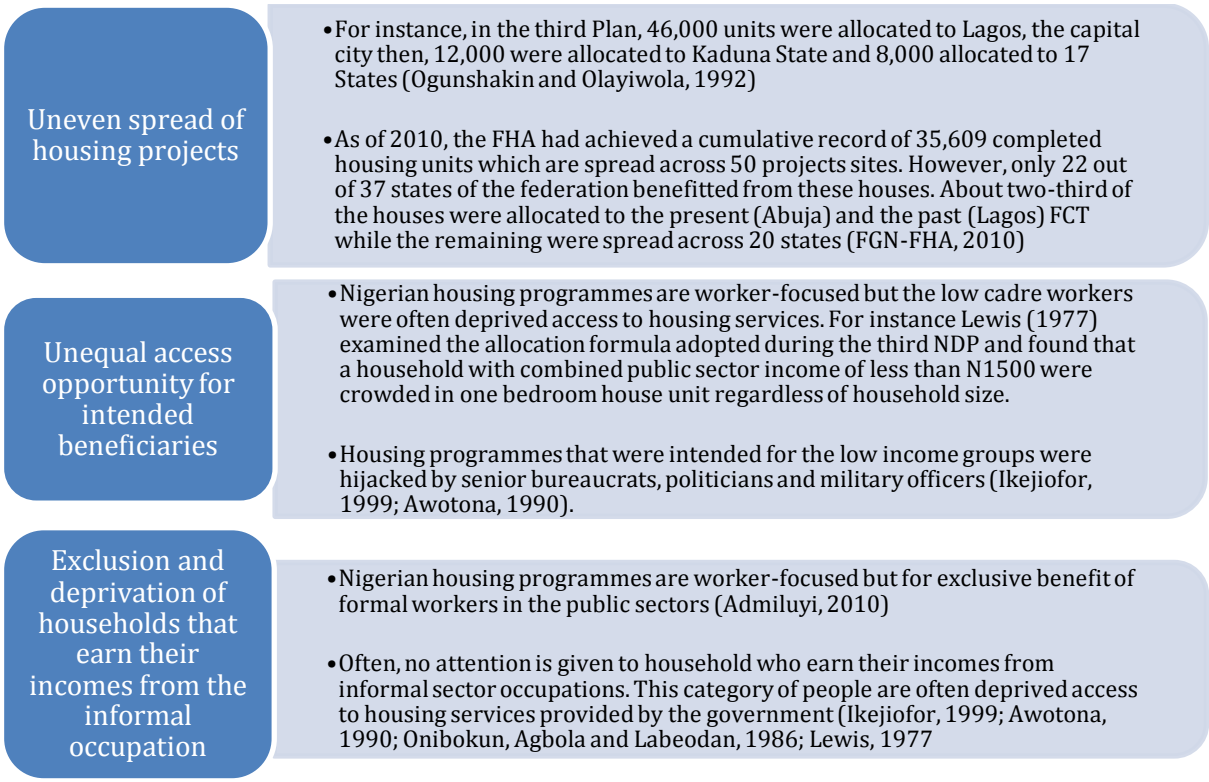

Figure 2: Factors arising from faulty process of housing allocation in Nigeria

SHIFT TO MARKET FRIENDLY SYSTEM

Since the late 80s, most developing countries have experienced a shift in policy thrust from direct provision of housing, to enabling the provision of shelter. This policy change started occurring in developing countries of Asia (Sri Lanka, Thailand, Indonesia among others), South America (Costa Rica, Mexico, Brazil, and Chile among others), the Sub-Saharan Africa (South Africa, Zimbabwe, Nigeria, Namibia, Tanzania, Kenya, among others) and the Arab Region (Jordan among others) (UN-HABITAT, 2000 & 2006), after the concept of the "enabling approach to shelter" was introduced by the United Nations and its agencies (UN-HABITAT and UNDP) in 1988 (UN-HABITAT, 2004). The concept of "enabling shelter strategies," as it is has been popularised in successive documents of UN Agencies "*calls for a fundamental shift in the role of government, from provider to enabler. This is clearly outlined in the "Global Shelter Strategy to the Year 2000" and the "Habitat Agenda"*(UN-HABITAT, 2004 p. 1).

In response to this policy agenda, the Federal Government of Nigeria introduced the 1991 National Housing Policy which was revised in 2006 and 2011 respectively (FGN-NHP, 1991, 2006 & 2011). The design of 1991 and 2006 housing policy was both hinged on a number of assumptions. First, by 1991, Nigeria was already in a recessionary phase which was being addressed through SAP. The experience of SAP had pushed for neo-liberal macro economic framework in Nigeria and therefore, the 1991 housing policy was itself a neo-liberal policy of a sort. In recent policy documents, the assumptions of neo-liberalism and market mechanisms were further emphasised (FGN-NHP, 2006, 2011). One of the key assumptions of the subsisting housing policy is that liberalisation programme will promote growth of private institutions which could then partner with government agencies to finance the supply of low-income housing. It is on the basis of this assumption that the roles of the

Federal Mortgage Bank of Nigeria (FMBN) were redefined by the provisions of the National Housing Fund Act of 1992 and the FMBN Act of 1993 to serve as a networking agent. However, studies (Ibem, 2010; Ikejiofor, 1999) have document the impracticality of these Statutes and policy. Furthermore, the federal government has transferred the responsibility of housing provision to State and Local government authorities on the assumption that they would organise the provision at their respective domains (FGN-NHP, 2006). This aspiration has not been fulfilled and it is as a result of this failure that a case for a rethink is made.

CONCLUSIONS AND RECOMMENDATIONS

Previous efforts at increasing the supply of low-income housing through mass provision have not been successful in Nigeria. This study identifies fundamental issues in the policy framework, funding mechanism and organisational arrangement for housing production and allocation. Proposals for a rethink are made based on these findings (see figure 3).

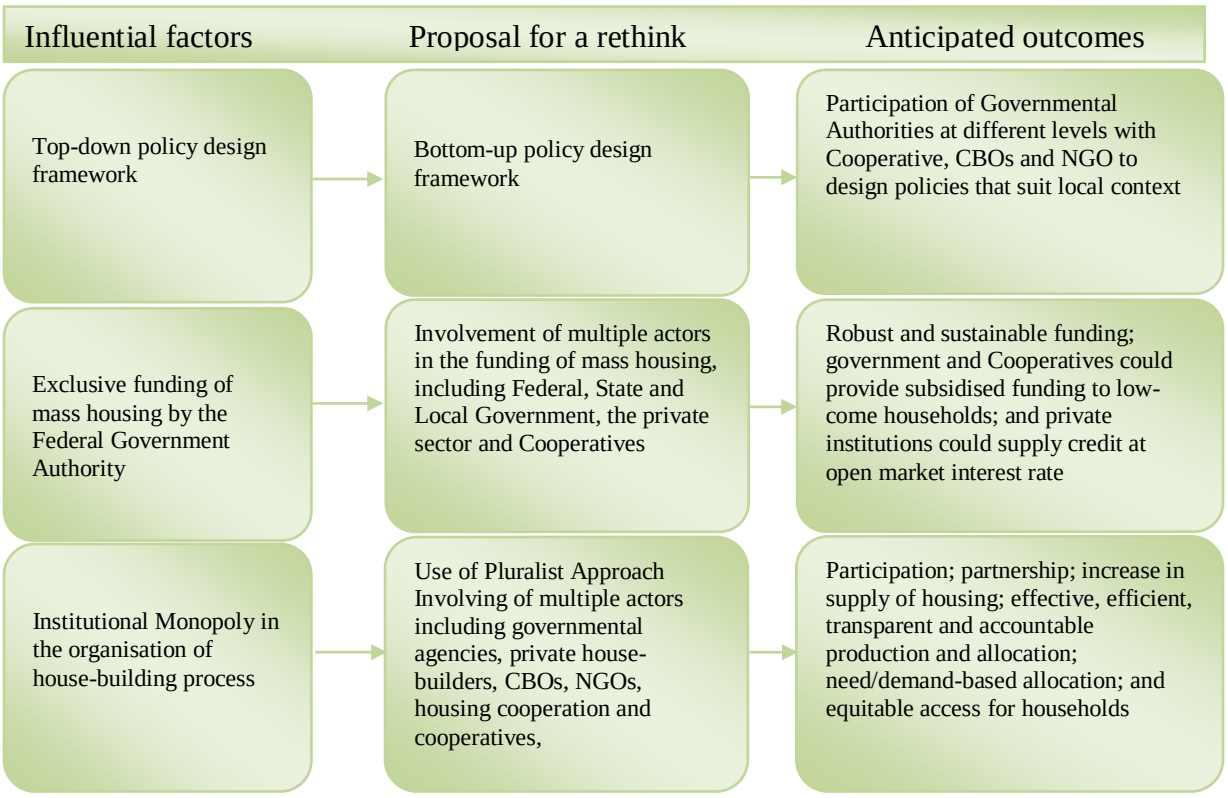

Figure 3: Summary of factors influencing the provision mass housing, proposals for a rethink and the anticipated outcomes

It is argued that reversing institutional monopoly and promoting institutional pluralism at local level through partnership and participation of key stakeholders (government agencies, households, land owners, private developers and financers, CBOs, NGOs etc) could increase the supply of low-income housing. It is also speculated that the engagement of multiple actors (stakeholders) at different levels of housing decision and implementation could lead to efficient, transparent and accountable provision of housing. This is the bottom up approach as opposed to the top down approach that is currently practiced in Nigeria. Empirical studies can examine the perspectives of stakeholders on these claims. It is important to note that governments in other parts of the world have adopted the objective of involving the public in planning decisions on matters that affect them. The Organisation for Economic Co-operation and

Development (OECD, 1996) observed the significance of public participation in various planning and development projects in Japan, Australia and Canada. Germany for instance, included requirements for public participation in its planning legislation - the Federal Building Code (Pahl-Weber and Henckel, 2008). Elsewhere in the United States of America and United Kingdom, government have supported, encouraged and adopted the use of design charrette and other public engagement techniques to involve all relevant stakeholders in development strategies and project implementation. It is possible for the government of Nigeria to utilize these techniques in addressing the problems facing the provision of housing to meet demands through successful implementation of projects. The application/applicability of these and other bottom up approaches within the Nigerian cultural, administrative and legislative systems will be investigated in future research.

REFERENCES

Achuenu, E. and Achuenu, S. A. (2008). Social Housing: An Initiative for increasing housing stock in Nigeria. *Journal of Environmental Sciences,* 12 (1), 129-138.

Adedokun, O. A. et al. (2011). Evaluation of the performance of national housing fund scheme toward housing delivery in Nigeria. *Journal of emerging trends in economic and management sciences (JETEMS),* **2** (6), 467-471.

Ademiluyi, I. A. (2010). Public housing delivery strategies in Nigeria: A historical perspective of policies and programmes. *Journal of sustainable development in Africa,* **12** (6), 153-161.

Akinbamijo O. B. (2012). Urbanization and Socio Economic Position Analysis – An Approach to Housing and Health Relationships in Residential Districts of Nigerian Cities. *The Built & Human Environment Review,* 5 (2012), 1-12.

Awotona, A. (1987). Government Policies for Housing Nigeria's Urban Poor and the Working Class: Laudable Promises, Great Expectations, and Colossal Failure. *HABITAT INTL.*, 11 (2), 89-103.

Awotona, A. (1990). Nigerian government participation in housing: 1970–1980. *Habitat international,* **14** (1), 17-40.

David, A. P. (2007). Path dependence - A foundational concept for historical social change. *Cliometrica journal of historical economics and econometric theory,* **1** (2), 91-114.

EFInA and FinMark Trust (2010). *Overview of the housing finance sector in Nigeria.* UK & USA, EFInA & FinMark Trust - Funded by UKDFID and Bill and Melinda Gates Foundation. Access to housing finance in Africa.

Ekundare, R. O. (1971). Nigeria's second national development plan as a weapon of social change. *African affairs,* 146-158.

Federal Government of Nigeria (1962). *Federal Government Programme 1962-68.* Sessional Paper No. 1, Federal Government of Nigeria, Lagos.

Federal Government of Nigeria (1991). National Housing Policy.

Federal Government of Nigeria (1992). *National housing fund act* 3. Abuja, Nigeria.

Federal Government of Nigeria (1993). *Federal mortgage bank of Nigeria act* 83. Abuja, Nigeria.

Federal Government of Nigeria (2006). *Housing Sector Reforms.* Abuja, Production, Publications and Documentation Department, Federal Ministry of Information and National Orientation.]

Federal Government of Nigeria (2006). *National housing policy.* Abuja, Federal Ministry of Lands, Housing and Urban Development.

Federal Government of Nigeria (2010). Schedule of Federal Housing Authority Completed Housing Projects. Federal Housing Authority, Abuja. Last accessed 22/04/2013 at: http://www.fha.gov.ng/index.php/past

Federal Government of Nigeria (2011) National Housing Policy (Revised). Draft submitted by Committee on the National Housing and Urban Development Policies.

Federal Government of Nigeria. (2010). *2006 population and housing census.* Abuja, National Population Commission.

Hitimana, L., Heinrigs, P. and Trémolières, M. (2011). West Africa Futures - Settlement, Market and Food Security. Sahel and West Africa Club Secretariat, Paris.

Ibem, E. O. (2010). An assessment of the role of government agencies in public-private partnerships in housing delivery in Nigeria. *Journal of construction in developing countries,* **15** (2), 23-48.

Ikejiofor, U. (1999). The god that failed: A critique of public housing in Nigeria, 1975–1995. *Habitat international,* **23** (2), 177-188.

Jessop, Bob (2008). *State power.* Policy Press, Cambridge, UK.

Lewis, A. O. (1977). Nigeria's third national development plan, 1975–80: An appraisal of objectives and policy frame. *The developing economies,* **15** (1), 60-79.

Metz, H. C. (ed.) (1992). *Nigeria, a Country Study.* Federal Research Division, Library of Congress, Washington D. C. USA.

Mongabay (2010). *Nigeria-planning.* [online]. Last accessed 12/06 2012 at: http://www.mongabay.com/history/nigeria/nigeria-planning.html

Oguonu, C. N. (2005). Due Process and Procurement in the Nigerian Public Sector. *Holler Africa.* [online]. Posted 2005. last accessed 24/01/2013 at: http://www.hollerafrica.com/showArticle.php?artId=248&catId=1&page=6.

Olotuah, A. O. and Bobadoye, S. A. (2009). Sustainable Housing Provision for the Urban Poor: A Review of Public Sector Intervention in Nigeria. *The Built & Human Environment Review,* **2** (2009), 51- 63.

Onibokun, A. G., Agbola, T. & Labeodan, O. (1989). World Bank assisted site-and-services projects: Evaluation of Nigeria's experiment. *HABITAT INTL,* **13** (3), 51-64.

Onwioduokit, E. A. (1999). Fiscal deficits and inflation dynamics in Nigeria: An empirical investigation of causal relationships. *Central bank of Nigeria economic and financial review,* **37** (2), 1-16.

Otubu, A. (2007). Land reforms and the future of land use act in Nigeria. *Nigerian current law review. (NIALS),* **2010**.

Pahl-Weber, E. & Henckel, D. (2008) The Planning System and Planning Terms in Germany – A Glossary. Akademie fu¨r Raumforschung und Landesplanung, Berlin, Germany.

UNDP (1982). *Second country programme for Nigeria.* United Nations Development Programme. Governing council special meeting - country and intercountry programmes and projects (DP/CP/NIR/NOTE/2).

UN-HABITAT (2001). *National Trends in housing Production Practices.* Volume 4, Information Services Section, Nairobi, Kenya.

UN-HABITAT (2004). *Enabling shelter strategies: Design and implementation guide for policy makers.* Nairobi, Kenya, United Nations Human Settlements Programme. Quick policy guide series (Volume 2).

World Bank (2009). Making finance work for Nigeria. Nigerian financial sector diagnostics series. The World Bank, Washington D. C.

World Bank (2010). Country Profile: Nigeria. World Development Indicators database, the World Bank, Washington D. C. USA. Last accessed 12/04/2013 at: http://ddp-ext.worldbank.org/ext/ddpreports/ViewSharedReport?REPORT_ID=9147&REQUEST_TYPE=VIEWADVANCED&DIMENSIONS=160

WORLD BANK. (2000). *Nigerian country procurement assessment report.* Nigeria, Nigeria Country Department, Africa Region. (22246/1).

HEALTH & SAFETY AND RESPECT FOR PEOPLE

ET IN ARCADIA EGO? 'ZERO TARGET' SAFETY PROGRAMMES IN THE UK CONSTRUCTION INDUSTRY

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Zero has become the biggest number in UK construction site safety. The emergence of zero within safety management programmes crosses industries and international boundaries, and has become a prominent safety feature of large construction contractors operating in the UK. However, zero has also attracted academic attention within these contexts; its practicality within practice as well as wider ethical and philosophical considerations. Indeed, a social constructionist perspective would suggest considerable variety in the way zero is approached, accepted and positioned within work and safety contexts. This incoherence will inevitably influence the reception and success of such programmes, and the potential for their impact in practice. 'Zero Harm', 'Mission Zero' and 'Target Zero', programmes currently in operation in the UK, may inspire commitment and safe working from some but disenchantment from others, depending on the individuals' constructions of safety in practice, the programmes' constructions of zero and safety, and the complex relationships between the two. Through a social constructionist approach, an initial exploration has been made of zero safety programmes within the UK construction industry. Discourse analysis was undertaken of the corporate promotional material for the programmes in the form of websites, reports and site signage, as well as talk data collected through conversations with site management and operatives who work with the programmes. The analysis found Zero constructed as both philosophy and target, the corporate and site voices developing alternative utopian visions in their incorporation of zero into practice. The findings identified incoherence and inconsistency in the wider discourses of zero, but also suggest it has a necessary place within industry health and safety management in order to support future developments and improvements in practice.

Keywords: discourse analysis, health and safety, social construction, zero

INTRODUCTION

'Zero Tolerance' entered the vernacular following the New York Police Department's tough stance on crime in the 1970s. More recently this approach has been adopted, developed and implemented around safety management on an international scale. 'Zero' has seeped into the rhetoric of safety, for example Scandinavia has set itself the 'Vision Zero' of accidents on its roads. This programme, which began in Sweden in 1997 has spread to neighbouring countries, and promotes a ' … new way of thinking about safety in road transport.' (Swuste 2012:1939).

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Sherratt F (2013) Et in Arcadia ego? 'zero target' safety programmes in the UK construction industry *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 299-308.

Within the construction industry zero accident cultures and programmes have also become popular (Wilkins 2011), a target proudly displayed on the hoardings of large construction sites throughout the UK. However, whilst a zero tolerance approach can be put into practice by those tasked with safety management on sites, to set 'target zero' is markedly different. The Olympic Delivery Authority adopted a 'zero tolerance' approach to unsafe practices and unhealthy working conditions on their project (Richardson 2006), which ultimately resulted in success. 12,000 people worked 80 million man hours in over five years to deliver the project, which was completed with an Accident Frequency Rate (AFR) of just 0.15 and no fatalities on the project for the first time in Olympic history (Wright 2012). Yet although this project can lay claim to zero fatalities, it did not achieve zero harm, or zero accidents; rather it achieved a highly impressive, albeit realistic safety record, which was acknowledged as such by the Royal Society for the Prevention of Accidents with a special Diamond Jubilee Award (RoSPA 2012).

The aim of this paper is to explore the use of zero within branded UK construction safety management programmes, rather than the association of zero tolerance with management practices. Yet this will inevitably examine to some extent how the former potentially affects the latter, and whether focus on a target of nothing is itself a distraction from the more practical matters of actually managing something (rather than nothing) on our sites.

CONSTRUCTING PARADISE

Despite significant improvements over the last decade, the construction industry remains 'high risk' (HSE 2012). Larger UK contractors continue to make efforts to improve this, supporting legislative adherence with sophisticated Safety Management Systems (SMSs). SMSs provide a structured approach to health and safety management (Howarth and Watson 2009), and often include a level of performance measurement (HSE 2006). Most recently the quest for a 'positive safety culture' has come to the fore (Dingsdag et al 2008). Zero Target safety programmes can be considered the next evolutionary step for safety management in practice. The target of zero is associated with performance measurement found within SMSs, yet this target is the ultimate goal rather than an incremental step on the road of continuous improvement. Zero Target programmes have also borrowed the safety culture use of 'identity', employing branding and engagement practices to deliver their message.

This is a paradigm shift in the underlying philosophical approach of safety management. Setting the ultimate goal to be achieved draws on enlightenment thinking, the belief that there will be an apocalypse after which ' … the flaws of human society will be forever abolished' (Gray 2007:2). This suggests there will be a moment of identifiable 'safety success', a realisation of a target achieved, a goal attained. The problematically practical nature of this 'apocalypse' is discussed later, however it naturally leads to the construction of the post-apocalyptic environment, a utopia in which zero accidents, incidents or ill health occurs. Yet since Thomas More introduced his Utopia in 1515, such thinking has been both lauded and derided.

In his work, Picture Imperfect, Jacoby (2007) calls for a revival of utopian thinking, the need to build 'castles in the sky', to picture a better society in which ' … practical reforms depend on utopian dreaming – or at least utopian thinking drives incremental improvements' (ibid 2007:1). Yet this challenges the construction of the Zero Target 'apocalypse'; a fixed value set to be achieved through articulated steps, in contrast to an emergent, organic process. Jacoby terms such constructions 'blueprint utopias',

where the future is mapped out in detail, a consequence of our ‘image-obsessed’ society (2005:xvii) where the propaganda around the utopian vision is more important that the thought behind the vision itself.

The contrasting utopian approach put forward by Jacoby is that of the 'iconoclastic utopia', where dreams of a better society remain just that, rather than articulated, detailed representations. This approach allows thinking to ‘ … escape the spell of the quotidian’ (Jacoby 2005:xvii), and would encourage questioning of the accepted 'norms' of construction health and safety practice. For example whether the recent absorption of health and safety into the realm of ‘Corporate Social Responsibility’ (Rawlinson and Farrell 2010) is beneficial to its management in practice, or simply relegation in status? Whether the continued application of SMSs to a production driven management system which neither supports nor fosters implementation in practice (Patel et al 2012) is admirable perseverance or a quixotic venture?

Indeed, this wider system emerges within more critical approaches to utopian thinking. Gray (2007:28) feels a project is utopian if there are no circumstances under which it can be realised. If a project seeks to eliminate the fundamental contradictions of human needs it will break down. Human needs in the construction site system are arguably focused on time and money, where people are essentially paid to work faster (Spanswick 2007) and take risks to get the job done (Channing 2008). Within the industry as it is presently structured, health and safety improvements are, by Gray’s definition, a utopian venture.

It is arguably the nuanced distinctions in approach and consideration of utopian or dystopian visions that are most critical. Despite the need for construction health and safety management to consider its utopia from an iconoclastic position, to challenge current practice to catalyse change, it has instead developed a blueprint approach with a focus on zero as the bull's-eye of the target.

The Devil is in the Details

Yet the actual target of 'zero target' programmes is not always clear. Scandinavia’s Vision Zero caused ‘ … confusion as to whether (it) is to be seen as a concrete goal or more general ethical imperative …’ (Swuste 2012:1939), an opinion that differed from country to country. Norway considered Vision Zero to be an ‘ … ethical foundation …’ that ‘… the vision was not be interpreted as a target …’ (Elvebakk and Steiro 2009:958). In contrast, Sweden set themselves very ambitious targets including a reduction in fatalities in traffic by 50% within a 10 year period.

This latter approach is reminiscent of the construction industry itself, and the grand gestures made at the safety summit of 2001. The Construction Industry Advisory Committee (CONIAC) pledged to beat the target of 10% reduction in fatal and major injury rates by 2010 set at the summit, and boldly committed to a reduction of two-thirds by 2010 (HSE 2009). Although industry achieved the 10% target, and continued in the same positive direction, it dramatically failed to make the giant leap to achieve the targets it set itself. Although targets give ideas ‘ … a certain weight and plausibility.’ (Jacoby 2007:32), providing comfort through the tangibility of measurement, commitment to a target does not mean automatic achievement, despite the celebrations that often accompany their announcements.

In the UK construction industry health and safety targets are somewhat sensitive, with recent concerns officially raised around the accuracy of major and 3-day accident reporting (HSE 2009). Setting a target of zero could encourage sites to ‘game the

system', to re-classify incidents to meet targets, or to seek out alternative processes for measurement. This relates to the achievement of Zero Target in practice; construction work is an ongoing process and although each project has a definite timescale, this does not translate to the wider organisation and achievement at a higher level of operations could prove problematic. Poor definition of parameters for success with regard to safety Key Performance Indicators has been shown to create vague claims of achievement; 'broadly achieved' (Rawlinson and Farrell 2010) can no longer be acceptable when the target is a very clear zero. As found in other applications of measurement to the potentially immeasurable, additional targets and more complex management controls are likely to be needed to support the initial target (Curtis 2007); 'zero' proving deceptive in its own simplicity.

Et in Arcadia Ego

Poussin's Arcadian Shepherds (1638-40) traced the carved words on the tomb in their utopia of Arcady, to read that 'I too am in Arcadia'; death was also with them in paradise. In the UK construction industry accidents, and deaths, also occur, and all too frequently. Sadly, they are such a part of the contemporary construction industry that a fatality on a site is often not even newsworthy.

Yet in their aim to eliminate all accidents, Zero Target programmes are stating that 'accidents won't happen'. However there is the potential for this approach to fall foul of its own constructions. Zero Target programmes must challenge the commonplace nature of accidents on sites, which suggest zero is unattainable in practice. Responses to the Scandinavian Vision Zero suggested the '… zero of Vision zero …' was ' … unrealistic … ' (Elvebakk and Steiro 2009:963). Such thinking may lead to instant dismissal of the programme as a consequence of its perceived unattainability. In setting a blueprint utopian target of zero the entire vision becomes vulnerable to just one incident; as a consequence of one accident the target becomes unachievable, it is lost, potentially disenchanting those it is seeking to inspire.

Arguably Zero Target programmes begin from an untenable position as defined by their own terminology. It has also been suggested that there has been a reluctance to consider that zero accidents would mean zero incidents, which would mean zero near misses, which would mean zero mistakes, which would be impossible (Hosier 2012). A further complication in the application of an unflinching Zero Target to the complex and messy social contexts of UK construction sites.

Tilting at Windmills?

The vision of Zero Target safety programmes is certainly not to be derided, indeed their intentions must be firmly supported, yet the construction and positioning of these programmes within the context of construction site safety raises concern. Whilst a paradigm shift is needed to move safety management on from its current plateau, setting Zero Target may not be the necessary catalyst. Where iconoclastic thinking is to be championed, the blueprint incarnations of Zero Target safety management in practice can be challenged philosophically, even by the most ardent supporters of utopian thinking in our anti-utopian age (Jacoby 2005). By their very construction, Zero Target programmes may inadvertently have a negative effect on the very environment they wish to change; the potential for disenchantment, disengagement, and their ultimate dismissal.

This study sought to examine how these blueprint utopian programmes are perceived in practice, how they are implemented by management through safety propaganda,

and whether they are supported or derided by the workforce they are seeking to protect; to explore whether they are seen as utopian visions, wider ethical approaches, concrete targets to be aimed for, or even whether they are ‘considered’ at all.

METHODOLOGY

This study took a social constructionist approach (Gergen 2009), examining the different constructions, associations and discourses that surround Zero Target programmes in practice. Two voices of Zero Target were sought; the corporate voice of the safety propaganda of the programmes as articulated by posters, leaflets and corporate web-pages; and the site voice of those who implement the programmes in practice and those who spend every day working with them.

Web-page data were collected from five large UK construction organisations, all of whom promoted a 'Zero' safety management programme. Navigation was made from the organisation's homepage to pages referencing the programme, and all pages were collected individually. In total nine webpages, two 'sustainability reports' and one corporate flyer were included in the documentary data. Two live sites, under the management of two of these organisations, were visited to collect further documentary and talk data. Documentary data comprised digital images of five site posters and one site hoarding, and one hard copy site safety guide. Nine semi-structured informal conversations were held with three managers and six operatives on the sites; a total of 28min34sec of talk was recorded and transcribed. Where elements of the transcripts are reproduced in this paper, I: indicates the voice of the researcher, R: the respondent.

The data was subsequently coded and discourse analysis undertaken (Augoustinos et al 2006). This fine grain approach (Horton-Salway 2001) enabled triangulation both within and between the different data sources, and enabled key themes within the data to be identified and developed (Potter and Wetherell 1992). The analytical process resulted in the development of a wide variety of discourses of Zero in practice, and also saw the re-emergence of several master discourses of 'safety' which have been previously identified in other safety research (Sherratt et al 2012).

Due to constraints of space, only the most prominent discourses have been presented here to enable both a consideration of the critiques found in the literature and a detailed exploration of the realities of Zero Target in practice.

FINDINGS AND DISCUSSION

Constructing Zero

The corporate voice presented zero through bespoke safety programmes, all of which positioned zero as part of a two word brand: Zero Harm (two organisations), Mission Zero, Target Zero and Beyond Zero. The first positions zero as the lack of negative action, although the use of harm is not restricted to health and safety, and indeed may be more immediately associated with environmental and sustainable considerations in some contexts. The other programmes position zero as a participant in an active process, with variations in that process as journey, fixed point or commencement point.

These brands were physically contained within logos, used as visual tags for safety management in practice both on the websites and the site documents. Beyond this iconography, significant variation developed in the constructions of zero within the dataset as a whole.

Within the talk of the operatives, zero itself did not emerge within their considerations of the Zero Target safety programmes. Rather the programmes were associated with practice, as illustrated in the talk of a subcontracted floor layer:

> I: obviously, being a (company name) site it's got (programme name).
>
> R: right
>
> I: what does that mean to you?
>
> R: well, just, you know, making sure everything that you do is done in a safe way

Here, the speaker positions the programme as relevant to all work practice, safety constructed as an inherent aspect of work, rather than a distinct practice itself. This construction was also personalised to the individual, although not the speaker himself, who placed responsibility for safety with the actions of 'you'. Within this extract, and indeed the talk that followed, focus remained on practice and zero was not invoked in any way; it was not considered until directly introduced by the researcher, and simply remained an inert aspect of the safety brand.

Zero did emerge through managers' talk in the construction of accidents, targets and approaches to safety management. These developed to form two associated constructions of zero; the intangible and tangible. Throughout the talk data, zero was most dominant in its intangible form; positioned as a 'philosophy', a 'mind-thing', an 'idea', an 'awareness'. This was also identifiable in the corporate voice, which positioned zero as a way of 'thinking' and, more complexly, a 'culture'; either seeking a cultural shift to assist in the attainment of zero, or positioning the process of zero as critical in the development of a new culture. This intangible zero often accompanied a discourse of practice, enabling the positioning of zero as process, to encompass the everyday practices of work without tangible challenges to their operational reality.

Yet such challenges emerged in both the talk of the management and from the corporate voice. An incoherent relationship developed between the intangible and the tangible; a 'vision with targets' supporting the desire to quantify a tangible zero, which was further developed and defined through the process of measurement itself.

Measuring Zero

Measurement by time constructed zero as a tangible target, a future year assigned to the achievement of zero by the corporate voice '… by 2012'. Yet setting a date for apocalyptic success can become nonsensical without further explication; whether the target is to be implemented from the target year onwards, or from a fixed point before in order to 'achieve zero' at this date, making it highly problematical in terms of parameters, measurable criteria and ultimately interpretation. However, this articulation could be deliberate, constructing associations with ongoing improvement and progress necessary to meet this target in the future, creating a reality in which action is needed now, to encourage and instil support for the programme within the workforce, without further articulating its measurement.

Yet this becomes highly problematic should the year be reached and the target not be achieved; despite making significant improvements in overall safety performance, Balfour Beatty did not achieve 'Zero Harm by 2012' and have yet to publically re-brand at the time of writing. Although measurement by time has the potential to create clashes with reality upon its inevitable arrival, it could also construct

commitment through the future positioning of the target to a point in time where reality may have changed to one where zero is attainable, if not the norm. This resonates with the more intangible constructions of zero, articulating a target in the future with time to work towards it, whilst continuing with everyday practice.

Positioning zero as a tangible, numerical target also creates the potential for just one accident to bring failure and cancel its attainment, as found in the talk of a directly employed site manager:

> I: has it made a difference?
>
> R: I believe it has, I mean the numbers say that it has, at least on some of the projects. Obviously you've got the odd project that something happens, and it ruins the figures, but most of them, yeah.

Here, the speaker associates zero with numbers and measurement, quantifying his evaluation and positioning of difference within site practice. Yet this construction of measurement as success is necessarily associated with ruin should an incident occur. The speaker does not clarify what this 'something' could be, and makes no evaluation of the incident in terms of severity or potential consequences to a worker in reality, rather the focus remains on numbers and measurement of safety.

One corporate voice did consider that just one accident could and would cancel achievement of zero, and repositioned zero as the target for ' … the next day', as an ongoing aspiration placed within a reality where accidents can and do occur. However, this particular construction of zero was also associated with a highly complex web of supporting targets and other health and safety measurement criteria. Whilst zero itself was constructed as fluid, improvement and measurement of improvement could still be made towards these associated tangible goals.

Measurement was frequently positioned as vital to the wider construction of zero; that it was ' … necessary to manage and improve performance', associating both with the ongoing process of zero, as well as zero as a tangible target. It often constructed zero through associated criteria, such as incremental reductions in AFRs, targets positioned as a measurement of ' … impact against …zero'. This approach constructed zero as something larger than the targets themselves, a solid and tangible entity, and the programme an attritional process in achieving the wider aim.

These various constructions of zero through measurement also hold repercussions for the attainment of success. Parameters of time or quantification construct zero as something tangible which can either meet with success or failure. Zero in its intangible construction arguably cannot fail or succeed, yet the everyday associations of measurement with any number make this evaluation to some extent unavoidable.

Achieving Zero

Positioning zero as a numerical target creates a goal to be achieved at a real point in time, and the inevitable construction of a post-apocalyptic utopia in which people will be ' … safe from harm'. Yet, within the talk data achievement of zero in practice was constructed as an unattainable, as illustrated in the talk of a directly employed gateman below:

> I: do you think we can actually get to (programme name) in reality?
>
> R: no

I: why?

R: well, its just like, you could never get rid of human error

I: right

R: so, obviously people are coming to work and they're working long hours and they're tired and things happen, but going back to the (programme name), if you've always got that in your head, there's always gonna be a minimum risk anyway.

I: right

R: but, like, you'll never get rid of injuries.

This speaker also associates zero with practice, positioning zero firmly within their own site reality in which people are the cause of unsafety, and the reason zero cannot be achieved. The speaker further develops this apportioning of blame by invoking the practice of work as a further causal factor, linking zero-people-work. Zero itself is constructed as intangible, something 'in your head', but this is subsequently positioned again within a reality of 'risk' and the speaker concludes that consequently the current reality will dominate; injuries can never be eliminated.

This reality emerged throughout the talk data; that it is people and practice that make zero unachievable. Safety management, legislation, PPE or other manifestations of safety in practice were not constructed as lacking, rather it was the fundamental 'nature' of the site itself. These discourses of 'safety and practice', safety as a hindrance to site practice, and site practice as a hindrance to safety (Sherratt et al 2012), have previously been identified as key to safety on sites.

Although the corporate voice positioned zero within a controllable and manageable site context, the operative voice struggled; the clinical, clean zero and the complex, confused site environment could not be reconciled within the context of everyday practice. Whilst zero is deceptively simple, people are simply complicated, and the practice of work on site is highly influential in the constructions of a reality of unsafety, in which zero remains a number that can never be attained.

However, this mythical status does not completely negate the value of zero in practice; no other number will do. Despite concerns with measurement, despite the potential for failure, despite the hostile context and despite the fact it is 'unachievable', zero was positioned within the talk data as an essential component of health and safety management on sites. Whilst setting an AFR target constructed a reality accepting of accidents; apocalyptic visions of zero did not. The apocalyptic discourse of elimination in the removal of accidents from sites was identifiable within the talk data, employed with no recourse to the events that might realise this in practice. This is arguably an iconoclastic utopian vision; Zero becomes a necessary goal. In contrast, the corporate apocalyptic discourse constructed a blueprint utopia, implementing Zero Target safety programmes through temporal and numerical measurement. This approach does not appear to have challenged the fundamental issues of practice that the site voice positions as critical in their reality of health and safety, and the ultimate attainment of Target Zero on sites.

CONCLUSIONS

The emergence of Zero Target safety programmes arguably reflects a wider societical desire to quantify and measure human life. Following the shift in political thinking of the 1990s and the application of scientific game theory to practice, target driven systems have become the norm (Curtis 2007). When health and safety on UK construction sites is considered, ethical and moral concerns become paramount. In an industry where Corporate Social Responsibility has developed into a significant marketing and pre-qualification tool for commercial success (Rawlinson and Farrell 2010), no target other than zero could ever be acceptable.

Consequently, the corporate voice of Zero Target speaks of an achievable tangible goal, positioned as future reality, which can be counted and measured through a plethora of targets. Yet this is challenged and derided by the workforce who position zero as an unachievable target, preferring instead an iconoclastic vision of zero. Their utopian vision operates beyond the current challenges of practice they face on a daily basis, and is simply content to look towards a potential future.

It is the desire for measurement that brings zero into an ugly reality, blueprint utopian thinking does not seek to challenge and change current practice; rather it aims to operate within the same hostile environment, seeking engagement of the workforce without addressing problems of practice. Furthermore, associations with measurement have arguably encouraged a focus on the numbers and continuous improvement, rather than the practices and the people behind them.

There is the potential for Zero Target thinking to bring change to health and safety management on UK construction sites, yet the approach must shift focus from the miniature, the numbers and the 0.01% improvements, and look to the bigger picture. To ask why practice is so prominently positioned as a challenge to zero, to ask why people are happy to position zero as a vision for the future, but remain derisive of its achievement within current working contexts. It is the Target that is arguably hindering the achievement of Zero, providing distraction and comfort in the application of numbers and mathematics to something that is actually about the complex, awkward and immeasurable world of people and practice.

REFERENCES

Augoustinos, M, Walker, I and Donaghue, N (2006) "Social Cognition: An Integrated Introduction". 2ed. London: Sage Publications Limited.

Berlin, I (2001) "The Power of Ideas", Ed Hardy H. London: Pimlico.

Channing, J E (2008) Risk Management and Behaviour Modification. In: J Ridley and J E Channing (Eds.) "Safety at Work". 7ed. Oxford: Butterworth Heinemann.

Curtis, A (2007) "The Trap: What Happened to Our Dream of Freedom - The Lonely Robot". 18th March 2007. UK: BBC2.

Dingsdag, D, Biggs, H and Sheahan, V L (2008) Understanding and defining OH&S competency for construction site positions: worker perceptions. "Safety Science", 46(4), 613-33.

Elvebakk, B and Steiro, T (2009) First principles, second hand: Perceptions and interpretations of vision zero in Norway. "Safety Science", 47, 958-66.

Gergen, K J (2009) "An Invitation to Social Construction". 2ed. London: Sage Publications Limited.

Gray, J (2007) "Black Mass: Apocalyptic Religion and the Death of Utopia". London: Penguin Books.

Howarth, T and Watson, P (2009) "Construction Safety Management". West Sussex: Wiley-Blackwell.

HSE (2006) " HSG65: Successful Health and Safety Management". London: HSE Books.

HSE (2009) "Underlying Causes of Construction Fatal Accidents - A comprehensive review of recent work to consolidate and summarise existing knowledge". Norwich: HMSO.

HSE (2012) "Construction – Work Related Injuries and Ill Health". Health and Safety Executive http://bit.ly/Sgu84d [6 March 2013].

Horton-Salway, M (2001) The Construction of M.E.: The Discursive Action Model. In: M. Weatherell, S. Taylor and S.J. Yates (Eds.) "Discourse as Data: A Guide for Analysis". London: Sage Publications Limited in association with the Open University, 147-188.

Hosier, F (2012) "Has 'zero' become a dirty word in safety?" Safety News Alert http://bit.ly/Zit4yM [20 December 2012].

Jackoby, R (2005) "Picture Imperfect: Utopian Thought for an Anti-Utopian Age". New York: Columbia University Press.

More, T (1515) trans Turner, P (1965) "Utopia". London: Penguin Books.

Patel, M, Sherratt, F and Farrell, P (2012) Exploring human error through the safety talk of utilities distribution operatives. In: Smith, S.D (Ed.). "Proceedings 28th Annual ARCOM Conference". 3-5 September 2012, Edinburgh, UK. Association of Researchers in Construction Management, 403–12.

Potter, J and Weatherell, M (1992) "Discourse and Social Psychology - Beyond Attitudes and Behaviour". London: Sage Publications Limited.

Poussin, N (1638-40) "The Arcadian Shepherds". oil on canvass. Musée du Louvre, Départment des Peintures, Paris.

Rawlinson, F and Farrell, P (2010) UK construction industry site health and safety management: an examination of promotional web material as an indicator of current direction. "Construction Innovation", 10(3), 435-46.

Richardson, S (2006) How will this man make the Games safe for workers? "Building" Delivering 2012 Supplement. November.

RoSPA (2012) "Diamond Jubilee marked with RoSPA award for London 2012 safety achievements" RoSAP http://bit.ly/10LY25c [29th June 2012].

Sherratt, F, Farrell, P and Noble, R (2012) Inconsistent, incomplete and incidental: Site safety culture from a constructionist perspective. In: Smith, S D (Ed.), "Proceedings 28th Annual ARCOM Conference". 3-5 September 2012, Edinburgh, UK. Association of Researchers in Construction Management, 393–402.

Spanswick, J (2007) Dangerous Drop. "Building" 06.

Swuste, P (2012) Editorial – WOS2010, on the road to vision zero? "Safety Science", 50, 1939-40.

Wilkins, J R (2011) Construction workers' perceptions of health and safety training programmes. "Construction Management and Economics", 29(10) 1017-26.

Wright, E (2012) Olympic Health and Safety: Record Breakers "Building" 1st June.

CONSTRUCTION MOTOR VEHICLE ACCIDENTS IN SOUTH AFRICA: CAUSES AND IMPACT

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The focus of health and safety (H&S) in South African construction has resulted in a decrease in all classes of injury. However, approximately 40% of fatalities are attributable to MVAs in the course of employment and MVAs contribute a substantial percentage to the other classes, in particular, non-fatal permanent disabling injuries. Given the limited extent of public transport, the location of many construction sites, and the general use of non-enclosed light delivery vehicles (LDVs) and flat-bed trucks to transport workers, which are not secured to secured seats with seat belts when being transported, a study was initiated to determine the nature of transport used to convey workers, the incidence of MVAs and the resultant injuries, and the causes of such MVAs. The study entailed the completion of a self-administered questionnaire by contractors registered with the Construction Industry Development Board (CIDB). Findings include: workers sitting on sides / or beds of vehicles predominates in terms of unsafe transport / traffic practices contribution to injuries arising from MVAs; lack of secured seats, lack of seat belts, and lack of roll over protection exacerbate the injuries incidental to MVAs, and fall from vehicle in motion predominates in terms of the cause of MVA related injuries. Recommendations include: the implementation of a comprehensive traffic safety programme in all construction organisations and on all projects; conveyance of workers in appropriate vehicles, and banning of mixed transportation of materials, plant and equipment, and workers

Keywords: accident, construction, fatality, South Africa

BACKGROUND

Although, motor vehicle accidents (MVAs) as a subject area have captured the attention of researchers in other countries such as Turkey and the United States of America (USA), this is not the case in South Africa. Despite the revelation inside the 2009 Construction Industry Development Board (cidb) report entitled 'Construction Health & Safety in South Africa: Status & Recommendations', the uptake in MVAs related studies can be considered non-existent in the sector. The cidb report revealed that with 47%, the dominating cause of fatalities among other causes is MVAs (cidb, 2009). This revelation corroborates a previous assertion that MVAs contribute

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Emuze F and Smallwood J (2013) Construction motor vehicle accidents in South Africa: causes and impact *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 311-321.

substantially to fatalities and injuries in construction because of common unsafe transport / traffic practices (Smallwood, 2002). Such practices are not limited to: non-wearing of seat belts; workers sitting on the sides and beds of vehicles; workers mounting or dismounting from moving vehicles and the overloading of vehicles, and non-roadworthiness of vehicles.

As mentioned earlier, the menace of MVAs have been addressed in, inter alia, Turkey. In fact Mungen and Gurcanli (2005) suggest that as the fourth leading cause of deaths in Turkish construction, MVAs related research and preventive safety efforts should be given a greater priority. In another empirical study conducted in Turkey, Gurcanli, Mungen and Akad (2008) observed that MVA related fatalities were due to negligence of basic safety measures. They suggested that employees responsible for traffic safety should be trained and H&S programmes should be continuously re-evaluated. These findings in the literature mirrored MVA related events in South Africa.

It is notable that MVAs involving construction workers are significant in work zones because of the severity of such accidents. Three of such accidents involving workers: worker struck-by vehicle inside work space; worker struck-by vehicle entering / exiting work space, and flagger struck-by vehicle; usually account for fatalities and injuries (Mohan and Zech, 2005). Thus, the overarching vision of this study is to reverse the increased MVAs related trend in South Africa through a literature review and a pilot survey conducted in South African construction. When these are concluded, they will form the basis for a comprehensive questionnaire and an interview guide that will generate the primary data for the study. The pilot survey constitutes the basis for this paper, which resulted from a study that was aimed at determining the nature of transport used to convey workers, the incidence of MVAs and the resultant injuries, and the causes of such MVAs.

RESEARCH RATIONALE

According to Emuze and Smallwood (2012), the South African construction industry is presently grappling with MVA related issues. They contend that in spite of increased awareness in the form of academic and media reports, MVAs appear to be increasing in South African construction. In particular, there has being a steady rise in MVAs in South African construction since 2001 when available statistics are considered. The statistics show that between year 2000 and 2006, the rank of MVAs among other causes was between 6 and 5. However, from 2007 onward, the statistics indicate an increase in the malaise. In particular, since 2007, the numbers of accidents have been oscillating between 850 and 950 as indicated in Table 1. It is notable that 984 MVAs and 63 fatalities occurred in the year 2010 alone. In effect, MVAs have emerged as a major cause of fatalities and permanent disabilities in South African construction. In order to examine the reporting of MVAs by the South African media, Emuze and Smallwood (2012) used 4 newspaper reports to illustrate the causes and impacts of MVAs in the sector. For example, a case shows that eyewitnesses reported that a ready mix concrete truck driver lost control while driving to a construction site. The vehicle swerved, overturned and crushed oncoming vehicles adjacent to the construction site (La Grange, 2009). Three people died in the accident.

As a result of consequences concerning permanent disabilities, fatalities among construction workers and the general public, and the increasing cost per accident, it can be argued that there is major scope for reversing the MVA trend in South Africa. Preliminary findings suggest that accidents that occur either on site or off-site are often due to H&S failures that could have being averted if, inter alia, the tenets of the

Construction Regulations were strictly upheld by the concerned parties (Emuze and Smallwood, 2012). The survey of the literature also indicates that inappropriate transportation of workers, overloading of vehicles, and mixed transportation are often causes of such MVAs.

Table 1 MVAs in South African construction from 2000 to 2011

Year	Accidents		Consequence (No.)	
	Percentage	No.	Fatality	Permanent Disability
2011	12.47	892	23	25
2010	10.85	984	63	57
2009	9.18	949	31	51
2008	8.35	910	31	30
2007	8.30	871	30	37
2006	6.95	629	34	29
2005	7.54	674	26	24
2004	7.66	624	28	26
2003	7.55	557	36	30
2002	8.15	561	33	29
2001	4.26	278	26	11
2000	3.59	264	15	11

Emuze and Smallwood (2012: 206)

LITERATURE REVIEW

The idea of conditional H&S and the notion that human behaviour is always influenced by systems issues beyond the control of workers are key H&S concepts underpinning MVA causation and prevention. This is perhaps valid as it is important to recognise that worker behaviour directly impact H&S outcomes, and that identifying critical behaviours such as precaution and controlling the systems involved, are valid methods to improve H&S performance outcomes (Mathis and Galloway, 2013). Such line of thinking has informed a number of MVAs or traffic studies.

In a recent study, Caroee and Singh (2012) examined different strategies adopted around the world to decrease the number of casualties in traffic. The study of these strategies addressed the different approaches, goals, and outcomes, and provided a comparison between the strategies, and a summary of best practices. Caroee and Singh (2012) noted that not only does 'Vision Zero' strategies decrease the number of people killed or seriously hurt in traffic, it also saves society money. The aim of 'Vision Zero' is to prevent traffic fatalities and people injured in traffic; it is not an attempt to prevent all accidents as it does improve road design, so if drivers follow the rules laid out by road designers, such as speed limits, seatbelts and not drinking and driving, then there will be no traffic fatalities or people seriously injured in traffic. Studies cited by Caroee and Singh (2012) determined that traffic accidents increase during construction times unless traffic rules are strictly enforced. However, they also

determined that traffic control and restraints can reduce traffic accidents. Therefore, the authors argued that a well-designed 'Vision Zero' for construction zones could be helpful to reach the goals of the vision.

However, compliance with regulations and legislation is reportedly sub-optimal in South Africa. That is, even if the government and the management of firms provide the minimum requirements to be met in terms of traffic and vehicular movement, the behaviour of workers is still critical to the achievement of zero MVAs. Othman (2012) conducted a study that researched the causes and effects of contractors' non-compliance with the Construction Regulations in South Africa and concluded that it appears that the importance of the regulations seems to have been overlooked. Othman (2012) noted that, inter alia, negligence and carelessness by labourers; lack of supervision; unskilled and uninformed workers, and lack of PPE constituted major sources of non-compliance. The net effects of these shortcomings are not limited to reduced productivity as well as increased injuries and fatalities.

Another USA based study that was reported in 1997 shows that construction workers were twice as likely to be killed by a motor vehicle; injury prevention efforts in construction have had limited effect on motor vehicle-related deaths, with death rates falling by only 11% during a 13-year period (1980-1992); construction accounts for more than one-fourth of all pedestrian deaths; and these pedestrian fatalities were mostly flaggers or surveyors (Ore and Fosbroke, 1997). As the leading cause of traumatic death in construction, exceeded only by falls, Ore and Fosbroke (1997) argued that the prevention of work-related motor vehicle research should become a greater priority in the construction industry. While this particular argument was made as far back as 1997, MVAs related studies have not enjoyed prominence in construction management related research in South Africa even as MVAS have been cited as a major cause of pedestrian injuries and fatalities in the country (Hobday and Knight, 2010). A focused review of the construction plant and equipment management research of Edwards and Holt (2009) also shows that MVAs have not gathered enough attention since it was missing from the H&S related discussions that were reported upon in terms of plant and equipment in construction.

METHODOLOGY

The preliminary literature review led to an exploratory quantitative survey that was conducted among all 62 medium and large sized general contractor members of the East Cape Master Builders Association (ECMBA) as categorised by the ECMBA, which constitutes an employer association for, inter alia, building contractors based and or operating in various cities and towns in the Eastern Cape Province of the Republic of South Africa. Although, only 15 responses were received and included in the analysis of the data, the pilot nature of the study at this stage mandates a future rigorous empirical study. Thus, the response rate of 24.2% realised for the pilot survey was deemed acceptable. It should be noted that two follow up communications were made in an endeavour to enhance the response rate. It is envisaged that the findings of this pilot survey will further inform future studies that are anticipated to use a mixed method approach.

In this pilot survey, the self-administered questionnaire that was delivered per e-mail consisted of 10 questions, 4 of which were 5-point Likert scale type questions. Due to the sensitive nature of the subject, demographic questions were not included, despite assurances of anonymity. The limited number of responses inferred that only

descriptive statistics in the form of percentages and mean scores could be computed for the presentation of the findings.

RESULTS OF THE PILOT SURVEY

When asked if they transported workers to and from and between construction sites, 93.3% of the respondents affirmed that their organisations did. Furthermore, all the firms (100%) used light delivery vehicles (LDVs) referred to as 'pickup' trucks in the USA, and 57.1% used flatbed trucks for transporting their workers. Whereas 40% of respondents' organisations simultaneously transport materials, plant and equipment, and workers; 60% do not. Of those that do, 83.3% used LDVs, and 16.7% used flatbed trucks. However, the analysis of the data shows that 26.7% of respondents' organisation's vehicles have been involved in accidents while transporting workers, 25% of which had had one accident, and 75% had had two accidents. In terms of incidence, those that had experienced two accidents had all experienced them over a period of five years, and the other organisation had experienced the one accident in 21 years. The accidents resulted in the following injuries: 1 fatality; 2 temporary disablements, and 2 medical-aid injuries. LDVs were involved in all (100%) the accidents. When asked if there is a need for a specially adapted construction vehicle to transport workers, 60% of respondents indicated yes, 20% indicated no, and 20% were unsure. Similarly, 33.3% of the respondents indicated that there is a need for a specially adapted construction vehicle to transport materials, plant and equipment, and workers, 40% indicated no, and 26.7% were unsure. A further 3 main likert scale types questions were asked based on the issues gleaned from the literature.

In this context, Table 1 indicates the extent of exposure or vulnerability of five categories of personnel to MVAs in terms of percentage responses to a scale of 1 (minor) and 5 (major), and a mean score (MS) between 1.00 and 5.00. It is notable that 2 (40%) of the categories have MSs > 3.00, which indicates that in general, the exposure is deemed major as opposed to minor, whereas in the case of those 3 (60%) categories which have MSs ≤ 3.00, the exposure is deemed minor. It is notable that general workers are the only category of worker that has a MS > 3.00. However, the MS of 2.93 for semi-skilled workers is marginally below 3.00. In terms of the various ranges, only (20%) first ranked drivers / operators has a MS > 3.40 ≤ 4.20, which indicates that the extent of exposure or vulnerability is between moderate to near major / near major.

Table 1: Extent of exposure or vulnerability of various categories of personnel to MVAs

Category	Unsure	Minor……Major					MS	Rank
		1	2	3	4	5		
Drivers / Operators	6.7	6.7	13.3	26.7	26.7	20.0	3.43	1
General workers	0.0	26.7	6.7	20.0	20.0	26.7	3.13	2
Semi-skilled workers	0.0	20.0	13.3	33.3	20.0	13.3	2.93	3
Skilled workers	0.0	20.0	40.0	13.3	13.3	13.3	2.60	4
Site management (supervisors, foremen)	0.0	42.9	14.3	28.6	7.1	7.1	2.21	5

Thereafter, those categories ranked second and third have MSs > 2.60 ≤ 3.40, which indicates that the extent of exposure or vulnerability is between near minor to moderate / moderate. Included in this range are general workers and semi-skilled workers. The categories ranked fourth and fifth, namely skilled workers and site management (supervisors, foremen) have MSs > 1.80 ≤ 2.60, which indicates that the extent of exposure or vulnerability is deemed between minor to near minor / near minor. However, the MS of skilled workers is on the upper end of the range, namely 2.60.

Table 2 indicates the extent fourteen unsafe transport / traffic practices contribute to the occurrence of accidents in South African construction in terms of percentage responses to a scale of 1 (minor) and 5 (major), and a MS between 1.00 and 5.00.

Table 2: Extent unsafe transport / traffic practices contribute to the occurrence of MVAs in South African construction

Practice	Unsure	Minor……Major					MS	Rank
		1	2	3	4	5		
Overloading of vehicles	7.1	7.1	0.0	14.3	7.1	64.3	4.31	1
Non-roadworthiness of vehicles / unsafe vehicles	14.3	7.1	7.1	7.1	14.3	50.0	4.08	2
Workers sitting on sides / or beds of vehicles	6.7	6.7	0.0	20.0	20.0	46.7	4.07	3
Worn tyres	6.7	13.3	6.7	13.3	26.7	33.3	3.64	4
Misjudgement / disregarding traffic control	21.4	0.0	21.4	7.1	28.6	21.4	3.64	5
Workers mounting / dismounting vehicles in motion	7.1	7.1	14.3	21.4	14.3	35.7	3.62	6
Inattentive driving of vehicles	21.4	7.1	7.1	21.4	21.4	21.4	3.55	7
Loss of vehicle control due to driver tiredness	28.6	7.1	28.6	7.1	14.3	14.3	3.00	8
Loss of vehicle control due to unsecured loads	7.1	28.6	0.0	28.6	28.6	7.1	2.85	9
Loss of vehicle control due to alcohol abuse	35.7	14.3	7.1	28.6	7.1	7.1	2.78	10
Loss of vehicle control due to adverse weather	20.0	13.3	26.7	13.3	20.0	6.7	2.75	11
Loss of vehicle control due to brake failure	21.4	21.4	21.4	14.3	7.1	14.3	2.64	12
Lack of adequate construction site signage	28.6	14.3	35.7	14.3	7.1	0.0	2.20	13
Loss of vehicle control due	42.9	28.6	7.1	14.3	0.0	7.1	2.13	14

to drug abuse

It is notable that 7 (50%) of the practices have MSs > 3.00, which indicates that in general, the extent to which they contribute is deemed major as opposed to minor, whereas in the case of the other 7 (50%) categories which have MSs ≤ 3.00, the exposure can be deemed minor. It should be noted that the MS of ‘loss of vehicle control due to driver tiredness’ falls on the midpoint of the range 3.00. Furthermore, the high level of ‘unsure’ responses is notable.

In terms of the various ranges, only first ranked ‘overloading of vehicles’ has a MS > 4.20 ≤ 5.00, which indicates that the extent is deemed between near major to major / major. This is notable as literature and anecdotal evidence inform that overloading of vehicles often contribute to the occurrence of accidents in South African construction. The practices (42.9%) ranked second to seventh have MSs > 3.40 ≤ 4.20, which indicates that the extent is deemed between moderate to near major / near major. Two practices are vehicle related, namely ‘non-roadworthiness of vehicles / unsafe vehicles’ and ‘worn tyres’; two are load related, namely ‘workers sitting on sides / or beds of vehicles’ and ‘workers mounting / dismounting vehicles in motion’, and two are driver related, namely ’misjudgement / disregarding traffic control’ and ‘inattentive driving of vehicles‘. The five practices (35.7%) ranked eighth to twelfth have MSs > 2.60 ≤ 3.40, which indicates that the extent is deemed between near minor to moderate / moderate. These include ’loss of vehicle control due to driver tiredness', 'unsecured loads', 'alcohol abuse', 'adverse weather', and 'brake failure'. In essence, four (80%) of the five are driver related, and one (20%) load related, which could also be construed to be driver related. The two (14.3%) practices ranked thirteenth and fourteenth have MSs > 1.80 ≤ 2.60, which indicates that the extent is deemed between minor to near minor / near minor. One is street furniture related, namely ‘lack of adequate construction site signage’ and the other is driver related, namely ‘loss of vehicle control due to drug abuse’.

Table 3 indicates the extent five contributors exacerbate the injuries incidental to MVAs in South African construction in terms of percentage responses to a scale of 1 (minor) and 5 (major), and a MS between 1.00 and 5.00. It is notable that four (80%) of the practices have MSs > 3.00, which indicates that in general, the extent to which they exacerbate the injuries incidental to MVAs is deemed major as opposed to minor, whereas in the case of the one category which has a MS ≤ 3.00, the extent can be deemed minor. The high level of ‘unsure’ responses is once again notable. In terms of the various ranges, only first ranked ‘lack of secured seats’ has a MS > 4.20 ≤ 5.00, which indicates that the extent is deemed between near major to major / major.

The problem relative to MVAs in the course of construction is that workers are generally transported while not seated in secured seats. Furthermore, if they are seated then they are not availed of seat belts – ‘lack of seat belts’ is ranked second, which along with ‘non-wearing of seat belts‘, and ‘lack of roll over protection’ have MSs > 3.40 ≤ 4.20, which indicates that the extent is deemed between moderate to near major / near major. ‘Non-wearing of seat belts’ and ‘lack of roll over protection’ are contributors frequently cited in South African literature, particularly the latter, which applies when workers are being transported on the back of flatbed trucks or pickups. 'Lack of pre-start up inspections', ranked fifth has a MS > 2.60 ≤ 3.40, which indicates that the extent is deemed between near minor to moderate / moderate.

Table 4 indicates the extent incidents eventuate due to MVAs in South African construction in terms of percentage responses to a scale of 1 (minor) and 5 (major), and a MS between 1.00 and 5.00. It is notable that only 3 (30%) of the incidents have MSs > 3.00, which indicates that in general, the extent to which they eventuate is deemed major as opposed to minor, whereas in the case of the other 7 (70%) categories which have MSs ≤ 3.00, the extent is deemed minor. The high level of 'unsure' responses is once again notable.

Table 3: Extent contributors exacerbate the injuries incidental to MVAs in South African construction

Contributor	Unsure	Minor…….……Major					MS	Rank
		1	2	3	4	5		
Lack of secured seats	20.0	0.0	6.7	6.7	26.7	40.0	4.25	1
Lack of seat belts	21.4	0.0	7.1	7.1	35.7	28.6	4.09	2
Non-wearing of seat belts	13.3	0.0	6.7	20.0	20.0	40.0	4.08	3
Lack of roll over protection	20.0	6.7	13.3	13.3	26.7	20.0	3.50	4
Lack of pre-start up inspections	21.4	21.4	7.1	28.6	21.4	0.0	2.64	5

Table 4: Extent incidents eventuate due to MVAs in South African construction

Incident	Unsure	Limited……..…Always					MS	Rank
		1	2	3	4	5		
Fall from vehicle in motion while getting on / off	13.3	6.7	6.7	26.7	33.3	13.3	3.46	1
Fall from vehicle in motion	26.7	0.0	13.3	20.0	33.3	6.7	3.45	2
Collision with other vehicles	14.3	14.3	14.3	14.3	35.7	7.1	3.08	3
Collisions between vehicle and other equipment	21.4	0.0	35.7	14.3	28.6	0.0	2.91	4
Crunched / run-over by highway vehicle	42.9	7.1	28.6	14.3	0.0	7.1	2.50	5
Crunched / run-over by manoeuvring vehicle	28.6	28.6	28.6	14.3	0.0	0.0	1.80	6
Worker struck by vehicle exiting work area	21.4	57.1	7.1	0.0	14.3	0.0	1.64	7
Worker struck by vehicle	21.4	57.1	14.3	0.0	7.1	0.0	1.45	8

entering work area								
Worker struck by vehicle inside work area	14.3	64.3	14.3	0.0	7.1	0.0	1.42	9
Crunched / run-over by vehicle entering the site	21.4	50.0	28.6	0.0	0.0	0.0	1.36	10

Only the first two (20%) ranked incidents have MS > 3.40 ≤ 4.20, which indicates that the extent is deemed between moderate to near major / near major. 'Fall from vehicle in motion while getting on / off' and 'fall from vehicle in motion' are also frequently cited in South African literature. 'Collision with other vehicles' and 'Collisions between vehicle and other equipment', which have MSs > 2.60 ≤ 3.40, indicate that the extent is deemed between near minor to moderate / moderate. Fifth ranked 'crunched / run-over by highway vehicle' has a MS > 1.80 ≤ 2.60, which indicates that the extent is deemed between minor to near minor / near minor. The incidents (50%) ranked sixth to tenth have MSs > 1.00 ≤ 1.80, which indicates that the extent is deemed between minor to near minor. The low MSs relative to 'crunched / run-over by manoeuvring vehicle', the three 'worker struck by vehicle exiting, entering, and inside work area' and 'crunched / run-over by vehicle entering the site' indicates that the incidents eventuating due to MVAs occur on the public roads as opposed to on site or in proximity thereto.

DISCUSSION AND CONCLUDING REMARKS

The respondent contractors use LDVs and flatbed trucks to transport workers to and from, and between construction sites. A percentage of these contractors also simultaneously transport materials, plant and equipment, and workers. Therefore, it can be concluded that workers are at risk and the incidence of MVAs in the course of construction is unlikely to reduce till such time that a strategy is evolved and appropriate interventions taken. This conclusion is underscored by the finding that 26.7% of respondents' organisations had experienced such accidents. All categories of personnel are exposed to and vulnerable to MVAs, but more so drivers / operators, and general workers. The literature leads to the conclusion that MVAs in the course of employment are a universal problem and reflect the general road safety status quo.

A range of unsafe transport / traffic practices contribute to the occurrence of MVAs in South African construction. However, based upon the responses it can be concluded that the 'overloading of vehicles' is attributable to the simultaneous conveyance of materials, plant and equipment, and workers. Furthermore, 'workers sitting on sides / or beds of vehicles' and 'workers mounting / dismounting vehicles in motion' have their origin in the conveyance of workers on inappropriate vehicles. It can also be concluded that vehicle related practices such as 'non-roadworthiness of vehicles / unsafe vehicles' and 'worn tyres' contribute substantially. Then a range of driver related practices contribute to a varying extent. Therefore, in summary, load, vehicle condition, and driver practices all contribute. The findings relative to the extent contributors exacerbate the injuries incidental to MVAs, namely 'lack of secured seats', 'lack of seat belts', 'non-wearing of seat belts', and 'lack of roll over protection' further point to the conveyance of workers on inappropriate vehicles.

'Fall from vehicle in motion while getting on / off' and 'fall from vehicle in motion' in terms of the extent incidents eventuate due to MVAs further point to the

conveyance of workers on inappropriate vehicles. Contractors should thus deliberate the practice of conveying workers on inappropriate vehicles. This recommendation is reinforced by 60% of the respondents who indicated that there is a need for a specially adapted construction vehicle to transport workers. Although, only 33.3% of respondents indicated that there is a need for a specially adapted construction vehicle to transport materials, plant and equipment, and workers, and 40% indicated no, 26.7% were unsure. Therefore, it is recommended that contractors deliberate the practice of simultaneously transporting materials, plant and equipment, and workers as they are different in terms of characteristics and fragility. In terms of driver practices, and the management of loads it is recommended that: drivers be subjected to 'refresher' driver training; pre-driving inspection schedules and processes be implemented; safe load transportation procedures be implemented, and a driver substance abuse programme be implemented. Having said this, it important to note that this research project is yet to reach maturity as a comprehensive data and subsequent analysis is needed for designing effective strategies, setting achievable goals, ranking actions, and checking the effectiveness of the strategies. Thus, future studies would draw on lessons learnt so far in order to propose remedial strategies for the use of the stakeholders in South African construction. The implication of the literature reviewed (Emuze and Smallwood, 2012) and the preliminary empirical data is that MVAs and their attendant effects will continue to plague South African construction if suitable interventions are not implemented. The significance of the study is that the minimisation of the direct and indirect costs of MVA related accidents has reached a 'tipping point', which requires a multi stakeholder solution.

REFERENCES

Construction Industry Development Board (cidb) (2009) Construction Health & Safety in South Africa Status & Recommendations. Pretoria: cidb.

Caroee, M and Singh, A (2012) Towards zero traffic accidents: a study of best practices. In: Proceedings of CIB W099 International Conference 2012: Modelling and Building Health and Safety, 10-11 September 2012, Singapore, 44-53.

Edwards, DJ and Holt, G (2009) Construction plant and equipment management research: thematic review. Journal of Engineering, Design and Technology, 7(2), pp. 186-206.

Emuze, FA and Smallwood, JJ (2012) Construction Motor Vehicle Accidents in South Africa: Preliminary Findings. In: Proceedings of CIB W099 International Conference 2012: Modelling and Building Health and Safety, 10-11 September 2012, Singapore, 203-208.

Gurcanli, GE, Mungen, U and Akad, M (2008) Construction equipment and motor vehicle related injuries on construction sites in Turkey. Industrial Health, 46, pp. 375-388.

Hobday, MB and Knight, S (2010) Motor vehicle collisions involving adult pedestrians I eThekwini in 2007. International Journal of Injury Control and Safety Promotion. 17(1), pp. 61-68.

La Grange, B (2009) I just closed my eyes and waited for it to happen [online]. Available from: http://www.timeslive.co.za/sundaytimes/2009/09/01/ [Accessed 6 March 2012]

Mathis, TL and Galloway, SM (2013) STEPS to safety culture excellence. New Jersey: Wiley.

Mohan, S and Zech, W (2005) Characteristics of worker accidents on NYSDOT construction projects. Journal of Safety Research, 36, pp. 353-360.

Mungen, U and Gurcanli, GE (2005) Fatal Traffic Accidents in the Turkish Construction Industry. Safety Science, 43, pp. 299-322.

Ore, T and Fosbroke, DE (1997) Motor vehicle fatalities in the United States construction industry. Accident Analysis and Prevention, 19(5), pp. 613-626.

Othman, AAE (2012) A study of the causes and effects of contractors' non-compliance with the health and safety regulations in the South African construction industry. Architectural Engineering and Design Management, 8(2), pp. 180-191.

Smallwood, JJ (2002) Traffic accidents contribute substantially to fatalities in construction. SA Builder, September 2002, p. 9.

A SAFETY CULTURE SHAPED BY COMMON SENSE

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A positive safety culture among construction firms is known to be an invaluable means by which accident prevention and employee safety on sites can be improved. Workers of small construction firms strive to create and maintain safe working environments for each other and for the safety of stakeholders. Based on the organisational and safety cultures developed within small construction firms, the workers have been known to incorporate informal and situational practices in order to improve site and project safety. This paper investigates the safety cultures found in small construction firms including workers' informal practices in relation to hazard identification and accident prevention. The paper is based on a research project that has an overall aim of investigating 'good' safety practices of workers of small construction firms in the East Midlands region of the United Kingdom. In this qualitative research, rich data was acquired through semi-structured interviews and non-participant observations from five construction sites. Findings from the empirical work suggest that owners and experienced workers of small construction firms significantly shape the outcome of the firms' safety cultures. For example, when they show initiative for producing safe working environments, other workers are compelled to follow suit and vice-versa. Furthermore, workers of small construction firms undertake 'informal' practices that help improve safety on site including informal risk assessment and subsequent management of hazardous events. In addition, new and less experienced worker receive effective guidance and vital on-the-job training in a way that is not documented. Unlike much research in the field, this project seeks to identify and encourage activities and approaches that help workers of small construction firms create working attitudes and environments.

Keywords: safety culture, small firm, common sense, informal practice.

INTRODUCTION

The debate on construction health and safety (H&S) approaches: common sense versus bureaucracy has divided academics, industry practitioners and policy makers as different opinions of this spectrum are held (see Lord Young of Graffham, 2010). Small construction businesses in particular tend to adopt a 'common sense' approach to H&S (Vassie et al, 2000). This could be as a result of finding the regulations complex and time consuming. Furthermore, the construction industry (small firms in particular) uses an unorthodox approach to employee development (informal training) and this can easily be confused for 'no training' at all (UK Commission for

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Aboagye-Nimo E, Raiden A, King A and Tietze S (2013) A safety culture shaped by common sense *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 323-333.

Employment and Skills (UKCES), 2012). The approaches adopted by small construction firms may have come about in response to resource limitations, for example not having specific departments or group of people solely responsible for training new workers as practiced by large firms (Health and Safety Executives (HSE), 2010).

Owners of small construction firms (who often work as site operatives as well) have a considerable amount of influence on the overall culture of the firm: if the owner is very conscious about good H&S practices (i.e. promoting a good safety culture), other workers in the firm tend to follow suit (Hinze, 2004). Furthermore, trust and a supportive environment amongst workers is helpful in developing a safety culture as workers believe they can rely on their colleagues when 'dangerous' situations arise and this also demonstrates workers genuine concern for each other's safety (Conchie and Burns, 2009; Mohamed, 2002).

The aim of this paper is to explore the safety culture of small construction firms and how this culture is influenced by a common sense approach. It utilizes in-depth interviews and non-participant observations. The paper is based on a larger research project which has an overall aim of critically examining the safety practices undertaken by workers of small construction firms in the East Midlands region of the UK, with particular emphasis on 'good' practices i.e. practices that lead to the prevention of accidents on site (see Aboagye-Nimo et al, 2012).This research does not seek to offer a 'best' and prescriptive approach to attaining site safety (as proposed by Choudhry et al, 2008), but instead seeks to highlight effective practices that aid in the prevention of accidents. This paper explores the safety cultures of small construction firms created as a result of the 'common sense approach' and thus sheds light on specific values and beliefs of workers of such firms that lead to accident prevention.

The paper begins with a literature review on safety culture before discussing the research methods and case study findings.

SAFETY CULTURE

Safety culture is a subculture found under the larger umbrella of overall organisational culture. Organisational culture can be explained as a pattern of shared basic assumptions that a group has learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems (Schein 2006: 17). There are two broad perspectives of organisational culture, namely: functionalist and interpretive perspectives. The functionalist approaches assume that organisational culture exists as an ideal to which organisations should aspire so that it can, and should be, manipulated to serve corporate interests (Waring, 1996). Interpretive approaches on the other hand, assume that organisational culture is an emergent complex phenomenon of social groupings, serving as the prime medium for all members of an organisation to interpret their collective identity, beliefs and behaviours (ibid). These contrasting perspectives on organisational culture can be used as a framework for appreciating how values, attitudes and beliefs about workplace safety are expressed and how they can influence directions that organisations take in respect of safety culture (Glendon and Stanton 2000: 201).

Researchers define safety culture according to shared values, understandings, belief patterns and expectations of members of organisations (Rousseau, 1990). While

numerous researchers and scholars (such as Berends, 1996; Geller, 1994) offer their versions of the definitions and explanations for safety culture, the underlying message among the definitions is that safety culture is fundamental to organisations' ability to manage safety-related aspects of their operations (Guldenmund, 2000). Geller (1994) explains a good and effective safety culture as a situation, or setting, where everyone feels responsible for safety and pursues it on a daily basis. In contrast, Berends (1996) describes it as the collective mental programming towards safety of a group of organisation members. The definition of safety culture adopted for this research is:

"…the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organisation's health and safety management. Organisations with a positive safety culture are characterised by communications founded on mutual trust by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures." (Cooper 2000: 114)

The above definition essentially embodies other explanations of safety culture offered by scholars in the field (see Guldenmund 2000: 228). A concept broadly synonymous with safety culture is safety climate (Denison, 1996). While differences can be identified, both safety culture and safety climate research address a common fundamental phenomenon: the influence of social contexts on safety. Therefore, within this study this conceptual arena is considered in an integrated fashion.

Large construction firms tend to have several management layers, along with several departments and perhaps regional offices, and for this reason a firm ordinarily has formalised policies and procedures to cover its large number of workers (Hinze and Gambatese, 1996). On the other hand, small companies where the owner, superintendent, foreman and lead carpenter are all one in the same person, can likely do fine by following proper safety arrangements even though the arrangements may be informal (ibid). Small firms and projects do not require the types of procedures and practices required by large organisations as long as the firm's operatives incorporate measures that will ensure safe working conditions (HSE, 2010) and this is reflected in the difference in safety cultures. This is to say that small construction firms do not approach safety through formal policies as their often simple organisational structures do not have a top level management style and decisions are usually made by owners together with their workers (Ruben et al, 2008). In order for organisations to have a positive safety culture, the most important element that is needed is successful communication rather than safety policies and procedures (Hartley and Cheyne, 2009). Thus overly demanding and standardized official policies and procedures hinder the formation of a positive safety culture (HSE, 2003).

Changes frequently occur on construction sites, including varying activities and different craftsmen for the different tasks which effectively alters existing cultures (Dainty et al, 2007). In addition, values and assumptions of individuals and teams can also change as such assuming cultures (particularly safety culture) are a stable entity will be inaccurate (Maloney, 2003). Thus safety culture is dynamic.

As highlighted, common sense plays an important role in the safety practices of small construction firms. Unlike the everyday definition of common sense whereby a basic level of practical knowledge and judgement is enough to keep individuals safe (Cambridge Advanced Learner's Dictionary, 2008: 278), it can be agreed that a construction site certainly requires 'a little more' than just the basic level of knowledge for one to be safe. Thus it can be concluded that common sense in the context of a

construction site is different from the everyday meaning and may require some intricate form of knowledge. A novice to construction work may not have a clue about what experienced workers consider as basic knowledge or common sense (Baarts, 2009). Practical knowledge and judgement on site requires knowledge gained through training, experience, guidance by leaders, experiential learning in new situations and learning from individuals considered experts due to their experience in the trade. (Gherardi and Nicolini 2002: 192). Common sense is found in practices such as communication and risk management techniques.

The next section discusses the research methods chosen for this project.

RESEARCH METHODS

Interviews and non-participant observations were carried out on five construction sites - see table 1 for details of sites visited. Projects on the various sites were at different stages. The projects of case studies 2 and 3 were in the early stages while case studies 1 and 4 were about halfway complete. Case study 5 was near completion. Research participants included the owners and the workers of the companies thus helping the research acquire different perspectives on good H&S practices and an overall safety culture for that matter. The different trades and sites included in the study offered a broader understanding of the behaviours and attitudes of workers of different firms.

The two methods employed in the collection of data: semi-structured interviews and non-participant observations, helped acquire rich and in-depth data on the safety culture of workers of small construction firms. Interviews and non-participant observations were carried out on all five construction sites with great care and aim for minimal researcher influence. The non-participant observation method was meant to reveal hidden or unconscious practices that may not have been discovered or mentioned during the interviews, or alternatively practices that cannot be uncovered through the use of tools such as questionnaires. Table 1 below presents a summary of sites included in the case studies.

Table 1: Profile of case studies

	Nature of the project/ work	Activities on site	Trades of respondents	Workers on site
Case study 1	Refurbishment of existing structure	Electrical, plumbing, brickworks, screeding, ceiling works	Builders (carpenters, labourers, skilled labourers)	15
Case study 2	Preparation for new builds	Excavation, roofing, plumbing, building envelopes	Groundworkers	30
Case study 3	New building	Ground preparation, trench digging, foundation, building envelopes,	Brick layers	19
Case study 4	Preparation and laying foundation for new housing community	Clearing ground, reinforcing foundations, building envelopes	Steelworkers/ Groundworkers	15
Case study 5	Completing new building	Pavement and landscaping, external decoration, clean up	Builders, painters, labourers	6

General consents for the sites were obtained from site managers; due to the complexity of site arrangements, seeking individual consents would be problematic

and hence the general consent of managers was found more practical. Small businesses and small sites are known to fall within a category described by the HSE as the 'hard-to-reach' group (Willbourn, 2009) and as such access to research participants were negotiated through gatekeepers trusted by these firms.

Analysis of the data was conducted starting with a thorough thematic coding of the information (transcribed interview data and field notes from observations) with the assistance of QSR NVivo 9. Using qualitative data analysis software helped the researchers with the storage and organisation of their data (i.e. interview transcripts, observation notes, personal comments, relevant literature and personal reflections). Furthermore, this approach facilitated the coding process and helped researchers draw out patterns and refine the research ideas, and hence assisted in efficient data retrieving and handling (King, 2008).

CASE STUDY FINDINGS AND DISCUSSION

This section presents the case study findings on safety culture and the common sense approach from the five sites presented in table 1. As shown in the table, the site activities of the different cases varied considerably. Logically, responses and observations obtained from interviews and observations offered different perspectives with regards to common sense in site safety as well. Common sense was not a probe employed by the researcher in conducting the interviews but emerged as a topic of importance during the data analysis. Respondents used the term 'common sense' freely and frequently when discussing how they managed safety on site. The main themes presented in this section include workers' experience and informal risk identification, employee training and finally the influence of bureaucracy on site safety. The key participants that are presented in the findings and their job roles are as follows: Rick (case study 1- skilled labourer), Mark (case study 1 - labourer), Andy (case study 5 - skilled labourer), George (case study 3 - bricklayer), Scott (case study 3 - owner), Steve (case study 3 - bricklayer), Mickey (case study 4 - groundworker) and John (case study 1 - owner). The above were chosen as key participants for this paper due to their extensive experience in the construction industry, and their views towards the common sense approach to site safety.

Unlike common sense in the everyday context which is regarded as an uncomplicated form of knowledge, workers with extensive site experience believed that spotting certain risks and hazards would be difficult for some workers (particularly new ones). As far as informal risk assessment and experience went, some of the statements recorded included:

"Experience told you they're not safe. Somebody new on site might not see them [the same way]." (Rick)

"...you see things that you need like scaffolding, hand rails missing, you automatically know it's not safe. You'll have to point it out to the lads" (Mark)

Rick is one of the most experienced workers interviewed - over 30 years on site. While he does not point out exactly how experience informs him in relation to what is safe or unsafe, he points out that a newer person on site may not be able to spot the danger. Mark also uses an interesting word 'automatically' to describe the manner in which he ascertains dangers on scaffolds. As Mark clearly states, a newer worker will require some guidance in spotting this danger as they could probably assume the missing handrails are a part of the scaffold design and proceed to use it. Alternatively, a new worker could see this danger and if they are not warned about it, may assume

unnecessary risk taking is acceptable in the group. In other words, teaching new workers how to spot dangers does not eliminate the danger quite yet because a site with a negative safety culture can carry out works on the scaffold with missing handrails and disregard the risk and its potential consequences i.e. falling from a height. Thus teaching new workers to spot dangers is equally as important as teaching them to avoid the situation. Langford et al (2000) explain that when employees believe that the managers and leaders care about the safety of workers, the employees are more willing to cooperate to improve safety performance, thereby yielding a positive safety culture. Unlike the workers with years of experience, none of the relatively new workers on site used the terms 'common sense', 'general knowledge' or referred to any reactions as 'obvious' or 'automatic'. This begs the question: are new workers not aware of common sense? Maybe they are aware of the concept but do not refer to this kind of skill as common sense or general knowledge yet. Also, they may not be making reference to common sense because they are not confident enough to take this kind of knowledge for granted as expressed by the experts. Expert knowledge is the reward of years of concentrated effort (Bartholomew 2008: 21)

While most of the workers with the wealth of experience made similar claims in line with Rick and Mark's statements, a close look at the other responses reveals that not all the workers believe that new workers may not be able to sense the dangers.

"...people should just follow common sense. As you can see, it's all up and down. It's just common sense." (George)

"Everything, everything has got to do with common sense on site. This is what we do, this is how we do it. This is how I like to see this certain job done. That's the way we keep that tidy. If you stick to those guidelines everything will be fine." (Andy)

George and Andy (almost 50 years of experience between them) both discuss what they believe people should know and do. Expecting or assuming people know or understand issues can be extremely dangerous especially when issues of potentially fatal consequences are involved such as construction work (Bartholomew, 2008). The subtle difference between the two responses is that Andy's views are inclusive of some form of training and supervision and this can help him determine how much the new worker knows or understands. Furthermore, Andy clearly states that the new workers must join the culture i.e. 'This is what we do, this is how we do it'. He however does not state 'this is the right way of doing it and for this reason new workers must do it this way'. Therefore a new worker joins this culture regardless of whether their culture makes use of safe methods or otherwise. Andy also mentions that there are guidelines and as such he expects to see activities carried out in this manner something which goes to show that there will be some form of demonstration or display that the newcomer is expected to follow. In contrast, George shows more of a laissez faire leadership and also makes no mention of specific training strategies or guidance. Leaving safety matters to newcomers (without guidance), as suggested by George can result in new workers picking up wrong attitudes and unsafe practices that can eventually lead to the occurrence of accidents to themselves and workmates (Gherardi and Nicolini, 2002).

Interestingly, the above statement from George and other comments such as "…my basic opinion is that health and safety is a load of rubbish but people should just follow common sense" only show that site safety may not be his topmost priority. Also, his views may have been influenced by the views of the company owner (Scott). Scott had the following to say about health and safety on site:

"[health and safety on site] should be general knowledge really… [the workers] know what they're doing anyway"

The owner's views in this situation have clearly influenced a worker (in this case George) confirming the findings of Hinze (2004) who found that owners' views can be reflected in the views of their workers. Furthermore, Scott and George also mentioned that they did not interact with the workers of the other small firms (other subcontractors) on the site. This mentioned behaviour was also confirmed through observation. However, Scott and George's views can also be interpreted as a form of dislike for bodies of authority as health and safety as a concept is regarded by some workers as a bureaucratic initiative established by the HSE. Unexpectedly, not every member of their company shared the owner's views. Steve showed a view similar to that of Rick that even though he refers to something as common sense, he believes training and guidance cannot be excluded. He states:

"...you've got to keep an eye on [the newcomer] until you know he's alright to himself. It's just common sense really." (Steve)

Even though Steve discusses common sense as though it were obvious, his previous statement shows that common sense is not just 'a given' and thus guidance from more experienced workers is required. An interesting phenomenon observed in this group (case study 3) was that even though Scott was the owner of the business, Steve was acting as the leader of the team. He was observed giving instructions on how the team members (including Scott) should look out for truck drivers delivering blocks, because he believed the trucks could slip on the muddy roads and cause an accident. With regards to safety, he was his company's 'moral compass' (Mohamed, 2002). Another opinion Steve did not share with his colleagues was keeping to one's self as he believed that people could learn from workers of other teams on site.

Andy who initially stated that 'everything on site depends on common sense' later stated that he keeps a close watch on the less experienced workers and 'he would never ask them to do something that he was not comfortable doing himself'. This and previous statements allow the following inference to be drawn: even though common sense may be discussed as a basic level of knowledge, experienced workers know that it requires both skill and experience in order for people to be able to execute it efficiently. As such experienced workers monitor new workers until they (experienced workers) are sure of an improvement in the level of expertise of the newcomers. This traditional and yet informal technique of passing on knowledge about the way things are done in a particular setting or in a given culture is known as mentoring (Bartholomew 2008: 119).

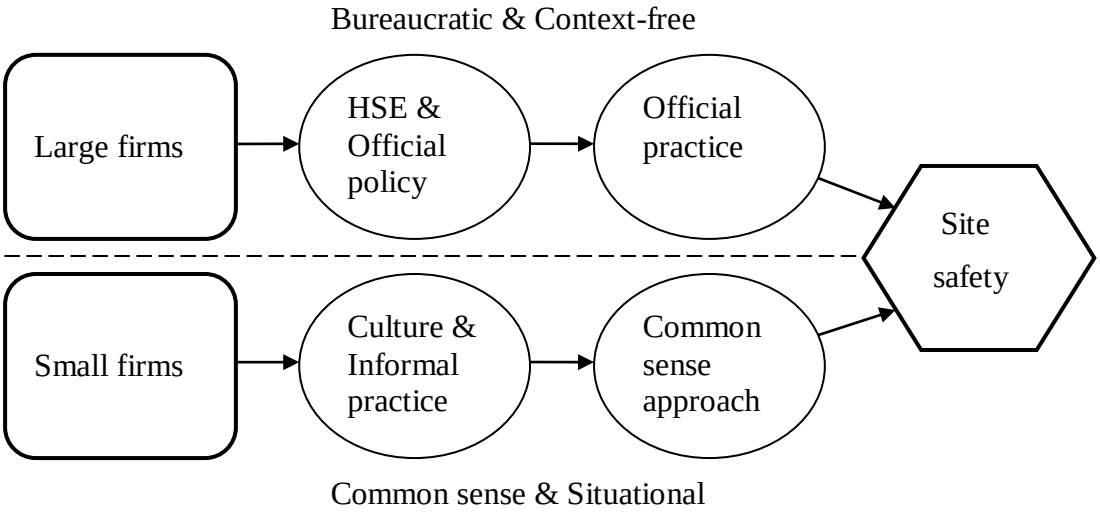
Even though the experienced workers were confident of their own knowledge, it was surprising that they all believed in the idea of further training. They actually embraced the idea of further training for experienced workers and explained that such training is always good as it helps keep them alert to new risks and hazards and also keeps them constantly safety conscious. These findings are consistent with the findings of Reynolds et al (2008), which suggests that good and experienced workers admit that further safety training is always important as it enhances their safety awareness and also helps them to stay focused.

As far as contributing aspects of their safety cultures that can be valuable to the wider construction community, the respondents believe that they possess practical knowledge that can be beneficial to the whole construction industry but are hesitant to come forth with their opinions. Simon described voicing your opinion on this matter

as 'committing commercial suicide'. In other words, raising concerns and suggesting safer techniques (contrary to practices of principal/large contractors) can cause the organisation to lose their contract or even become 'blackballed' in their work circles. He recalled making suggestions on safety practices to a site manager on a previous project and that permanently severed his company's ties with the large contractor. Such revelations support recent reports that large contractors use blacklists to exclude certain companies from acquiring contracts (Taylor, 2013). While this may seem like a myth to outsiders, this fear surely exists among workers of small construction firms and during periods of economic downturn, workers consider it 'unwise' to cause one's own demise by 'complaining'. For this reason some workers stated that they would rather stay mute on situations they find unsafe.

Figure 1 summarises this research's analysis of workers' views on the differences in safety approaches adopted by construction companies with respect to their sizes.

Figure 1: Difference between site safety approaches for small and large firms



Workers of small construction firms approach safety through their culture and informal practices and this is what is being described as the 'common sense approach'. John explains that the reason why small firms are able to work without the need for formal policies and procedures is because of their small size and their ability to call for informal meetings to discuss implementing different strategies at any time of the project. He also added that he encourages his workers to bring forth their opinions as he believes there is no one way of carrying out tasks. He states:

"You have to be prepared to discuss the right way of doing it [as a leader] and you have to be prepared to say if you don't agree." (John)

However, such debates and discussions cannot be carried out in large firms especially when it comes to decisions made by top level executives as it would be going against company policies that have been strictly reinforced (Hartley and Cheyne, 2009) usually created as abstract and context-free policies. Such policies are also undertaken due to the challenging practicalities of employing and managing a large workforce.

CONCLUSIONS

This paper has presented findings on five small construction firms operating in the East Midlands region of the UK with respect to their safety culture and the common sense approach. Most of the findings from the various sites support discussions found in literature, such as experienced workers believe in implementing informal

techniques in identifying and assessing risks on site, and they also believe that their knowledge and experience in the industry is the basis for this quality. Thus, it can be inferred from this study that experienced workers from small construction firms use the common sense approach to attain a positive safety culture on site. A finding that was not consistent with literature showed another experienced worker had assumed the leadership role in the organisation as the owner was demonstrating less enthusiasm towards a positive safety culture; therefore the experienced worker was acting as the conscience of the group in relation to safety.

This research uncovered that small firms still fear to approach the HSE and large contractors with their safety concerns and this fear may have been worsened by recent economic crisis. Thus workers would rather work under unsafe conditions brought about by 'bureaucratic' measures of contractors rather than complaining as they could lose their present job as well as future contracts.

This paper acknowledges that there are other aspects that influence the outcome of safety cultures including leadership methods, site communication and training approaches and these themes will be explored in subsequent research.

REFERENCES

Aboagye-Nimo, E., Raiden, A. and Tietze, S. (2011) Investigating Good Health and Safety Practices in Small Construction Firms in the United Kingdom In: Egbu, C. and Lou, E.C.W. (Eds.) Procs 27th Annual ARCOM Conference, 5-7 September 2011, Bristol, UK, Association of Researchers in Construction Management, 289-298.

Baarts, C. (2009) Collective individualism: The Informal and Emergent Dynamics of Practising Safety in a High-risk Work Environment, Construction Management and Economics, 27 (10), 949-957.

Bartholomew, D. (2008) Building on Knowledge: Developing Expertise, Creativity and Intellectual Capital in the Construction Professions, Oxford: Blackwell.

Berends, J.J. (1996) On the Measurement of Safety Culture (Unpublished graduation report), Eindhoven University of Technology, Eindhoven.

Cambridge Advanced Learner's Dictionary (2008) Third Edition, Cambridge: Cambridge University Press.

Choudhry, R., Fang, D., and Ahmed, S. (2008) Safety Management in Construction: Best Practices in Hong Kong. Journal of Professional Issues in Engineering Education and Practice, 134(1), 20–32.

Conchie, S. and Burns, C. (2009) Improving Occupational Safety: Using a Trusted Information Source to Communicate Risk, Journal of Risk Research, 12(1), 13-25.

Cooper, M. (2000) Towards a Model of Safety Culture, Safety Science, 36 (2), 111-136.

Dainty, A., Green, S. and Baglihole, B. (2007) People and Culture in Construction: Contexts and Challenges. In: A. Dainty, S. Green and B. Baglihole People and Culture in Construction. Oxford: Taylor and Francis.

Denison, D. (1996) What is the difference between organisational culture and organisational climate? A native's point of view on a decade of paradigm wars. Academy of Management Review, 21(3), 619-654.

Geller, E.S. (1994) Ten Principles for Achieving a Total Safety Culture, Professional Safety September, 18–24.

Gherardi, S. and Nicolini, D. (2002) Learning the Trade: A Culture of Safety in Practice, Organization, 9 (2), 191-223.

Glendon, A.I. and Stanton, N.A. (2000) Perspectives on Safety Culture, Safety Science, 34, 193–214.

Guldenmund, F. (2000) The Nature of Safety Culture: A Review of Theory and Research. Safety Science, 34 (1–3), 215–257.

Hartley, R. and Cheyne, A. (2009) Safety Culture in the Construction Industry. In: Dainty, A R J (Ed.), Procs 25th Annual ARCOM Conference, 7-9 September 2009, Nottingham, UK. Association of Researchers in Construction Management, Vol. 2, 1243–52.

HSE (2003) Causal Factors in Construction Accidents, Loughborough University and UMIST, HSE.

HSE (2010) Safety Initiative Targets Region's Small Construction Sites, Available at: http://www.hse.gov.uk/press/2010/coi-nw-14constructionsafety.htm [Accessed: 30-03-2013].

Hinze, J. (2004) Construction Planning and Scheduling (2nd edn), New Jersey: Prentice Hall.

Hinze, J. and Gambatese, J. (1996) Factors that Influence Safety Performance of Specialty Contractors, Journal of Construction Engineering and Management, 129(2), 159-164.

King, A. (2008) Using Software to Analyse Qualitative Data. In: A. Knight and L. Ruddock (Eds.) Advanced Research Methods in the Built Environment. Oxford: Blackwell.

Langford, D., Rowlinson, S. and Sawacha, E. (2000) Safety Behaviour and Safety Management: Its Influence on the Attitudes of Workers in the UK Construction Industry, Engineering Construction and Architectural Management, 7 (2), 133-140.

Lord Young of Graffham (2010) Common Sense Common Safety, London: Cabinet Office.

Maloney, W.F. (2003) Reciprocal Model of Construction Safety Culture. In: F. Bontempi (Ed.) System-based Vision for Strategic and Creative Design, 23-26 September 2003, Rome, International Structural Engineering and Construction Conference, 397-402.

Mohamed, S. (2002) Safety Climate in Construction Site Environments, Journal of Construction Engineering and Management, 128 (5), 375-384.

Reynolds, J.H., Tutesigensi, A. and Lindsell, D.J. (2008) An Evaluation of Health and Safety Management in Small Construction Enterprises in the UK. In Hinze, J. (Ed) Procs CIB W99 International Conference, 9-11 March 2008, Gainesville Florida, 14th Rinker International Conference, 541-550.

Rousseau, D.M. (1990) Organisational Climate and Culture. In: B. Schneider (Ed.) Organisational Climate and Culture. Oxford: Jossey Bass.

Ruben, M., Hinze, J. and Feronti, T. (2008) Safety Practices of Small Construction Contractors. In Hinze, J. (Ed) Proceedings CIB W99 International Conference, 9-11 March 2008, Gainesville Florida, 14th Rinker International Conference, 649-658.

Schein, E. (2006) Organizational Culture and Leadership (3rd edn), San Francisco: Jossey-Bass.

Taylor, M. (2013) Blacklist Used by Construction Firms to Disrupt Environmental Protests, Guardian, 28th January, http://www.guardian.co.uk/business/2013/jan/28/blacklist-construction-firms-environmental-protests [Date accessed 18 March 2013].

UKCES (2012) UK Commission's for Employment and Skills Survey 2011: England Results. UKCES.

Vassie, L., Tomas, J. and Oliver A. (2000) Health and Safety Management in UK and Spanish SMEs: A Comparative Study, Journal of Safety Research, 31 (1), 35-43.

Waring, A.E., (1996) Safety Management Systems, London: Chapman & Hall.

Willbourn, C. (2009) Report of Qualitative Research Amongst 'Hard to Reach' Small Construction Site Operators. Health and Safety Executive.

EXPLORING FACTORS AFFECTING UNSAFE BEHAVIOURS IN CONSTRUCTION

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Why do workers take a chance and work from height without any safety protection? Is it because of their age, inexperience or lack of training? Is it to do with their risk perception or desire for risk taking and thrill seeking? Is it bad management style, poor safety culture or a substandard design? Does this happen everywhere around the globe or is it just one particular culture? To help us understand why there are different behavioural responses to hazards (e.g. working at height) in construction, we must first understand the factors that have affected that individual's decision-making. This paper presents early investigations taking place on a £1.6B project in the UK involving construction workers from many different backgrounds and nationalities. Through a process of literature exploration, a safety climate survey and focus group discussions, factors have been identified and explored to consider how they impact behaviours. The results suggest that time pressure, training, experience, risk perception, safety culture, culture and management are the factors most likely to be influencing behavioural responses of individuals. Time pressure is perhaps the most important factor as it was often regarded as having the greatest influence by the focus group. Survey results revealed 31% of 475 participants thought that alcohol and drugs were 'always' a factor in accidents, and hence this factor has somewhat surprisingly been identified as having a fairly significant influence. These factors will be further explored in future work using an ethnographic approach, which will yield significant insight from fine-grained, observational analysis on the project.

Keywords: behavioural safety, human response, time pressure.

INTRODUCTION

Over the last two to three decades, an increase in research and awareness in safety has reduced fatalities by over half (HSE, 2012). However, 22% of UK employee (employed and self-employed) fatalities and 10% of reported major injuries are in the construction industry despite only accounting for 5% of British employment (HSE, 2012). During this period, construction safety has reduced fatalities mainly through focusing on improving the 'hard' issues such as managerial systems, policies and better safety technology e.g. nets, MEWPs, harnesses. However, in recent times many organisations have realised that their accident rates have 'levelled off'. This has ignited a search for improvements in other areas to reduce accident numbers; and has led to the research into behavioural safety issues of the workforce.

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Oswald D, Sherratt F and Smith S (2013) Exploring factors affecting unsafe behaviours in construction *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 335-344.

The £1.6B project is not only significant in size, but also multi-national in composition; the project team involving eleven major organisations from five different countries, the contractor Joint Venture alone comprising four separate nationalities, and a workforce of over 22 nationalities. This project has therefore provided the opportunity for a PhD study to investigate behavioural safety issues on a significant infrastructure project, and how these may be influenced by the many national cultures and backgrounds involved.

This paper presents the initial findings from the study, in the form of an exploration of the factors influencing behavioural safety issues, evaluated through a workforce-wide survey and further supported by a focus group discussion. Considerations of national culture influence will form the next stage in the project and are consequently not presented here.

IDENTIFYING BEHAVIOURAL SAFETY FACTORS

Within previous health and safety research, various factors have been identified as potentially contributing to behavioural safety issues. These are summarised below:

Alcohol and Drugs

Using the validated AUDIT test, a study (Biggs & Williamson, 2012) of nearly 500 construction workers in Australia deemed 286 (58%) were above the cut off score (8) for hazardous alcoholic consumption. Though it is not clear how great an affect hazardous drinking out of work hours will have on safety during construction, it would be naïve to think that none of the workers would be impaired. This problem is unlikely to be just isolated to Australia, especially when the global drinking habits are considered: vast areas of Europe, including the UK, consume more pure alcohol than Australia (World Drug Report, 2012). Regarding other drug use, 292 (59%) had used cannabis at some point during their life, with 16% admitting to using it within the last 12 months. 196 (40%) had used ecstasy or meth/amphetamine type substances (ATS) during their life, with 162 (32%) having used it within the last year. Comparing that with the whole of Australia: 10.3% admitted to taking cannabis within the last year, 3% ecstasy and 2.1% ATS (World Drug Report, 2012). Drug takers of such highs, are generally high risk takers that live for the “buzz” (sensation seeking). They are aware of the risks (e.g. heart attacks, addiction etc.) but the “buzz” feeling still outweighs this consequential thinking. Therefore, one would suspect that employees with such a buzz or high thrill personality trait would be more willing to chase adrenaline-rushes through risk-taking on site.

Experience and Training

These two factors could be strongly linked. Experienced and skilled construction workers are reported to being less prone to hazards than inexperienced workers (Laukkanen, 1999), while human experiences influence safe or unsafe actions on-site and involvement in safety management systems (Fang et al., 2004). There is evidence which suggests that more than half of all accidents on site occur within the victim’s first week (Stokdyk, 1994). This indicates that training and in particular site specific inductions are perhaps important safety initiatives.

Management

The management have the opportunity to control risk and employ behavioural-based management systems. Such techniques are very important considering that 80 to 90% of accidents are triggered by unsafe employee behaviour (Lingard & Rowlinson,

2005) and that, in one study, risk management was a factor in 84% of accidents (Haslam et al., 2005). Unsafe behaviours are in the individual's control and also within the scope of supervisors and management to control effectively (Lingard & Rowlinson, 2005). Evidence implies that behavioural-based safety management systems are very effective in improving performance (Lingard & Rowlinson, 1997).

National/Cultural Clashes

The most important theme in modern times is that the universal recognition that culture exists (Ankrah, 2007). Hofstede's (1983) cultural dimensions theory expresses the effects that a society's culture has on the values of its members and how behaviours relate to these values. Different cultural backgrounds may influence behaviours on site and could potentially cause cultural clashes leading to unsafe systems and acts; although management itself has been considered a more important determinate of behaviour at work than national culture (Mearns & Yule, 2009).

Risk Perception

General hazard/risk perception of construction workers has been found to be far from ideal (Carter & Smith, 2006). This could be a significant issue as if one does not recognise there is a risk, then one may not act appropriately. Fluctuation of risk perception amongst individuals makes it difficult to identify the causes, effects and prevention techniques for risk-taking behaviour (Haines et al., 2004).

Risk Taking and Thrill Seeking

Sensation/thrill seeking and risk taking have a strong correlation (Zuckerman, 1994). Sensation seekers take risks purely for a thrill factor rather than any other reason. Those that scored highly on the Zuckerman's sensation seeking scale (Zuckerman, 1994), a validated psychometric test, have been found to be related to higher accident rates (Bierness and Simpson, 1988).

Sleeping Pattern/Tiredness

An alteration to sleep pattern or a lack of sleep could affect awareness and alertness, which could increase the chance of an accident. This could be linked to the use of alcohol or drugs, a shift change, clocks phase change or a return from a holiday period. While one study (Holland & Hinze, 2000) found no statistical evidence between accident rates and clock phase advances, another significantly larger study (Barnes & Wagner, 2009) established that following phase advances employees had 40 minutes less sleep, 6% more accidents and lost 68% more working days, than on non-phase change days. These findings were based on mining injuries between 1983 and 2006 – comparing the Monday after the phase advance with other days.

Safety Culture

The term "safety culture" first appeared in the 1987 OECD Nuclear Agency Report following the devastating Chernobyl disaster in 1986 (Cox & Flin, 1998). A 'poor safety culture' has often been identified as contributory factor in accidents, including high profile disasters such as the Kings Cross Fire (ACSNI, 1993). Safety culture is essentially a subculture of organisational culture, where the three levels of organisation culture (artefacts and behaviours, espoused values and assumptions) (Schein, 2004) can equally be applied to safety culture (Whittingham, 2012). Though this factor is widely publicised as being very important, few authors have been able to pin-point exactly what its influence is, let alone quantify it. Further research and theoretical modelling is required to fully determine its significance.

Summary: A Safety 'Equation'

A combination of all these behavioural factors will potentially create a very complex safety equation on site, with behaviours influenced by some factors more than others, at different times and in different situations. These factors have all been highlighted within previous safety literature, and their relevance within a large multinational workforce was explored, in order to establish their perceived influences in practice.

RESEARCH METHOD

This study has three phases. The initial literature review, above, has informed on the likely factors as identified in previous research. The next phase was to take advantage of an existing ‘management safety climate survey’ that had already been established on the project. The third phase was closer examination of the attitudes of the workforce to the factors identified through the literature and the survey via a focus group. The safety climate survey is completed by the vast majority of project workers, office staff and site operatives, on a given day, taking a 'snapshot' of the site. Additional questions were included within the standard project survey by the research team to enable further exploration of the workforce perceptions of the behavioural safety factors identified within the literature.

Restricted by the delivery mechanism of the survey, a four point Likert attitude scale was used to examine 'which factors contribute to on-site accidents?'. Factors could only be presented as headings with no further clarification or explanation as to their content. Although the results from the survey are therefore limited to the respondents own understandings of the factors, and which cannot themselves be further explored through this mechanism, they are arguably able to support further directed investigation by providing an indication of the perspectives of the workforce.

Following the survey more fine detailed understanding was developed via a focus group, which consisted of four employees working on the project: a safety advisor, two works managers from different departments and an operative. The focus group examined ten safety-related case studies (photographs and descriptions) through the findings of the survey, seeking to reinforce and further examine the factors as they related to practice through the perceptions of the group members. The group comprised of two stages, firstly each participant individually determined if the factors were 'likely', 'could be' or were 'unlikely' to be influencing safety behaviours in each of these case studies presented, if the participants felt that from the data provided they were not able to comment, there were able to select a 'not possible to tell' option. After this task was completed, the group then discussed the case studies collectively, and came to a general consensus of the influence of the factors on the case studies presented.

SURVEY FINDINGS AND ANALYSIS

The survey was completed by n=475 respondents. Key sample characteristics are that 92% were male, 55% considered themselves to be labour force, 45% supervised others, and 38% had worked less than 6 months on the project.

Respondents could assign 'always', 'sometimes', 'rarely' or 'never' to the presented factors in terms of their perceived contributions to on-site accidents. Safety culture, risk taking, experience/training and poor risk perception were the most prominent factors, felt to 'always' contribute to on-site accidents. A notable result was the perceived prominence of alcohol and drugs to 'always' be a factor in accidents,

possibly suggesting that there is a strong alcohol and drug culture on the site or in wider industry. National/cultural clashes were least likely to 'always' be a factor in on-site accidents, potentially surprising given the multinational nature of the project and its workforce, but also possibly reflecting a harmonious site where this factor is not considered as a safety consideration at all.

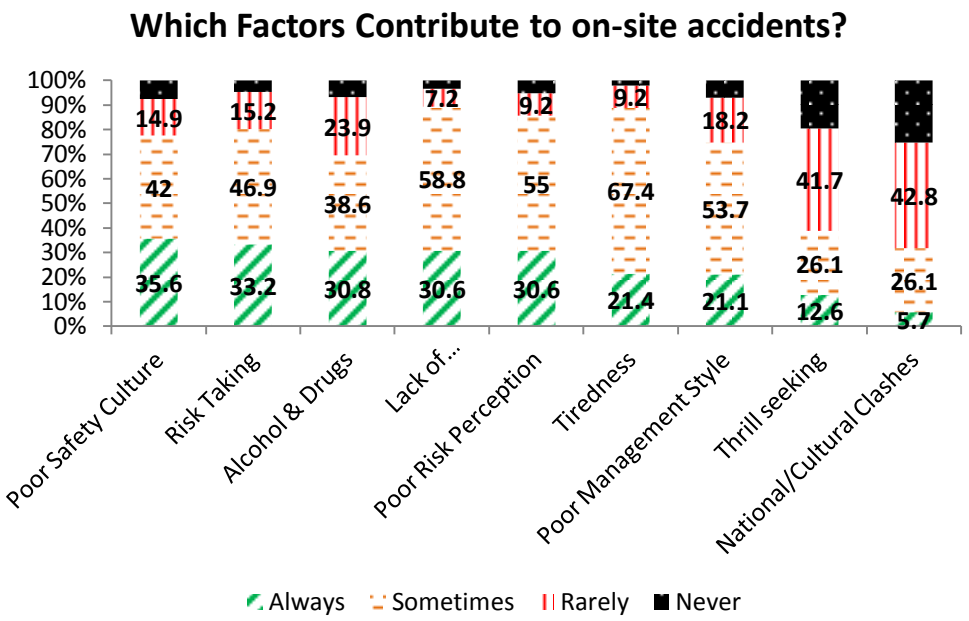

Figure 1 Survey Results

Further survey analysis was undertaken in order to draw out the factors that were felt to be most relevant in their contribution to on-site accidents. A score was assigned to each category (always=3, sometimes=2, rarely=1, never=0), and although this four-point scale does not correlate exactly to a linear scale, it can be used to give an indication of the most important factors. The graph below gives a total of the scores in each factor:

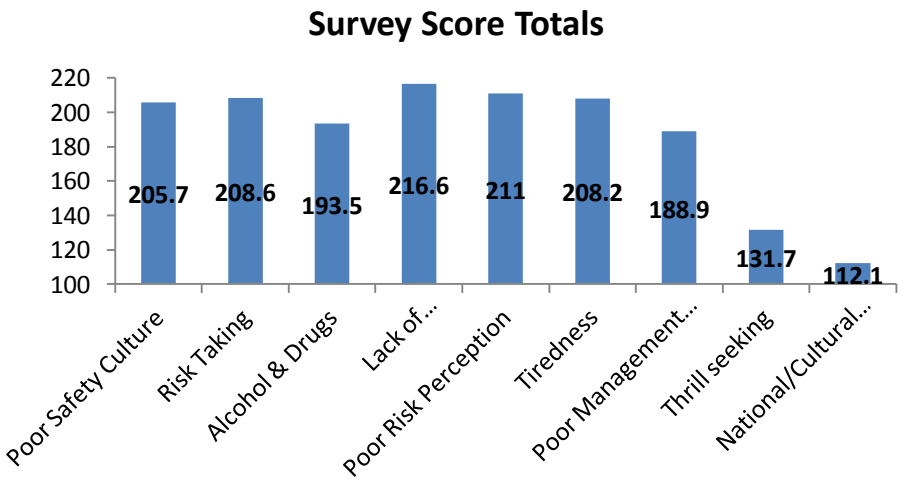

Figure 2 Ranked Survey Results

A shift in the overall rankings of each factor can now be seen when compared to the Figure 1. Thrill seeking and National/Cultural clashes are still the two least influential factors, whilst lack of experience/training has now become the most significant

contributory factor. This ranking now indicates that: lack of experience/training, poor risk perception, risk taking, tiredness and poor safety culture are the factors with the highest (217 - 205) contributory influence to on-site accidents. Alcohol and Drugs and poor management style are factors with moderate (194 - 188) influence, whilst thrill seeking and national cultural clashes have the lowest (132 - 112) influence.

Addition and Amendment of Factors

In the processing and analysis of the survey results, it emerged that some participants had been motivated to include factors of their own, writing them on the survey unprompted. This act, combined with informal discussions with survey participants post completion, led to the additional of the following factors: 'age', 'gender', 'design' and 'time pressure'. These new factors were consequently taken back to the literature, and explored further.

Age was has been highlighted in investigations seeking a correlation between age of workers and accident rates. However, the findings from such studies have tended to be contradictory with no fixed conclusions (Laflamme & Menckel, 1995). Some studies have concluded younger workers (Lin, Chen, & Luo, 2008) are more accident prone, while others have deemed older workers are (Charg-Cheng et al., 2007). Despite there being contradictions in conclusions, there is one generality: the greatest number of accidents occurs in either the younger or older workers. Gender has also been considered in health and safety research as a contributory factor; Lin, Chen and Luo (2008) found that male workers had a much higher occupational fatality rate than female workers (7.4 compared to 0.9 per 100,000 full time workers).

The influence design has on accident causation has been well documented (for example Donaghy, 2009) and hence the existence of legislation such as the Construction Design & Management regulations in the UK (CDM, 2007) which places duty on designers to eliminate and reduce risk at the design stage. Szymberski's (1997) conceptual model hypothesises that the ability to influence safety is reduced through each stage of the project schedule.

Time Pressure as a causal factor has been identified in several studies. A case study in Hong Kong reported that the tight construction schedule was the most serious factor affecting construction site safety (Ahmed et al., 1999). Another study found that production bonuses can cause unsafe acts (Sawacha et al., 1999), while Langford et al. (2000) state that supervisors knowingly ignore unsafe acts due to time pressure set by agreed upon programs.

Following this analysis, 'experience' and 'training' were also separated into two factors as they were deemed not to correlate closely enough to be combined as one factor.

FOCUS GROUP FINDINGS AND ANALYSIS

A revised factor list, developed from the literature and survey findings, was then employed within a focus group analysis of ten safety-related case studies, in order to appraise the potential contribution of the factors to the safety issues illustrated in the case study material.

Initially, the group were asked to individually consider the factors and their potential influence within the case study examples. The results from this individual consideration can be seen in Figure 3:

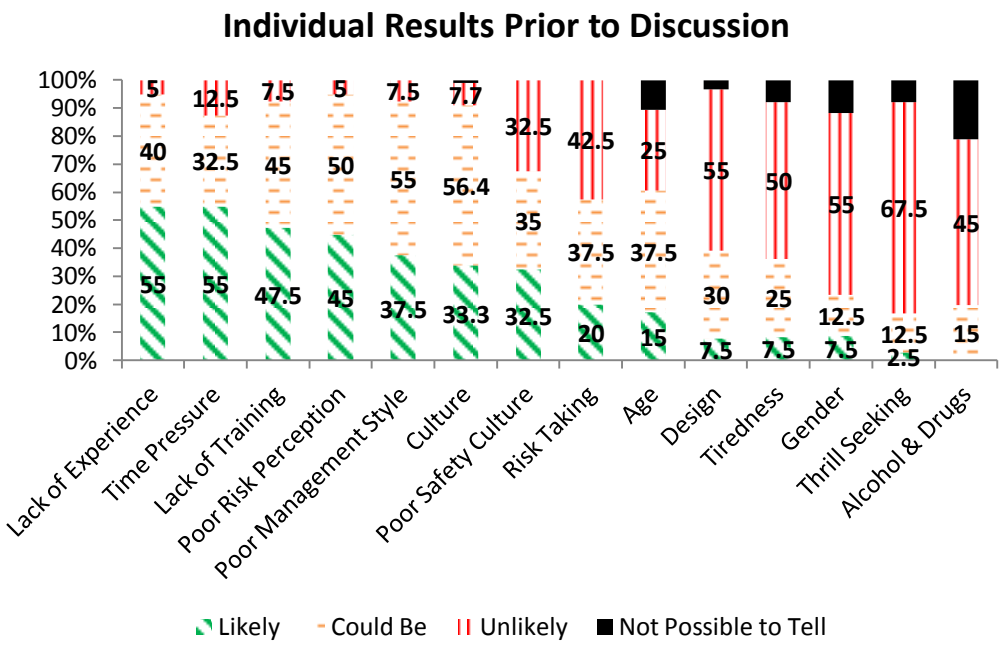

Figure 3 Focus group results prior to discussion

Upon completion of the individual assessments, a group discussion was undertaken and collective agreement reached:

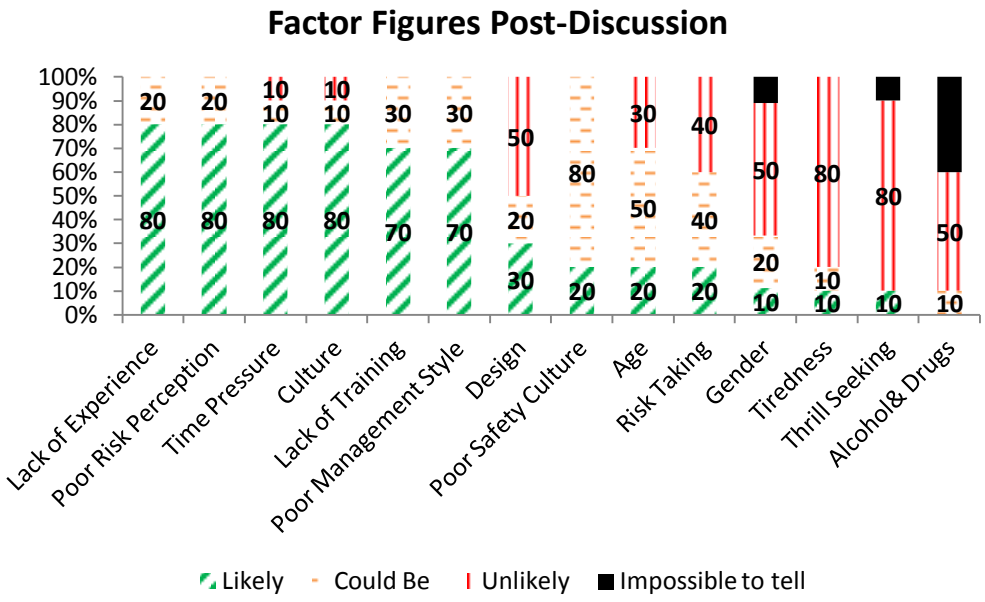

Figure 4 Focus group results post-discussion

Following the focus group discussion, there was an overall reduction in the 'could be' allocation of the factors, a decrease of 44% overall, as participants were swayed one way (likely) or another (unlikely) by other members of the group. Most of the factors increased in the "likely" category by between 30% and 90%. The greatest increase was in design (433%), which was often due to a design change that the majority of the group hadn't considered in their individual appraisals, but once they had been enlightened by another participant they altered their assessment. Safety culture was the only factor to decrease, although only by 8%. Safety culture also had the highest

'could be' allocation, potentially this was due to the information provided for the case studies from which it may be difficult to disclose whether it was a factor or not. Furthermore this factor is itself highly subjective, although the group did acknowledge that in many of the case studies it 'could be' an influence. Time pressure, a factor developed from the survey findings, was considered to be a very important factor by the focus group. Participants stated 'we all want to save time by taking risks'; 'it is time nowadays, everything is time'; 'we are having to put things together as a budget and a cost and we are cutting it too fine to be fair. We are not given enough time' and 'here we go again, it is time. Time is the first one [factor] guaranteed'. This was a recurring theme throughout the discussions and positioned this factor as a key influential factor in safety issues on site. The top six factors that were defined as 'likely' by the panel to contribute to a safety issue in at least 7/10 case studies were experience, risk perception, time pressure, culture, management and training. Although the survey findings suggested that direct national/cultural clashes were very rarely a factor in an accident, the focus group results imply that culture is an influential factor in accidents. In two case studies, laziness was also suggested.

DISCUSSION

The prominence of safety culture within both the survey and focus-group findings, and its perceived influence as a factor in on-site accidents, suggests that this is a factor that merits further exploration. Indeed, safety culture can be seen as the summation of all other factors in practice, and it is proposed that this factor is further explored in detail, including examination of what this term means to the workforce themselves as a collaborative aspect of the project. The survey findings when ranked suggest a more individual and tangible consideration of the influential factors in accidents. Tiredness, risk taking, lack of experience/training and poor risk perception are all practical characteristics of the individual at work. Risk perception within the industry workforce has been identified as far from ideal (Carter and Smith, 2006), something the workforce themselves seem to acknowledge. Experience scored very highly in the focus group as well as the survey suggesting that the workforce agree with Fang et al. (2004) that human experiences influence safe or unsafe acts. A surprising result was that 31% of participants thought that alcohol and drugs were 'always' a factor in accidents. This could suggest an alcohol and drug culture within the project workforce, or even in the wider construction industry as the findings in Biggs & Williamson (2012) indicate that there is an alcohol and drugs culture within the Australian construction industry. The focus group found it difficult to conclude if alcohol and drugs were a factor from the case study information provided. It was not deemed to be 'likely' a factor in any of the case studies but the group agreed it could have been a factor in one case study, where an incident had occurred early in the morning on return from the Christmas holidays. Again, this is another factor that merits further examination. Perhaps the most important factor however was time pressure, it was suggested unprompted by the workforce as worthy of consideration, and was often regarded as the most important factor by the focus group. The evidence from this research and a case study in Hong Kong, (Almed, 1999) that revealed a tight construction schedule was the most serious factor that influences safety, perhaps indicates that the time pressure factor is not just restricted to a particular country or continent. Laziness was identified in the focus group, by the group's own accord, in two out of the ten case studies. From an investigation into the literature after this suggestion, a case study in Thailand (Aksorn & Hadikusumo, 2007) found laziness to be an important factor in the unsafe act of leaving nails or sharp objects in dangerous

locations. From the findings, the factors have been grouped into four categories, from very high to low influence in on-site accidents, and therefore behavioural safety:

VERY HIGH: Time Pressure

HIGH: Culture, Experience, Management, Risk Perception, Safety Culture, Training

MEDIUM: Alcohol & Drugs, Age, Design, Tiredness, Risk-Taking

LOW: Gender, Laziness, Thrill-seeking

CONCLUSIONS

Through a critical analysis of the literature potential factors that could influence the behavioural response of an individual to hazards have been identified. The combination of results from the questionnaire survey and case studies considered by a focus group suggests that time pressure, training, experience, risk perception, safety culture, culture and management are the factors perceived to be most likely to influence the behavioural responses. When identified as a factor, time pressure was often regarded as very influential. Perhaps the most surprising conclusion was the survey results suggested that alcohol and drugs was such an important factor. The findings indicate that safety culture, which could be seen a summation of all the others factors, is an important factor despite an acknowledgement from the focus group that, with the information provided, it was difficult to interpret. Hence alternative methodological approaches will be explored to investigate this factor further, and the others outlined. It is anticipated that fine-grained, observational analyses will yield significant insight as to safety the influence of these factors in practice, and in order to accomplish this, an ethnographic participant observer approach is to be employed. Results of these further investigations will be reported in future ARCOM conferences.

REFERENCES

Advisory Committee on the Safety of Nuclear Installations (ACSNI) (1993). Study group on human factors, Third report: Organising for safety. London:HMSO

Ahmed, S. M., Tang, S. L., and Poon, T. K. (1999). Problems of implementing safety programmes on construction sites and some possible solutions. Council for Research and Innovation in Building and Construction, Working Commission W99, 525–529.

Aksorn, T & Hadikusumo, B (2007). The Unsafe Acts and the Decision-to-Err Factors of Thai Construction Workers, Journal of Construction in Developing Countries, Vol. 12:1

Ankrah, N. A. (2007). An Investigation into the Impact of Culture on Construction Projects.

Barnes, C., & Wagner, D. (2009). Changing to Daylight Saving Time Cuts Into Sleep and Increases Workplace Injuries. Journal of Applied Psychology. Vol 94: 5, 1305-1317

Beirness, Douglas J., and Herbert M. Simpson. (1988), "Lifestyle correlates of risky driving and accident involvement among youth." Alcohol, Drugs & Driving

Biggs, H. C., & Williamson, A. R. (2012). Safety Impacts of Alcohol and other Drugs In Construction: Development of an Industry Policy and Cultural Change Management Program, (September), 445–454.

Carter, G., & Smith, S. D. (2006). Safety Hazard Identification on Construction Projects. Journal of Construction Engineering and Management, 132(February), 197–205.

Charng-Cheng, Tsaur., Hsin-Ying, Chiu., Chung-Yun, Gau., Yu-Hsien, Cho (2011). Characteristic Analysis of Occupational Accidents of Aged Workers in the Construction Industry. Journal of Occupational Safety and Health 19: 516-532

Cox, S & Flin, R. (1998) Safety culture: Philosopher's stone or man of straw? Work & Stress: An International Journal of Work, Health & Organisations, 12:3, 189-201

Donaghy, R. (2009). One Death is too Many – Inquiry into the Underlying Causes of Construction Fatal Accidents: Report to the Secretary of State for Work and Pensions

Fang, D., Huang, X. and Hinze, J. (2004) Benchmarking Studies on Construction Safety Management in China, Journal of Construction Engineering and Management, ASCE, 2004.130:424-432.

Haines, V., Hitchcock, D., Osman, Z., Way, H., Craven, M., Drive, B., & Hussey, M. (2004). Recidivist risk takers who work at height. HSE Books

Haslam, R., Hide, S., Gibb., A Gyi, D., Pavitt, T., Atkinsona, S., Duff (2005) Contributing factors in construction accidents. Applied Ergonomics 36. pp 401–415

Hofstede (1983) National cultures in four dimensions: a research-based theory of cultural differences among nations. International Studies of Management & Organisation

Holland, N., & Hinze, J. (2000). Daylight Savings Time Changes and Construction Accidents. Journal of Construction Engineering and Management, 126(October), 404–406.

HSE (2007) The Case for CDM: Better Safer Design - A Pilot Study. HSE Report 148

HSE (2012) HSE Website, [http://www.hse.gov.uk/statistics/industry/construction/index.htm]

Laflamme, L., & Menckel, E. (1995). Aging and occupational accidents a review of the literature of the last three decades. Safety Science, 21(2), 145–161.

Langford, D., Rowlinson, S., & Sawacha, E. (2000) Safety behaviour and safety management: Its influence on the attitudes of workers in the UK construction industry. Engineering, Construction and Architectural Management, Vol. 7: 2, pp.133 - 140

Laukkanen, T. (1999) ‘‘Construction work and education: Occupational health and safety reviewed.’’Construction Management Economics, 17 53–62.

Lin, Y.-H., Chen, C.-Y., & Luo, J.-L. (2008). Gender and age distribution of occupational fatalities in Taiwan. Accident; analysis and prevention, 40(4), 1604–10.

Lingard, H, Rowlinson, S (1997) Behavior-based safety management in Hong Kong’s construction industry, Journal of Safety Research 28 243–256

Lingard, H, Rowlinson, S (2005) Occupational health and safety in construction project management, Spon Press

Mearns, K & Yule, S (2009) The role of national culture in determining safety performance: Challenges for the global oil and gas industry, Safety Science, Vol 47:6, pp 777-785

Sawacha, E., Naoum, S., and Fong, D. (1999). ‘‘Factors affecting safety performance on construction sites.’’ International Journal of Project Management, Volume 17, Number 5, October 1999 , pp. 309-315(7)

Schein, Edgar (2004) Organisational culture and leadership, 3rd Edition, Jossey Bass

Stokdyk, (1994) No falling back, Building Magazine, June 3: 38-39

Szymberski, R. (1997). Construction Project Safety Planning. TAPPI Journal, 80(11), 69-74.

Whittingham, R (2012) Preventing Corporate Accidents, Routledge

World Drug Report. (2012), United Nations.

Zuckerman, (1994) Behavioural expression and biosocial bases of sensation seeking. Cambridge University Press.

INSTITUTIONAL DETERMINANTS OF CONSTRUCTION SAFETY MANAGEMENT STRATEGIES OF CONTRACTORS IN HONG KONG

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From an institutional perspective, organisations are not only a production system; but also a social and cultural system. The external institutional environment in which organisations are embedded plays a critical role in shaping organisational structures and practices. Organisations as active agencies respond strategically to the institutional pressures and expectations in a variety of ways, such as conformity, compromise and avoidance. Building on the conceptual framework established by Oliver (1991), this study explores how contractors respond to institutional demands in terms of compliance with construction health and safety requirements, involvement in voluntary safety initiatives and safety campaigns, and commitment to zero accidents in the context of the Hong Kong construction industry. A case study was conducted to collect empirical evidence of contractors' strategic responses. The results indicate that the contractor prefers to adopt compromise and avoidance strategies in the face of the client's stringent safety requirements and tight project progress demands. This study contributes to the knowledge of safety management by offering an institutional explanation of contractors' safety management strategies.

Keywords: construction safety, institution, management, strategy, Hong Kong

INTRODUCTION

The Hong Kong construction industry has achieved remarkable progress in construction safety. The accident rate per thousand workers has dropped from 85.2 in 2002 to 49.7 in 2011 (Labour Department 2013). Nevertheless, a plateau in the downward trend has been reached (Construction Industry Institute 2009). The number of fatalities fluctuates, with 9 in 2010 and 24 in 2012 (Labour Department 2013). To achieve a continuous improvement in safety performance, it is vital to review the current safety management strategies and issues rooted in the industry.

Safety management activities cannot be fully understood unless the broader context of industry, market, and regulations in which contractors are embedded is taken into account (Hale 1998). In line with the transition of safety management approach from prescriptive to performance-based in Hong Kong, contractors are not only exposed to prescriptive rules of safe conduct, but also an increasing public awareness of construction safety, a series of safety campaigns and initiatives, changing market conditions and financial pressure. Contractors on one hand have to comply with

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Ju C and Rowlinson S (2013) Institutional determinants of construction safety management strategies of contractors in Hong Kong *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 347-356.

prescribed safety requirements; on the other hand they are expected to conduct various safety management activities to satisfy the demands of multiple stakeholders. Good safety performance helps contractors to gain business opportunities in the highly competitive market, and to earn legitimacy in the eye of key stakeholders. However it has been recognised that players in the construction industry have not made concerted efforts to improve industry-wide safety performance in Hong Kong (Construction Industry Institute 2009). Contractors are confronted with complex institutional demands for safety.

This paper, drawing upon the institutional theory, aims to examine contractors' response to the institutional environment in Hong Kong. The next section reviews the institutional theory and resource dependence view. It is followed by an introduction to Oliver's (1991) framework that adopted a convergent insight of institutional and resource dependence theories. The paper then discusses the institutional environment in which construction safety management activities are embedded (e.g., regulatory pressures, industry norms) and elaborates how this environment might affect contractors' safety management strategies. Through a case study, empirical evidence was collected to verify the explanations.

INSTITUTIONAL AND RESOURCE DEPENDENCE PERSPECTIVES

The traditional task environment based on resource dependence theory focuses on the roles of markets, resources, and competition in determining organisational processes and outcomes (Pfeffer and Salancik 1978). Managerial choices within an organisation are guided by an economic rationality and motives of efficiency, effectiveness and profitability (Conner 1991). The external strategic factors that impact the organisation include buyer and supplier power, intensity of competition, and industry and product market structure (Oliver 1997). Whether resource selection and deployment lead to enduring variations across organisations depends on factor market imperfections (Oliver 1997). It is recognized that the resource dependence view, albeit being insightful on organisational behaviours, has made the role of institutional environment implicit.

From an institutional perspective, organisations operate within a social framework of rules, norms, values and taken-for-granted assumptions about what constitutes appropriate behaviours (Meyer and Rowan 1977; Zucker 1977). One important tenet of institutionalism is structural isomorphism which describes how the structures and practices of organisations in a certain institutional field become isomorphic over time (Meyer and Rowan 1977; DiMaggio and Powell 1983; Powell and DiMaggio 1991). Through conformity to institutional pressures and social expectations, organisations gain organisational legitimacy, resources and survival capabilities (DiMaggio and Powell 1983; Ashforth and Gibbs 1990; Suchman 1995). However, the institutional perspective has been criticised for its lack of attention to the role of organisational self-interest and active agency (Oliver 1991).

Oliver (1991) constructed a framework grounded on the institutional and resource dependence theories, explaining that organisations may respond to institutional pressures in a variety of modes ranging from passive compliance to active manipulation of the environment. This framework was adopted in this study to examine contractors' safety management strategies, with the consideration of the following issues.

Firstly, safety management activities are regulated by mandatory rules and regulations, beyond which safety is viewed as “moral obligation” by stakeholders who do not hold legal responsibilities. Secondly, professional or trade associations play an important role in formulating, transforming, and disseminating industry norms. Thirdly, safety culture is regarded as a social construction, concerning what and how people believe, feel, think and how they behave (over time) and how this is reflected in collective habits, rules, norms, symbols and artefacts (Rollenhagen 2010). Safety accidents may cause severe deterioration in organisations’ intangibles (Fernández et al. 2000), such as image and reputation (Smallman and John 2001).

Besides the intangibles, construction safety performance also has vital economic and business implications. Good safety performance, for example, reduces costs associated with accidents, improves productivity, and brings about business opportunities for companies (Fernández-Muñiz et al. 2009). These economic benefits make it clear that it is in the company’s best interests to take measures to manage safety on the work site (Wilson and Koehn 2000). Overall, it seems tenable and potentially meaningful to examine contractors’ safety management strategies building on Oliver's framework.

INSTITUTIONAL PRESSURES AND STRATEGIC RESPONSES

Oliver (1991) identified five types of organisational strategic responses to institutional processes, consisting of acquiescence, compromise, avoidance, defiance, and manipulation. Acquiescence implies a full conformity to institutional pressures and expectations. Compromise indicates a partial compliance with institutional demands. Organisations may also avoid institutional pressures by concealing non-conformity, responding symbolically and buffering themselves from the requirements. Defiance refers to active resistance to institutional norms and expectations. Organisations may attempt to change or exert power over institutional pressures through manipulation strategies. The five broadly defined strategies may have alternative forms. For example, tactics of compromise strategy consist of balance, pacifying and bargaining (Oliver 1991).

In the framework, Oliver (1991) also identified the critical characterizing factors of institutional pressures that predict organisations' strategic choices, including cause, constituents, content, control and context. Their connection with contractors' strategic responses is discussed in the case study section.

INSTITUTIONAL ENVIRONMENT OF CONSTRUCTION SAFETY MANAGEMENT

The institutional pressures related to construction safety in Hong Kong's construction industry are complex and fragmented (Construction Industry Institute 2009). To analyse the institutional elements related to construction safety in the context of Hong Kong, Scott’s (2008) three pillars of institutions theory - regulative, normative and cultural-cognitive -is adopted in this study.

Legal environment

Regulative elements include formal regulations and rules such as constitutions, laws and property rights (North 1990). Regulations may be created and maintained by states, provinces, or local regimes with power to formulate and enforce rules, and to sanction deviators (Orr and Scott 2008). In Hong Kong, statutory provisions governing work safety on construction sites are set out under the Factories and Industrial Undertakings Ordinance (FIUO) (Cap. 59), the Occupational Safety and

Health Ordinance (OSHO) (Cap. 509) and their subsidiary legislation. The Ordinances and subsidiary legislation comprise both prescriptive and goal-setting types of legislation to address the safety and health in the construction industry (Labour Department 2011). The impact of the legal environment on organisations' conformity behaviours is discussed from two aspects: regulatory stringency and enforcement.

Regulatory stringency is defined as the complexity and burden of regulatory environments (Fennell and Alexander 1987). High regulatory stringency refers to particularly extensive or severe regulatory pressures exerted on organisations (e.g. a large number of enforceable rules, regulations and codes) that potentially impede organisational autonomy or efficiency (Oliver 1997). Biggs et al. (2011) found that plenty of 'paperwork' required by regulations distracts contractors' attention from specific safety problems and undermines the integration of safety practices into normal construction processes. The regulatory stringency can be measured through the extent to which contractors feel that workplace safety is or is not overregulated with too many government codes, rules and regulations, and the extent to which contractors feel that the regulatory environment does or does not reduce their discretion to manage safety effectively (Oliver 1997).

Enforcement is an important instrument in ensuring compliance with safety legislation. Anderson (2007) argued that the effective enforcement of the legislation on construction Occupational Health & Safety issues is just as important as the law itself. Site inspection is the primary enforcement tool used by the Labour Department (LD) in Hong Kong. The LD is empowered to initiate prosecutions, issue improvement notices (INs) and Suspension notices (SNs), when breaches of the law or imminent risks are identified during site inspections (Labour Department 2011). Companies are more likely to act in socially responsible ways when strong and well-enforced state regulations are in place to ensure such behaviours (Gainet 2010).

Normative institutional environment

Normative elements include both values and norms. Values are conceptions of the preferred or the desirable; norms specify how things should be done (Scott, 2008). Compared with regulative institutions that emphasise the "logic of consequentiality", normative institutions shift attention to the "logic of appropriateness" (March and Olsen 1989: 23). Many occupational groups, both professional and craft-based, generate and enforce work norms and actively promulgate standards and codes to govern conduct (Brunsson and Jacobsson 2000; Van Maanen and Barley 1984).

The Hong Kong LD provides non-statutory guidelines to facilitate compliance with the relevant safety and health legislation. The LD works closely with the Construction Industry Council (CIC) in publishing safety guidelines, such as the use of tower cranes, site vehicles and mobile plant, and working in hot weather (Labour Department 2011). The CIC, as a statutory industry coordinating body, performs an important role in promoting industry self-regulation, formulating codes of conduct and enforcing such codes. The Occupational Safety and Health Council (OSHC) is another statutory body for promoting safety and health at work. For instance, the OSHC launched a number of sponsorship schemes for small and medium enterprises aiming at enhancing their safety awareness (Labour Department 2011). It is noteworthy of the role of professional institutions in fostering safe work norms. For example, the Hong Kong Institute of Engineers collaborates with higher education institutions through accreditation of an engineering higher diploma programme to ensure the necessary

education on occupational safety. In addition to this, contractor associations are active in disseminating safety initiatives and good safety practices amongst their members.

These normative pressures manifest themselves through dyadic inter-organizational channels of firm-supplier and firm-customer (Burt 1982) as well as through professional, trade, business, and other key organizations (Powell and DiMaggio 1991). Corporate peer pressure has also been identified as an effective means of facilitating industry norms (Martin 2003). The influence of normative pressures on contractors can be measured through contractor's relationships with clients, contractor associations, trade unions and subcontractors.

Cultural-cognitive institutional environment

Cultural-cognitive elements of institutions stress both the symbolic systems perceived to be objective and external to individuals and the subjective interpretation processes of individuals (Scott 2008). Culture is the learning result of a group of people over a period of time. The deepest level of culture is in the cognition where a group shares perceptions, language, and thought processes that become the ultimate determinants of attitudes, espoused values, and overt behaviour (Schein 1990). Even though a clear consensus is yet to evolve on the definition of safety culture, the concept generally depicts the set of beliefs, values, attitudes, and perceptions guiding people behave in a safe manner. Such a constructed meaning system indicates what is important and legitimate to people (Turner et al. 1989).

Individuals as agents and entrepreneurs play an important role in the creation and change of institutions (Zilber 2002). It has been noticed that some industry leaders have adopted a zero accident vision in Hong Kong. The zero accident vision calls for a generative safety culture, wherein risks are not only controlled, but unforeseen risks are also anticipated, recognised, and adequately dealt with (Weick and Sutcliffe 2007). To cultivate such a culture, commitment to safety of every individual should be the starting point. Both technical and social innovations are needed, as well as out-of-box thinking for solving existing safety problems (Zwetsloot et al. 2013). Without collective commitment, it is quite difficult to break the improvement plateau.

The Hong Kong context

The Hong Kong government has introduced various safety initiatives to public works and dedicated tremendous efforts to their implementation. The Works Branch of the Hong Kong Government (currently the Development Bureau) published a Construction Site Safety Manual (Manual) in 1995 as a mandatory guideline for all staff and parties involved in the Public Works Programme (PWP). The Manual, which has been continuously updated, stipulates stricter safety requirements than the government regulations, specifies the contractual provisions on construction safety and formalises safety initiatives. Therefore, apart from the legislative prescriptions, contractors involved in public works are required to accept stringent contractual provisions on construction safety.

Contractors are more likely to adopt conformity strategies given that they depend on clients of public works for a continuous flow of contracts. This fits with the resource dependence construct that is defined as the extent to which a focal organisation depends on constituents in its environment for critical resources (Pfeffer and Salancik 1978). It can be measured through perceived dominance of suppliers or construction works purchasers (Teo et al. 2003).

In Hong Kong, the main contractor employs a multi-tier subcontracting strategy to cope with the dramatic changing demand for in-house resources (Ng et al., 2009). However this strategy traps the main contractor into a difficult situation of labour shortage and coaching newcomers during the boom period. According to the Labour Department (2013), the number of construction site workers increased by 40% from 51,000 in 2009 to 71,300 in 2012, including many new comers to the industry. Thus, the extent and effect of conformity may be influenced by the capability of the main contractor in managing its subcontractors.

Based on the above argument, contractors in Hong Kong are confronted with institutional pressures of regulatory compliance, voluntary involvement in industry initiatives and safety campaigns, as well as commitment to zero accidents.

CASE STUDY

The case study was conducted in a railway project at the early stage of the first author's PhD study, aiming to identify site safety issues, diagnose underlying causes, and provide further improvement advice. A case study is suitable for probing into the “how” type research question, which could offer new insights into links among variables (Yin 2003). The focus of the case study is on safety practices adopted by the main contractor at the project level where management strategies are implemented and the influence of the client can be investigated. This paper concentrates on the institutional explanations of the contractor's safety management strategies. The internal organisational factors, such as safety climate, although is able to explain the variation of safety practices, are beyond the scope of this paper.

Project background

The railway project, valued approximately at HK$ 1.34 billion, comprises one station and a 650 metre long overrun tunnel. The construction work started in March 2010 and is expected to end in June 2014.The main contractor is regarded as one of the leading construction companies in Hong Kong. The client with the Hong Kong Government as the sole shareholder implements stringent safety management standards. The safety target for contractors in 2012 is less than 0.30 (number of reportable accidents per 100,000 man-hours worked). However because of complex site conditions, stringent Health, Safety and Environmental (HSE) requirements, and separated construction sites, the main contractor faces huge safety management challenges.

At the time the case study was carried out in April, 2012, the accident frequency rate of the project was 0.42 which was the highest among the client's projects. The observed reasons pointed out by the client included poor house-keeping, and "walking by" safety issues. For this reason, the contractor appointed an independent third party led by the second author to identify the underlying causes of unsatisfactory safety performance.

Data collection and analysis

Multiple data collection techniques were adopted, consisting of project document review, safety climate questionnaire survey, open-ended interviews and participatory observation, to capture 360 degree perspectives of site issues. As noted above, since the focus of the study is on the institutional factors rather than internal organisational factors, the results of the questionnaire survey are not reported in this paper. The data collected through interview provides significant empirical evidence to support the theoretical argument. However the influence of the broad institutional environment on

safety management strategies of contractors may not be reflected through a single case study. The data collected can only partially support previous arguments.

The interview was designed to probe into safety issues in the project. Respondents were asked to describe their impression of site safety management, safety issues, and possible causes. Among 82 project participants who accepted the interview, only 62 provided relevant information. Each interview lasted for 5 to 40 minutes depending on the respondents' willingness to share their views and on their time convenience. The interview was tape-recorded, transcribed and analysed through the qualitative data analysis software NVivo 10.0. Thematic analysis was adopted whereby the data was analysed according to different themes (Creswell 2009).The themes were developed through an inductive coding strategy.

Findings

Six categories of safety issues emerged from the coding process (See Table 1). The number in the bracket indicates the frequency of issues mentioned by participants. Each category of safety issue is generated from several sub-codes.

Table 1: emerged Safety Issues from Interviews

Categories of safety issues	Sub-codes
Supervisory safety leadership (42)	Safety orientation(safety is the priority or not); Management pattern consistency
Safety practices (40)	Management words consistent/inconsistent with actions; workers follow/violate codes of safe conduct
Poor planning (38)	Work access and housekeeping; insufficient planning and design; progress and safety is in conflict
Safety awareness, knowledge, and competence of workers (21)	Workers take safety ownership; lack of safety awareness
Resources provision (22)	Human resources; provision of PPE; provision of other safety facilities
Communication (10)	Communication between main-con and sub-con, among sub-cons; within organisation

Discussion

Compromise strategies in response to the institutional pressure

Under the issue of poor planning, "progress pressure", "balance progress and safety" or "safety is in conflict with progress" were repeatedly mentioned by interviewees (see Table 2). The project management team of the main contractor complained that the project schedule was very tight, and even not realistic. Meanwhile the client set up a high safety target for site safety management. The self-interest of the contractor is more effectively served by obtaining an acceptable balance between progress pressure and safety target. Balance as one tactic of compromise strategies is likely to take place when organisations are confronted with conflicting institutional demands or inconsistencies between institutional expectations and internal organisational objectives related to efficiency or autonomy (Oliver 1991). One engineer from the client commented on the site safety management of the main contractor:" Site safety issues are old issues. Actually the main contractor recognises where the issues exist. However they would not take further action until pointed out by the client during the weekly safety walk." Indeed those 'old issues' may not cause instant incidents or accidents yet they have the potential to do so. The contractor's strategy is to conform

to at least the minimum standards of safety requirements, then to pacify the client by taking follow-up actions. Pacifying is another tactic of compromise strategies. Pacifying tactics constitute partial conformity with the expectations of one or more constituents (Oliver, 1991). One senior manager from the client side provided other evidence of the compromise strategy: "When we conducted the safety management system audit, the site safety was much better. Yet when it was over, the safety performance went back to the normal level."

Table 2: who are talking about the conflicting goals of "progress and safety?"

	Progress and safety	No. of Participants	Percentage
Client	5	6	83%
Main contractor supervisors	3	7	43%
Main contractor workers	6	11	55%
Sub-contractor supervisors	2	3	67%
Sub-contractor workers	6	35	17%

Avoidance strategies in response to the institutional pressure

The main contractor employed a large safety management team, comprising safety manager, senior safety officer, site safety supervisor, safety training officer, site nurse, HSE trainee and site clerk, dealing with safety related issues, which is the legislative requirement in Hong Kong. The major role of safety personnel is to maintain a “sound” safety management system, and to ensure that safety related works, documents, and activities meet regulatory as well as client’s requirements. However evidence revealed that the risks were not actually systemically managed: insufficient work planning and risk assessment, insufficient provision of safety resources, poor temporary work design, etc. The phenomenon of decoupling the actual safety practices from the "paperwork" of safety management system indicates the avoidance strategy. This agrees with the postulation that organisations may adopt avoidance strategy by concealing their nonconformity, buffering themselves from institutional pressures, or escaping from institutional rules or expectations (Oliver 1991). Besides, the top management of the main contractor maintain a very positive attitude toward improving site safety performance, which indicates "dispositional legitimacy" (Suchman 1995) from the client, even though the inconsistency of management talk and actual behaviour were frequently reported by the interviewees.

CONCLUSION

As an exploratory study, this paper takes the novel perspective of institutional and resource-dependence theories to examine the influence of the institutional pressures on contractor's safety management strategies. The case study results show that under stringent safety requirements and client's tight project schedule demands, the contractor tends to compromise the safety target by balancing the progress and safety goals and pacifying the safety pressures from the client. To avoid legal sanctions, the contractor devotes great effort on the standard safety management systems.

REFERENCES

Anderson, J M (2007) Health and safety- matching legislation and enforcement. In: Proceedings of the Institution of Civil Engineers- Management, Procurement and Law, Issue MP1, 11-12.

Biggs, S, Davey, J D and Freeman, J E (2011) Safety leaders' perceptions of safety culture in a large Australian construction organisation. In: 1st International Conference in Safety and Crisis Management, 24-28 June 2011, EUC Cultural Center, Nicosia, Cyprus.

Brunsson, N and Jacobsson, B (2000) "A World of Standards". Oxford: Oxford University Press.

Burt, R S (1982) "Toward a Structural Theory of Action: Network Models of Social Structure, Perception, and Action". New York: Academic Press.

Coble, R J and Haupt, T C (2000) Performance vs. prescription based safety and health legislation - a comparison. "The American Professional Constructor", 24(2), 22-25.

Conner, K R (1991) A historical comparison of resource-based theory and five schools of thought within industrial organizational economics: Do we have a new theory of the firm? "Journal of Management", 17, 121-154.

Construction Industry Institute (2009) "Safety initiative effectiveness in Hong Kong- one size does not fit all", Hong Kong Construction Industry Institute.

Creswell, J W (2009) "Research Design: Qualitative, Quantitative, and Mixed Methods Approaches", 3rd Edition. Los Angeles: Sage Publications, Inc.

DiMaggio, P J and Powell, W W (1983) The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. "American Sociological Review", 48, 147-160.

Fennell, M L and Alexander, J A (1987) Organisational boundary spanning in institutionalised environments. "Academy of Management Journal", 30, 456-76.

Fernández-Muñiz, B, Montes-Peón, J M and Vázquez-Ordás, C J (2009) Relation between occupational safety management and firm performance. "Safety Science", 47, 980-991.

Fernández, E, Montes, J M, and Vázquez, C J (2000) Typology and strategic analysis of intangible resources: a resource-based approach. "Technovation", 20, 81-92.

Gainet, C (2010) Exploring the impact of legal systems and financial structure on corporate responsibility. "Journal of Business Ethics", 95, 195-222.

Hale, A, Baram, M, and Hovden, J. (1998) Perspectives on safety management and change. In Hale, A and Baram, M (Eds.) Safety Management: The Challenge of Change. Oxford: Pergamon Press, 67-92.

Haupt, T C and Coble, R J (2000) International safety and health standards in construction. "The American Professional Constructor", 24(1), 31-36.

Labour Department (2013) "Legislative Council Panel on Manpower Hong Kong Measures to Enhance the Work Safety Performance in the Construction Industry". Labour Department, HKSAR.

Labour Department (2011) "Legislative Council Panel on Manpower Hong Kong's Safety Performance in the First Half of 2011 and Regulatory Framework for Construction Sector". Labour Department, HKSAR.

March, J G and Olsen, J P (1989) "Rediscovering Institutions: The Organisational Basis of Politics". New York: The Free Press.

Martin, R L (2003) The virtue matrix: calculating the return on corporate responsibility. "Havard Business Reivew on Corporate Social Responsibility", 83-104. Boston: Harvard Business School Press.

Meyer, J W and Rowan, B (1977) Institutionalized organizations: formal structure as myth and ceremony. "American Journal of Sociology", 83, 340-363.

North, D C (1990) "Institutions, institutional change, and economic performance". Cambridge: Cambridge University Press.

Oliver, C (1991) Strategic responses to institutional processes. "The Academy of Management Review", 16, 145-179.

Oliver, C (1997) The influence of institutional and task environment relationships on organizational performance: the Canadian construction industry. "Journal of Management Studies", 34, 99-124.

Pfeffer, J and Salancik G R (1978) "The External Control of Organisations: A Resource Dependence Perspective". New York: Harper & Row, Publishers, Inc.

Powell, W W and DiMaggio, P J (1991) "The New Institutionalism in Organizational Analysis", Chicago, University of Chicago Press.

Reason, J (1998) Achieving a safety culture: theory and practice. "Work & Stress", 12(3), 293-306.

Rollenhagen, C (2010) Can focus on safety culture become an excuse for not rethinking design of technology? "Safety Science", 48, 268-278.

Schein, E (1990) Organizational culture. "American Psychologist", 45 (2), 109-119.

Scott, W R (2008) "Institutions and Organisations: Ideas and Interests". California: Sage Publications.

Smallman, C and John, G (2001) British directors perspectives on the impact of health and safety on corporate performance. "Safety Science", 38, 227-239.

Suchman, M C (1995) Managing legitimacy: strategic and institutional approaches. "The Academy of Management Review", 20, 571-610.

Teo, H H, Wei, K K and Benbasat, I (2003) Predicting intention to adopt interorganizational linkages: an institutional perspective. "MIS Quarterly", 27, 19-49.

Turner, B A, Pidgeon, N F, Blockley, D I and Toft, B (1989) Safety culture: its importance in future risk management. "Position paper for Second World Bank Workshop on Safety Control and Risk Management", Karlstad, Sweden.

Van Maanen, J and Barley, S (1984) Occupational communities: culture and control in organisations. In: B. Staw and L. Cummings, (eds.) "Research in Organisational Behaviour, 6". Greenwich: JAI Press, 287-365.

Wilson, J and Koehn, E (2000) Safety management: problems encountered and recommended solutions. "Journal of Construction Engineering and Management", 126, 77-79.

Yin, R K (2003) "Case study research: design and methods (3rd Ed.)". New Delhi: Sage Publications.

Zilber, T B (2002) Institutionalisation as an interplay between actions, meanings, and actors: the case of a rape crisis center in Israel. "The Academy of Management Journal", 45(1), 234-254.

Zwetsloot, G I J M, Aaltonen, M, Wybo, J-L, Saari, J, Kines, P and Beeck, R O D (2013) The case for research into the zero accident vision. “Safety Science”, 58, 41-48.

KEY INPUTS INTO A DESIGNING FOR CONSTRUCTION HEALTH, SAFETY, AND ERGONOMICS MODEL IN SOUTH AFRICA

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Construction health, safety, and ergonomics is inadequately addressed by architectural designers during the design process and disturbing accident statistics prevail, despite evidence that construction hazards and associated risks can be mitigated through appropriate design. A review of relevant literature and a mix of quantitative and qualitative prior preliminary studies as part of a PhD (Construction Management) study provide a backdrop for this paper. A pilot study questionnaire comprising a quantitative and qualitative mix was developed and distributed to 73 architectural designers in the Border region of the Eastern Cape Province in South Africa who are registered with the SACAP in order to: establish the dynamics of a model; engender an appropriate framework for a model, and to identify a range of key inputs suited to the model framework. The salient findings based on response percentages and mean score, and a measure of central tendency: established that architectural designers would be encouraged to design for construction health, safety, and ergonomics if they had a technologically grounded, flexible model which promotes a buy-in situation without stifling architectural freedom to assist the design process; recognised the SACAP work stages as being extensively followed during the design process; found the NBR to be the most widely used construction documentation during the design process, and identified a range of key inputs suited to a proposed model framework. Further research is necessary and it is recommended that the structure of the NBR and the SACAP work stages be suitably integrated in order to form the framework for a proposed model as such a format would be readily understood by architectural designers, and that the proposed range of key inputs be integrated with the proposed model framework to create the proposed model.

Keywords: architectural designers, key input, model framework.

INTRODUCTION

Internationally, the construction industry has earned a poor reputation for health and safety (H&S) (Mroszczyk 2005; cidb 2009; Gangolells et al. 2010). The South African construction industry is no different and demonstrates disturbing accident statistics (Compensation Commissioner 1999). International regulation such as the UK's

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Goldswain C and Smallwood J (2013) Key inputs into a designing for construction health, safety, and ergonomics model in South Africa *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 359-367.

Construction (Design and Management) Regulations (CDM 2007), underpinned by The Approved Code of Practice (ACOP) (HSE 2007) place legal duties on architectural designers, among others, to engage in safe design. Similarly, the Construction Regulations of 2003 (with some recent amendment) in South Africa compel architectural designers to practice safe design (Republic of South Africa 2003), however a lack of appropriate education and competencies (Smallwood 2006; Toole and Gambatese 2006) and the level of attentiveness demonstrated by architectural designers (Behm and Culvenor 2011) severely hinders the process. The development of a user friendly model suited to the South African situation is expected to promote encouragement for architectural designers to practice healthy and safe design, and could be integrated into architectural education and training programmes (Smallwood 2006; Schulte et al. 2008). Mitigation of construction hazards and risks through healthy and safe design could eliminate up to 50% of construction accidents (Health and Safety Executive (HSE) 2003; Behm 2006; Toole and Gambatese 2006).

The review of the literature considers a range of possible key inputs suited to a proposed framework for an architectural design model aimed at improving construction health, safety, and ergonomics. These include: local and international literature; causes of construction accidents; hazard identification and risk assessments; international models, and design recommendations.

This paper follows three earlier preliminary studies as part of a PhD (Construction Management) study, and continues to forge the direction of the main study. This predominantly quantitative study set out to: establish the dynamics of a likely model; consider the extent to which architectural designers embrace the SACAP work stages; consider the application of the NBR as the most widely used construction documentation during the design process in order to consider it toward a model framework, and to identify a range of key inputs suited to a recommended model framework.

REVIEW OF THE LITERATURE

Local and international literature

This consideration overlaps other key inputs and is considered more general in nature. It is deliberately kept brief, but is included as a key input not only for consideration of extant literature, but to ensure consideration of future literature deemed suitable for constant evolution of the said model. While exercising healthy and safe design, it is imperative that the creativity of architectural designers is not inhibited (Gangolells et al. 2010). Examples exist where creativity and innovation have flourished while exercising safe design, and have simultaneously demonstrated a positive effect on cost, quality and schedule (Behm and Culvenor 2011). Architectural designers should be encouraged and demonstrate enthusiasm toward safe design which could be underpinned by regulation, rather than being driven by regulation (Behm and Culvenor 2011). Having an appropriate model in place could achieve just that and could enhance competencies by being included in architectural education and on-going training (Smallwood 2006; Schulte et al. 2008).

Hazard identification and risk assessments

Hazard identification involves identifying situations whereby people may be exposed to harm. Risk assessment involves the likelihood of harm occurring, and risk control involves the mechanisms applied to mitigate such hazards and risks (WorkSafe Victoria 2005). Relative to South Africa, Goldswain and Smallwood (2009) identified that "… architectural designers do not adequately conduct hazard identification and

risk assessments during the design process." In order to achieve this from a design and construction point of view, Gangolells et al. (2010) identified a range of construction processes which can relate to construction hazards, and consider these in terms of risk probability and consequence severity. They also consider these in terms of the volume of work or exposure to any given process. The processes included are surprisingly similar to the framework of the NBR and includes, for example, earthworks, foundations, and structures (Republic of South Africa 2010).

International models

The Australian CHAIR is a fitting acronym for the Construction Hazard Assessment Implication Review which encourages designers to "... sit down, pause and reflect on possible problems." (Workcover NSW 2001: 4) It offers three vital opportunities for all stakeholders to review design progression, respects the 'principles of safe design' and the 'hierarchy of control' offered by the Australian Safety and Compensation Council (2006). The United Kingdoms' Gateway model (HSE 2004) provides opportunity for all stakeholders to assess the work undertaken by designers', among others at given 'gateways' in the design and construction process. It includes a range of 'support tools' to facilitate such processes, and it expects stakeholders and designers to sign upon satisfaction of each gateway assessment before further work continues.

Design recommendations

Behm (2006) advocates and adds to the contributions of Gambatese and Weinstein who provided a range of design recommendations in order to promote safe design. These include, among others, recommendations relative to aspects of construction sites, inclusion of permanent safety features being incorporated into the design of structures, inclusion of safety information and warnings in construction documentation, appropriate scheduling of activities, establishing of procedures for specific activities, and includes the need for adequate competencies of all persons involved.

METHODOLOGY

This study follows three earlier preliminary studies, one of which was qualitative in nature, as part of a PhD (Construction Management) study which ultimately aims at developing a model suitable for use by architectural designers in South Africa in order to design for construction health, safety, and ergonomics. van Teijlingen and Hundley (2001) propose preliminary studies as crucial toward the success of the main study. All four have been dedicated to a gradualist approach of building a line of structured questioning for the 'action research' paradigm (Dick, 1993) using 'focus group' methodology for the main study (Azhar 2007; Cohen et al. 2007; O'Brien 1998). A survey of the literature and the previous preliminary studies contributed to the development of a questionnaire survey, chosen for cost effectiveness and to give respondents the opportunity to respond within their own time and in privacy (Leedy and Ormrod 2010). The primarily quantitative survey based on percentages, mean score and a measure of central tendency was conducted among a regional group of architectural designers in the Border region of the Eastern Cape Province in South Africa, registered with the SACAP. Questionnaires were distributed in hard copy to 73 randomly selected architectural designers and 15 responses were received, equating to a response rate of 20.5%. The low response rate can be expected from the South African construction industry (Crafford 2007). Relative to this paper, the questionnaire comprised 18 statements, inter alia, with respondents being required to

indicate on a rating scale or Likert type scale of 1 (totally disagree) to 5 (totally agree) the extent to which they concur (Leedy and Ormrod 2010). An ‘unsure’ option was included in order to accommodate uncertainty, as opposed to 'forcing' a 'scale' response. Open ended questions followed in order to solicit qualitative comments which could constitute additional emerging themes for the greater study. van Teijlingen and Hundley (2001), with reference to De Vaus' 1993 work, suggest the incorporation of both quantitative and qualitative questioning in pilot studies and what is referred to as 'mixed method design' by Leedy and Ormrod (2010). This quantitative study thus set out to: establish the need and nature of a likely model; consider the extent to which architectural designers embrace the SACAP work stages; consider the application of the NBR as the most widely used construction documentation during the design process in order to consider it toward a model framework, and to identify a range of key inputs suited to a recommended model framework.

FINDINGS

In the table which follows, the degree of concurrence is represented in terms of percentage responses to a scale of 1 (TD = totally disagree) to 5 (TA = totally agree), and a related mean score (MS) between 1.00 and 5.00, based upon the percentage responses. MSs > 4.20 < 5.00 indicate that the degree of concurrence can be deemed to be between agree (A) to totally agree / totally agree, while MSs of > 3.40 < 4.20 indicate that the degree of concurrence can be deemed to be between neutral (N) to agree / agree. MSs > 2.60 < 3.40 indicate that the degree of concurrence can be deemed to be between disagree (D) to neutral / neutral, while MSs of > 1.80 < 2.60 indicate that the degree of concurrence can be deemed to be between totally disagree to disagree / disagree. Allowance has been made for unsure (U) answers.

Table 1 indicates the degree of concurrence with statements related to designing for construction health, safety, and ergonomics. It is notable that 77.8% of the mean scores (MSs) are above the midpoint score of 3.00, meaning that architectural designers concur with most of the related statements. For purposes of discussion, the findings are elaborated in terms of themes as opposed to MSs, which are simultaneously reflected. The first theme seeks to establish the need and nature of a likely model. The MS of 4.18 relative to ‘architectural designers would be more encouraged to design for construction health, safety, and ergonomics if they had a guiding model to assist them’ is notable and motivates the need for a model. The profound MS of 4.60 relative to ‘a guiding model should be technologically grounded and should not stifle architectural freedom’ is significant. The MS of 4.07 relative to ‘a guiding model should include checklists and allow opportunity for design notes in order to assist the process’ is closely followed by the MS of 4.00 relative to ‘a guiding model should be flexible in nature and should promote a buy-in situation making architectural designers more willing to use the model’. To the statement ‘a guiding model should include a process which architectural designers can follow in order to design for construction health, safety, and ergonomics’, a lesser MS of 3.60 was recorded followed by a MS of 3.40 relative to ‘architectural designers would like a guiding model which includes prompts or keywords in order to engender deeper thinking during the design process’, however it should be noted that 13.3% of respondents provided an unsure answer. The low MS of 2.64 relative to ‘a guiding model should be prescriptive and regulatory in nature whereby architectural designers are forced by regulation to use the model’ is also significant. The second theme focusses on a framework for the proposed model and embraces the second and third objectives of this study. The most significant MS of 4.33 relative to ‘a guiding model

should have a framework which is familiar to architectural designers and offers ease of use' has substance. This is followed by the MS of 4.20 relative to 'architectural designers follow the SACAP work stages during the design process' and the MS of 4.00 relative to 'architectural designers use the application of the NBR during the design process'.

Low MSs are recorded relative to the use of other construction documentation and are significantly lower. The MS of 2.53 relative to 'architectural designers use a Bill of Quantities (BoQ) during the design process', the MS of 2.47 relative to 'architectural designers use the Preambles for Construction Trades during the design process', and the MS of 2.33 relative to 'architectural designers use a Work Breakdown Structure (WBS) during the design process' reflect this. The third theme seeks to identify a range of key inputs suited to a proposed model framework. To the statement 'architectural designers would need to understand the causes of construction accidents in order to design for construction health, safety, and ergonomics' a MS of 4.07 was recorded. The MS of 3.79 relative to 'consideration of existing design recommendations would prove beneficial to developing a guiding model suitable for use in South Africa' followed. The MS of 3.73 followed relative to 'consideration of local and international literature would prove beneficial to developing a guiding model suitable for use in South Africa'. Finally, two equal MSs of 3.53 were recorded relative to 'architectural designers would need to identify hazards and undertake risk assessments in order to design for construction health, safety, and ergonomics' and 'consideration of international models would prove beneficial to developing a guiding model suitable for use in South Africa' respectively.

Table 1: Degree of concurrence with statements related to development of a model

Statement	Response (%)						MS
	U	TD	D	N	A	TA	
Architectural designers would be more encouraged to design for construction health, safety, and ergonomics if they had a guiding model to assist them	6.7	0.0	0.0	0.0	73.3	20.0	4.18
A guiding model should be technologically grounded and should not stifle architectural freedom	0.0	0.0	0.0	0.0	40.0	60.0	4.60
Architectural designers would like a guiding model which includes 'prompts or keywords' in order to engender deeper thinking during the design process	13.3	0.0	0.0	26.7	40.0	20.0	3.40
A guiding model should be flexible in nature and should promote a buy-in situation making architectural designers more willing to use the model	6.7	0.0	6.7	13.3	20.0	53.3	4.00
A guiding model should be prescriptive and regulatory in nature whereby architectural designers are forced by regulation to use the model	0.0	13.3	33.3	20.0	26.7	0.0	2.64
A guiding model should have a framework which is familiar to architectural designers and offers ease of use	0.0	0.0	0.0	0.0	66.7	33.3	4.33
Architectural designers use the application of the National Building Regulations (NBR) during the design process	0.0	6.7	6.7	13.3	26.7	46.7	4.00
Architectural designers use a Bill of Quantities (BoQ) during the design process	0.0	13.3	26.7	53.3	6.7	0.0	2.53
Architectural designers use a Work Breakdown Structure (WBS) during the design process	6.7	13.3	33.3	40.0	0.0	6.7	2.33
Architectural designers use the Preambles for Construction Trades during the design process	0.0	20.0	26.7	40.0	13.3	0.0	2.47
Architectural designers follow the SACAP 'work stages' during the design process	0.0	0.0	0.0	13.3	53.3	33.3	4.20
Architectural designers would need to understand the causes of construction accidents in order to design for construction health, safety, and ergonomics	0.0	0.0	0.0	26.7	40.0	33.3	4.07
Architectural designers would need to identify hazards and undertake risk assessments in order to design for construction health, safety, and ergonomics	6.7	0.0	6.7	20.0	53.3	13.3	3.53
Consideration of 'local and international literature' would prove beneficial to developing a guiding model suitable for use in the context of South Africa	6.7	0.0	0.0	20.0	53.3	20.0	3.73
Consideration of suitable 'international models' would prove beneficial to developing a guiding model suitable for use in the context of South Africa	6.7	0.0	0.0	26.7	60.0	6.7	3.53
Consideration of existing 'design recommendations' would prove beneficial to developing a guiding model suitable for use in the context of South Africa	0.0	0.0	0.0	40.0	33.3	20.0	3.79
A guiding model should include a process which architectural designers can follow in order to design for construction health, safety, and ergonomics	0.0	6.7	0.0	33.3	46.7	13.3	3.60
A guiding model should include 'checklists' and allow opportunity for 'design notes' in order to assist the process	0.0	0.0	6.7	6.7	60.0	26.7	4.07

Relevant open ended questions and responses are included as follows:

'Do you have any comments or suggestions regarding a possible framework for a guiding model?'

- Exposure of professionals to necessity of a model would highlight shortcomings in knowledge, and
- Good idea to relate to SANS 10400 (NBR).

‘Do you have any comments or suggestions regarding possible inputs into the framework of a guiding model?’

- Checklist, and
- Exposure and understanding of construction technologies.

‘Do you have any comments or suggestions relative to construction health, safety, and ergonomics?’

- Designers and architectural practitioners should be actively exposed to the physical construction process of projects to ensure a practical understanding of the erection and construction process and constraints;
- Use CDM regulations from the UK as a benchmark, and
- Very important as deaths / accidents far too high.

CONCLUSIONS

Given the objectives and methodology of the study, it is likely that the responses received were from the more committed architectural designers.

The findings relative to the first theme querying the dynamics of a model indicate that architectural designers would be encouraged to design for construction health, safety, and ergonomics if they had a technologically grounded, flexible model which promotes a buy-in situation without stifling architectural freedom to assist the process. A flexible process is required which includes the need for checklists and allows opportunity for capturing of design notes. Slightly less enthusiasm was expressed relative to the need for prompts and keywords, but some doubt existed in this area. It was made clear that the model must not be prescriptive and regulatory in nature if a buy-in is to be expected.

The findings relative to the second theme clearly indicate that architectural designers suggest a model framework which is familiar to them and offers ease of use. As extensive use is made of both the SACAP work stages and the NBR during the design process, these strongly lend themselves as a model framework which will be familiar and easy for architectural designers to use. It is clear that BoQs, Preambles for Construction Trades and WBSs will not form a suitable model framework. The third theme sought to identify a range of key inputs suited to a proposed model framework. While an understanding of the causes of construction accidents predominated, consideration of existing design recommendations, consideration of local and international literature, the need to identify hazards and undertake risk assessments, and consideration of international models all proved valuable as key inputs. The open ended qualitative questions suggest the importance of the study as accidents and death rates are ‘far too high’, and that exposure and enhanced understanding by designers is required. International benchmarking in the form of the UK's CDM Regulations is also suggested and it is a ‘good idea’ to relate the model framework to the NBR.

Architectural designers require an enhanced contextual understanding of construction health, safety, and ergonomics and further research is required toward development of an appropriate model. It is recommended that the NBR and the SACAP work stages

be suitably integrated in order to form the framework for a proposed model as such a format would be readily understood by architectural designers, and that the proposed range of key inputs be integrated with the proposed framework toward development of the envisaged model.

REFERENCES

Australian Safety and Compensation Council (ASCC) (2006) "Guidance on the Principles of Safe Design for Work". Commonwealth of Australia.

Azhar, S (2007) "Improving Collaboration between Researchers and Practitioners in Constuction Research Projects using Action Research Technique" http://ascpro0.ascweb.org/archives/2007/CERT81002007.pdf

Behm, M (2006) "An Analysis of Construction Accidents from a Design Perspective". http://www.elcosh.org/en/document/841/d000795/an-analysis-of-construction-accidents-from-a-design-perspective.html

Behm, M and Culvenor, J (2011) Safe design in construction: Perceptions of Engineers in Western Australia. "Journal of health and safety research & practice", 3, 9-23.

Compensation Commissioner (1999) "Compensation for Occupational Injuries and Diseases Act, 1993 - Report on the 1999 Statistics". Pretoria: Department of Labour.

Cohen, L Manion, L and Morrison, K (2007) "Research Methods in Education, Sixth edition". New York: Routledge.

CDM (2007) "The Construction (Design and Management) Regulations 2007". UK: The Stationery Office Limited.

Construction Industry Development Board (cidb) (2009) "Construction Health and Safety in South Africa - Status & Recommendations". Pretoria: cidb.

Crafford, G (2007) "Clients' views on construction and design team competencies", Unpublished PhD Thesis, Department of Construction Management, Nelson Mandela Metropolitan University.

Dick, B (1993) "You want to do an action research thesis? " http://uqconnect.net/action_research/art/arthetis.html

Gangolells, M, Casals, M. Forcada, N, Roca, X and Fuertes, A (2010) Mitigating construction safety risks using prevention through design. "Journal of Safety Research", 41, 107-122.

Goldswain, C and Smallwood, J J (2009) Mitigating Construction Health, Safety, and Ergonomic Risks: Perceptions of Architectural Design Professionals. In: Haupt, T C and Smallwood, J J (Eds.) "Proceedings of TG59 People in Construction", 12-14 July 2009, Port Elizabeth, CREATE, 211-223.

HSE (Health and Safety Executive) (2003) "Causal factors in construction accidents.– Research Report 156". Suffolk: HSE Books.

HSE (Health and Safety Executive) (2004) "Integrated gateways: planning out health and safety risk – Research Report 263". Suffolk: HSE Books.

HSE (Health and Safety Executive) (2007) "The Approved Code of Practice (ACOP) - Construction (Design and Management) Regulations 2007". http://www.hse.gov.uk/construction/cdm/acop.htm

Leedy, P D and Ormrod, J E (2010) "Practical Research Planning and Design" 9 Ed (International Edition). Cape Town: Pearson Education International.

Mroszczyk, J W (2005) "Designing for Construction Worker Safety". http:www.asse.org/membership/docs/John%Mroszczyk%20Article.doc

O'Brien, R (1998) "An Overview of the Methodological Approach of Action Research" http://www.web.net/-robrien/papers/arfinal.html

Republic of South Africa (2003) "Construction Regulations 2003". Pretoria.

Republic of South Africa. (2010) "SANS 10 400: The application of the National Building Regulations (NBR)". Pretoria : SABS Standards Division.

Schulte, P A, Rinehart, R,. Okun, A, Geraci, C and Heidel, D (2008) National Prevention Through Design (PtD) Initiative. "Journal of Safety Research", c/o Science Direct, linkinghub.elserivier.com/retrieve/pii/s0022437508000054

Smallwood, J J (2006) The Influence of Architectural Designers on Health and Safety (H&S) during Construction. In: Haupt T C (Ed.), "3rd South African Construction Health and Safety Conference: A Team approach to Construction Health and Safety", 7-9 May 2006, Cape Town, CREATE, 29-46.

Toole, M and Gambatese, J (2006) The Future of Designing for Construction Safety. "Proceedings of CIB Leadership in Construction". http//www.designforconstructionsafety.org

vanTeijlingen, E.R and Hundley, V (2001) " The importance of pilot studies". file://localhost/C:/Documents%20and%20Settings/All%20Users/Documents/Research/Website%20Info/The%20

WorkCover NSW (2001) "CHAIR Safety in Design Tool". Suffolk: WorkCover NSW.

WorkSafe Victoria (2005) "Hazard identification, risk assessment & risk control in the workplace", http://worksafe.vic.gov.au

A RELATIONAL APPROACH TO HIGH RELIABILITY ORGANISING FOR CONSTRUCTION PROJECT SAFETY: A CONCEPTUAL FRAMEWORK

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In Hong Kong, current safety management regimes in the construction industry are largely based on compliance, error detection and prevention, and safety climate intervention. While these approaches have improved construction project safety performance, significant limitations still exist. First, compliance and error detection/prevention approaches are based on rigid and ideal formulations of construction work processes. Second, safety climate interventionist approaches have a limitation of mixing psychological and human factors issues that are somehow detached from construction work contextual consideration. As a result, current safety management approaches are less effective in ensuring safety in construction operations which are emergent and dynamically complex. These situations require adaptive human inputs and interactions to ensure safety on projects that are grounded in the social capital among project team members. However, as social capital is a primordial feature of human interactions that is likely to lie dormant, its impact on safety performance is likely to be indirect and mediated by some organising processes such as high reliability organising (HRO) processes. Adopting the systems view of safety, we draw on these concepts to highlight the relational aspects in the management of construction project safety, and explain how these relational aspects can contribute to improving project safety. We accomplish these objectives by putting forth a conceptual framework and methodological suggestion.

Keywords: health and safety, high reliability organising, human factor, project management, social capital.

INTRODUCTION

The building and construction industry of most countries and regions is often characterised by poor safety performance. This industry has often recorded a high rate of industrial accidents. The Hong Kong construction industry is no exception to this phenomenon. In fact, in Hong Kong, 79.31% of all industry fatalities in 2011 occurred in the construction industry (Labour Department 2012a). In addition, with the increase in construction activities and volume in recent years, there is a corresponding increase in the number of accidents. For example, the construction industry accident numbers have increased from 2,775 to 2,884 and to 3,112 from 2009, 2010, and to 2011 respectively. The number of fatality also increased from 9 in 2010 to 23 in 2011

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Koh TY, Tuuli MM and Rowlinson S (2013 A relational approach to high reliability organising for construction project safety: a conceptual framework *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 369-379.

(Labour Department 2012b). For the first six months of 2012, 7 fatalities were reported and this figure is an increase of 4.7% from the same period the previous year (Labour Department 2012c). With the strings of on-going construction projects, new projects that are recently rolled out, and those that are in the pipe line, the trend is likely to continue into the next few years.

Within the above context, a myriad of safety management initiatives have been introduced and implemented in construction projects since 1998 with the recognition of the need to manage construction project safety. While these initiatives have brought about improvement in the safety performance of the Hong Kong construction industry since 1998, the safety performance of the industry has plateaued since 2005. This stagnation, together with the phenomenon that accident statistics tends to trail the construction volume, calls the effectiveness of current safety management initiatives into question. Specifically, current safety discourse in Hong Kong construction industry neglects the construction team micro-processes of organising in the performance of construction operations in a safe manner. This aspect of human factor is however important as the construction operation system deviation can only be absorbed by the human operators interacting with the system components and organising processes (Dekker 2005; Leveson 2011). Hence, there is a need to explore new dimensions in the management of construction safety from the human and social perspectives.

Because the phenomenon of social capital is grounded on the utility of relationships of a group of technically inter-related individuals bounded in a project, and high reliability organising (HRO) is predicated on the premise that untoward event (e.g. safety breach that leads to an accident) can be prevented through the mindful organising processes of those individuals, we suggest that the concepts of social capital and HRO are possible avenues to pursue improvement in the safety management capacity of the workers and frontline staffs in construction projects.

In this paper, we first identify the gap in both literature and practice in managing construction project safety; invoke the systems view of safety management and the ensuing impetus of human inputs to cater for system deviations; follow by delineating the underlying conceptual and practical need to invoke the relational concepts and human factors through social capital given the systemic nature of safety; and encapsulate and synthesise these concepts into a theoretical framework. We conclude by suggesting methodological approach in pursuing this exploration.

THE THEORETICAL AND PRACTICAL GAPS

In Hong Kong construction industry, current initiatives in the management of construction project safety are largely based on compliance and error detection and prevention (Koh and Rowlinson 2012). In the compliance approach, the idea is to control project participants' behaviours by having them comply with the safe conduct and punishing them upon the breach of safety rules (Mitropoulos et al. 2009; Rasmussen 1997). The error detection and prevention approach concentrates on error management by the removal of the causes of error (Mitropoulos et al. 2009). These approaches inevitably focus on the internal and static nature of the construction production system. In the internal aspect, the approaches focus on the characteristics of the participants (e.g. skill level). In the static aspect, the approaches emphasize the nature of the tasks being performed (e.g. task design). Both approaches do not cater for the dynamics that emerge in the construction operations.

In the literary discourse, within the Hong Kong construction industry, a wealth of empirical studies has been conducted to investigate various aspects of construction safety management and its relationship to project safety performance. Tam and Fung (1998) studied a myriad of safety management strategies and their impact on safety performance and found that the provision of safety training, the use of direct labour, using post-accident investigation as a feedback, and safety promotion by safety award campaigns and incentive schemes are the effective tools in reducing site accidents. Fung et al. (2010) have developed a risk assessment model that purportedly predicts the high-risk construction activities which in turn prevents accidents from occurring. Several safety climate studies have also been undertaken within the local construction industry. In this string of works, Choudhry et al. (2009) find that perceived safety performance is inversely related to safety climate item of "inappropriate safety procedure and work practices." Hence, they conclude that safety climate can be used as an effective measure to assess and improve site safety for construction projects. Fang et al. (2006), in their study of safety culture and climate in a construction firm (including the firm's sub-contractors), have found that significant relationship exists between safety climate and workers' safety behaviours.

While these works illuminate some aspects of safety management in the industry, limitations still exist. The safety culture and climate conceptions have been criticised as a catch-all concept that mixes psychological and human factors issues that are devoid of contextual consideration (Guldenmund 2000; Reiman and Oedewald 2007). The context can be the work itself or the sociotechnical processes by which the work is accomplished. As such, (safety) climate phenomenon is somewhat disconnected from the physical performance of the work. The other stream of work, while concentrating on the management aspects of safety provision, neglects the team micro-processes of organising for safe work performance. Together with the mechanistic approach in managing construction safety noted earlier (i.e. the compliance and error detection and prevention approaches), the current Hong Kong construction safety management state of affairs urgently needs the exploration of new dimensions in the human and social aspects in improving the industry safety performance. We suggest that this aim can be achieved through project social capital and HRO.

We explore next the underlying structural features of construction operations that provide the impetus for human inputs.

THE SYSTEMS' VIEW OF SAFETY AND THE IMPORTANCE OF HUMAN INPUTS

Viewed from the total production system's perspective, current approaches are devoid of the attention to the dynamics and interactions among the production (construction) elements. These dynamics result from the interaction among the human operators, the physical objects to be put together, the tasks, and the operating environments and contexts. In the systems perspective, a production model needs to be considered as a socio-technical system in its entirety that includes not only the parts of the system but also the relationships among those parts and the ways they interact. The interactions of these parts give rise to the emergent property of safety (Leveson 2004) in which dysfunctional interactions of those parts lead to problems. When a localised decision which is correct under the limited context under which it is made come into interaction with other similarly localised decision, the independent decisions and the

organisational behaviours can interact in dysfunctional ways that likely lead to accident (Leveson et al. 2009).

In Hong Kong, from the systems perspective, current safety management approaches are less effective in ensuring safety in the construction projects as the result of the dynamics, complexities, and emergent interactions of components in construction operations. In this respect, because human operators and their interactions are the catalysts in managing projects, there is a gap in the lack of recognition of a social explication in the management of construction safety (Koh and Rowlinson 2012). This argument is predicated on the structural and organisational features of construction operations. Construction operations are reciprocally coupled at the site activity level. These activities are time dependent and are invariant in their sequence. At the work organisational level however, together with the human operators, these inter-related features are intertwined into forming a complex and dynamic sociotechnical systems. These systems are complex and dynamic because of the presence of multiple goals (speed, quality, cost, and safety), multiple interacting parties (various trades and professional disciplines some of which have different mental models, and work packages, heterogeneous client organisation), complex social structures (hierarchical sub-contracting arrangements, multiple stakeholders), and the complex technology and operating environments (market pressures, political and institutional regulations) (cf. Reiman and Oedewald 2007).

There is a high level of interdependence among these elements within the organisational environment that is continuously changing. These interactions are likely to lead to unexpected high-variety disturbances. The events that unfold through such a system are likely to be invisible nexus that are hard to anticipate. These events are also likely to cascade in an interactively complex manner whereby the interactions among various processes and elements can have hidden and unintended consequences (Perrow 1999). As the events unfold, the daily controlling and steering activities involve a continuing process of organising amidst the dynamics and complexity. In terms of organising for safety, the dynamics and complexity imply that operators continuously experience change in the form of adaptations in response to short-term productivity and cost objectives. In the course of these adaptations, it is possible that safety defences degenerate as a result of the production pressures and changes. When the system complexity increases and adaptations are required the need for human input is significant as a means to coordinate not only the work processes but also to achieve safety of the activities (Dekker 2005; Weick 1987). Thus, to keep the operating system within the safe limit and maintain system adaptation, human inputs are essential as it is through human inputs that recognition, communication, and improvisation of unexpected events, changes, and disruptions that system safety is achieved (cf. Mitropoulos and Memarian 2012).

THE HUMAN FACTORS IN PROJECT ORGANISATIONS

The above conceptions imply that human and social factors are fundamental in the management of construction project safety. In a project team, team members can exert considerable influence on one another. This influence may also shape the attitudes and in turn behaviours of the members. For example, the team's expectations of members to adhere to safety rules create strong social control in ensuring members' safe conduct (Lingard and Rowlinson 2005). In addition, the work practices and team processes shape the situations that the team members must face. Project participants need to deal with the work practices and systems on one hand, and their own

interactions within the organisational and production contexts on the other (Mitropoulos et al. 2009). These features have brought to prominence project team relations and processes in managing construction project safety. In construction project organisations, the congregation of individuals from an array of disciplines involves a network of firms, their relationships that are embedded in these networks and their interactions with a socio-technical system. This structural form implies distributed organising activities. The focus of organisational analysis should therefore be placed on a network view of the situation and, crucially, on the interactions among project participants. The emphasis should be placed on the way the web of relationships, especially those manifested as goodwill, facilitate actions among participants in the management of project safety (Koh and Rowinson 2012). Goodwill, generally referred to as social capital (Adler and Kwon 2002), has been known to be able to add value to network-based organisation such as a construction project. Specifically, social capital is conceptualised as "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit" (Nahapiet and Ghoshal 1998: 243). The project organisational characteristics of interdependence and intensive interactions, diffused authority, temporality, and relative closure of project membership make the application of the social capital concept relevant (Nahapiet and Ghoshal 1998; Jones and Lichtenstein 2008). Social capital provides a mechanism and means by which coordination and collaboration among project participants can be effected. As such, social capital can be appropriated and exploited to achieve project organisational objectives (Nahapiet and Ghoshal 1998; Coleman 1988), including safety objectives.

Social capital can be conceptualised by three dimensions - the structural, cognitive, and relational dimensions (Nahapiet and Ghoshal 1998). The structural dimension refers to the impersonal configuration of linkages between persons or social units. The main facets under the structural dimension are network ties among project participants and the existence of appropriable organisation (Coleman 1988; Nahapiet and Ghoshal 1998). The cognitive dimension refers to the shared representations, interpretation, and system meaning among group members (Nahapiet and Ghoshal 1998). It reflects the condition whereby project team members share a common understanding (Bolino et al. 2002) and the extent to which they have developed a shared cognitive scheme (Maurer and Ebers 2006). The relational dimension is characterised by the personal relationships group members develop among themselves through the history of interaction (no less in the construction project setting) (Granovetter 1992). Relational dimension involves emotional closeness and reciprocal services among actors that are affective in nature (Granovetter 1973). It focuses on the quality of the relationships in terms of trust, obligations, expectations, etc. (Bolino et al. 2002).

Previous study (c.f. Koh and Rowlinson, 2012) has indicated that the effects of social capital on construction project safety are mediated through project organisational processes. In social settings, social actors' interactions are effectuated on the basis of the social structure, roles, norms, and trust among the actors. These aspects of social life represent social capital among the interacting social unit(s). Social capital provides the foundation for actors' interactions (Orlikowski 2002). In addition, social capital that resides in participants may lie dormant unless actively seek out and act upon (Maurer et al. 2011). Thus, project social capital provides the conditions necessary for project organisational processes to take place, and those processes in turn contribute to safety performance.

SOCIAL CAPITAL, HIGH RELIABILITY ORGANISING (HRO) AND SAFETY - A CONCEPTUAL FRAMEWORK

However, what are the organisational processes that are effective in ensuring safety in construction projects? In the production systems that are interactively complex and highly hazardous, HRO processes have been suggested as possible ways to prevent errors in high hazard and complex organisations (Lekka and Sugden 2011; cf. Sutcliffe 2011). HRO theory is predicated on the premise that accidents are not unavoidable and there are processes that organisations can adopt to effectively prevent safety problems (Roberts 1990). HRO can be referred to as a set of organising processes that allow organisation to continuously operate under trying conditions, reduce the impacts of accidents, and help with the recovery process (cf. Weick and Sutcliffe 2007). In this conception, reliability refers to a group feature of "unusual capacity to produce collective outcomes of a certain minimum quality (and safety) repeatedly" (our addition) (cf. Hannan and Freeman 1984: 153; cf. Vogus and Welbourne 2003).

HRO is essentially grounded on group mental processes that increase the quality of attention across the group of individuals through their alertness and awareness so that they are able to detect subtle changes of contexts and react appropriately (Sutcliffe 2011: 137; Vogus 2012: 665). HRO is characterised by five principles. These are preoccupation with failure (operating with chronic wariness and engaging in proactive analysis of adverse events), reluctance to simplify interpretations (creating a more complete picture of current operations), sensitivity to operations (sharing information on the human and organisational issues to form an integrated big picture of current situation), commitment to resilience (developing capabilities to cope with adverse events), and deference to expertise (allowing decision to be taken by people with the most expertise in high-tempo events irrespective of rank) (Sutcliffe 2011; Vogus 2012; Weick et al. 1999).

The term “organising” in HRO suggests that the performance of safe activity is a continuing and dynamic process. The latter qualifier - the dynamic process - also implies that safe performance is a relating process in group settings. HRO theory emphasises the social and organisational underpinnings of systems safety. Operations can be performed in highly reliable manner despite complex interrelated human activities and interactions through improvisation and adaptation of personnel within the system. Even under trying conditions (hazardous and unpredictable environments), it is possible to achieve real-time problem solving and maintain system safety by incorporating human inputs. This line of reasoning suggests that safety is achieved through human processes and relationships (Sutcliffe 2011). In dynamic situation, safety is achieved by timely human adjustment. This adjustment is effected by organising processes that increases the participants’ quality of attention. This increased attention, in turn, enhances participants’ alertness to details of operations thereby enabling them to be able to detect subtle changes in contexts and respond as appropriate – a process of mindfulness (Weick et al. 1999). Mindfulness enables individuals to continuously interact with others in the system as they develop shared understanding of the situation they encounter and their capabilities to act. This collective capability can potentially forestall errors (Sutcliffe 2011).

Two interrelated human factors underpin the capability of mindfulness. The first factor is the norm of respectful interaction. In the situation characterised by respect, people are more likely to communicate their ideas to others. The opposite party, in

turn, is more likely to reciprocate by taking in the ideas. Such communication generates a shared interpretation of the situation (Christianson and Sutcliffe 2009). The outcome of this process is the integration of multiple strands of ideas into a socially shared mental repertoire that leads to cognitive ability of the group as a whole – the ability to speak up, ask questions, and challenge current perceptions. The second factor is the heedful interrelating among individuals at operational level. Heedful interrelating refers to a situation whereby individual understands the way the system is configured and how their actions fit into the larger scheme (Weick and Roberts 1993). The individual's understanding of the interrelationships between parts (his contribution) and whole (his contribution into forming a larger whole) forms a larger pattern of shared action. In the situation where individuals maintain a conscious awareness of their actions at both levels of the shared action scheme, they are likely to contribute to high reliability of the action system. The cognitive dimension of social capital, therefore, leads to HRO.

The two human factors also form the social foundation of HRO. The basis of HRO is that individuals interact continuously to develop, refine, and update a collective mental schema of the situation they encounter and act on that basis. The second human factors described above (i.e. the part-whole relationship) suggests that the access to other individuals within the same system, the intertwining of individuals from different work groups and networks facilitate the building of understanding of not only their contribution to the system goals but also the work norms conducive to HRO. In this respect, the structural dimension of social capital contributes to HRO. In addition, Colquitt et al.'s (2011) study suggests that trust to co-worker is highly relevant in task situation that is characterised by high situational unpredictability and hazard (e.g. tunnel boring operations). This work condition is referred to as high reliability task context. This situation suggests that the relational dimension facilitates HRO. In essence, HRO thrives on the social and relational infrastructure of organisation (Christianson and Sutcliffe 2009), and it is through these organising processes that the production (construction) system's (e.g. the project team) safety capability is improved (cf. Weick 1987; Weick and Sutcliffe 2007). This improved capability is likely to ensure better safety performance. Hence, as previously noted, a mediational proposition that links project social capital, HRO, and project safety performance is plausible. This framework is presented in Figure 1.

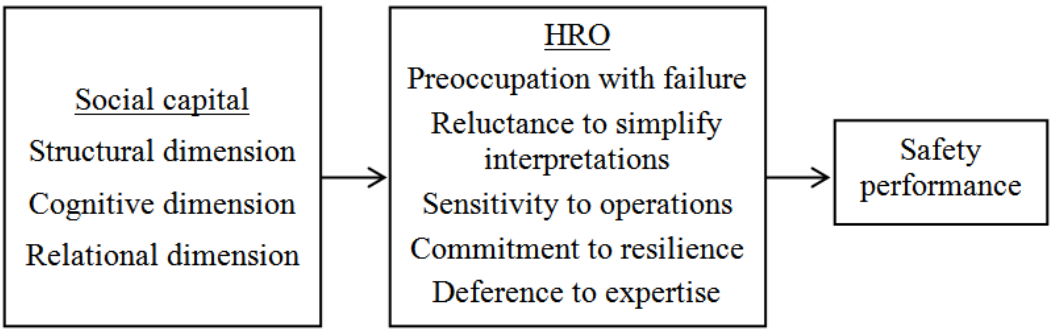

Figure 1: A mediational framework of social capital, HRO, and safety performance

CONCLUSIONS AND METHODLOGICAL SUGGESTION

In this paper, we set out to explore the proposition and the associated underlying relational conception and micro work processes in achieving construction project safety. The proposed framework links the structural, cognitive, and relational aspects

of social life within project organisation (in social capital) to the participants' micro processes of organising work (in HRO). The successful establishment of such relationship and the applicability of the concepts (relational paradigm and high reliability organising) could provide knowledge to inform future direction of construction project safety management through project organisational re-configuration (e.g. overlapping both formal and informal work groups, bi-directional communication infrastructure) and work practices re-design among the entire production (construction) system (e.g. incorporating high reliability principle of sensitivity to operations such as dynamic risk analysis of work conditions into supervision practices). The exploration informs on the impact of human factors on construction project safety. This endeavour is in line with the emerging research areas of social factors and systemic rationalisation of production. Further, the propositions and framework are also the recognition that in addition to the established institutional and macro-structural variables (e.g. regulations, regimented safety management system), an equally important dimension in safeguarding construction safety lies with human beings, their relational assets, and organising practices.

Due to the novelty, conceptual complexity, and explorative nature of the scheme, a mixed methods design may be suited for the exploration. Within this methodological approach, an embedded-sequential design could be adopted. The exploration could generally be conducted as a case study. Case study is an ideal design to explore the project team social capital and high reliability practices in the selected case projects, and to examine the organisational processes within these contexts (Yin 2003). To corroborate the results from the qualitative exploration and to ensure the validity of causality of the constructs derived from the qualitative phase, questionnaire survey could be conducted within the case study - hence the embedded-sequential design (cf. Creswell and Plano Clark 2007). With this methodological approach, differentiated yet complementary perspectives could be generated to provide better understanding of the phenomena.

ACKNOWLEDGEMENT

The authors acknowledge funding provided by The University of Hong Kong's to the first author (Project code 201301159001)]

REFERENCES

Adler, P S and Kwon, S W (2002) Social capital: prospects for a new concept. "Academy of Management Review", 27(1), 17-40.

Bolino, M C, Turnley, W H and Bloodgood, J M (2002) Citizenship behaviour and thte creation of social capital in organisations. "Academy of Management Review", 27(4), 505-522.

Choudhry, R M, Fang, D-P and Lingard, H (2009) Measuring safety climate of a construction company. "Journal of Construction Engineering and Management", 135(9), 890-899.

Christianson, M K and Sutcliffe, K M (2009) Sensemaking, high reliability organising, and resilience. In: P. Croskerry, K. Crosby, S. Schenkel, and R.L. Wears, (eds.) "Patient safety in emergency medicine". Philadelphia: Lippincott Williams and Wilkins, 27-33.

Coleman, J S (1988) Social capital and the creation of human capital. "American Journal of Sociology", 94(Supplement), S95-S120.

Colquitt, J A, Lepine, J A, Zapapa, C P and Wild, R E (2011) Trust in typical and high-reliability contexts: Building and reacting to trust among firefighters. "Academy of Management Journal", 54(5), 999-1015.

Creswell, J A and Plano Clark, V L (2007) "Designing and conducting mixed methods research". Thousand Oaks, CA: Sage.

Dekker, S W A (2005) "Ten questions about human error: a new view of human factors and system safety". Mahwah, N. J.: Lawrence Erlbaum.

Fang, D-P, Chen, Y and Wong, L (2006) Safety climate in construction industry: A case study in Hong Kong. "Journal of Construction Engineering and Management", 132(6), 573-584.

Fung, I W H, Tam, V W Y, Lo, T Y and Lu, L L H (2010) Developing a Risk Assessment Model for construction safety. "International Journal of Project Management", 28(6), 593–600.

Granovetter, M S (1973) The strength of weak ties. "American Journal of Sociology", 78(6), 1360-1380.

Granovetter, M (1992) Problems of explanation in economic sociology. In: N. Nohria and R.G. Eccles (eds.) "Networks and organisations: structure, form, and action". Boston, Mass: Harvard Business School Press, 25-56.

Guldenmund, F W (2000) The nature of safety culture: a review of theory and research. "Safety Science", 34(1-3), 215-257.

Hannan, M T and Freeman, J (1984) Structural inertia and organisational change. "American Sociological Review", 49(2), 149-164.

Jones, C and Lichtenstein, B B (2008) Temporary inter-organisational projects: how temporal and social embeddedness enhance cooperation and manage uncertainty. In: S. Cropper, M. Ebers, C. Huxham and P. S. Ring (eds.) "The Oxford handbook of inter-organisational relations". Oxford: Oxford University Press, 231-255.

Koh, T Y and Rowlinson, S (2012) Relational approach in managing construction project safety: a social capital perspective. "Accident Analysis and Prevention", 48, 134-144.

Labour Department (2012a) "Occupational safety and health statistics 2011". Occupational Safety and Health Branch, Labour Department, Hong Kong.

Labour Department (2012b) "Occupational safety and health statistics bulletin issue No. 12 (July 2012)". Occupational Safety and Health Branch, Labour Department, Hong Kong.

Labour Department (2012c) "Summary of occupational health and safety statistics of 1st half of 2012". Occupational Safety and Health Branch, Labour Department, Hong Kong.

Lekka, C and Sugden, C (2011) The successes and challenges of implementing high reliability principles: a case study of UK oil refinery. "Process Safety and Environmental Protection", 89(6), 443-451.

Leveson, N (2004) A new accident model for engineering safer systems. "Safety Science", 42(4), 237-270.

Leveson, N G (2011) Applying systems thinking to analyse and learn from events. "Safety Science", 49(1), 55-64.

Leveson, N, Dulac, N, Marais, K and Carroll, J (2009) Moving beyond normal accidents and high reliability organisations: a systems approach to safety in complex systems. "Organisation Studies", 30(2&3), 227-249.

Lingard, H and Rowlinson, S (2005) "Occupational health and safety in construction project management". Oxon: Spon Press.

Maurer, I, Bartsch, V and Ebers, M (2011) The value of intra-organizational social capital: how it fosters knowledge transfer, innovation performance, and growth. "Organisation Studies", 32(2), 157-185.

Maurer, I and Ebers, M (2006) Dynamics of social capital and their performance implications: lessons from biotechnology start-ups. "Administrative Science Quarterly", 51(2), 262-292.

Mitropoulos, P, Cupido, G and Namboodiri, M (2009) Cognitive approach to construction safety: task demand-capability model. "Journal of Construction Engineering and Management", 135(9), 881-889.

Mitropoulos, P and Memarian, B (2012) Team processes and safety of workers: cognitive, affective, and behavioural processes of construction crews. "Journal of Construction Engineering and Management", 138(10), 1181-1191.

Nahapiet, J and Ghoshal, S (1998) Social capital, intellectual capital, and the organizational advantage. "Academy of Management Review", 23(2), 242-266.

Orlikowski, W J (2002) Knowing in practice: enacting a collective capability in distributed organising. "Organisation Science", 13(3), 249-273.

Perrow, C (1999) "Normal accident: living with high risk technologies". Princeton, N. J.: Princeton University Press.

Rasmussen, J (1997) Risk management in a dynamic society: a modelling problem. "Safety Science", 27(2/3), 183-213.

Reiman, T and Oedewald, P (2007) Assessment of complex sociotechnical systems – theoretical issues concerning the use of organisational culture and organisational core task concepts. "Safety Science", 45(7), 745-768.

Roberts, K H (1990) Some characteristics of one type of high reliability organisation. "Organisation Science", 1(2), 160-176.

Sutcliffe, K M (2011) High reliability organizations (HROs). "Best Practice and Research Clinical Anaesthesiology", 25(2), 133-144.

Tam, C M and Fung, W H (1998) Effectiveness of safety management strategies on safety performance in Hong Kong. "Construction Management and Economics", 16(1), 49-55.

Vogus, T J (2012) Mindful organising: establishing and extending the foundations of highly reliable performance. In: K.S. Cameron and G.M. Spreitzer, (eds.) "The Oxford handbook of positive organisational scholarship". New York: Oxford University Press, 664-676.

Vogus, T J and Welbourne, T M (2003) Structuring for high reliability: HR practices and mindful processes in reliability-seeking organisations. "Journal of Organisational Behaviour", 24(7), 877-903.

Weick, K E (1987) Organisational culture as a source of high reliability. "California Management Review", 29(2), 112-127.

Weick, K E and Roberts, K H (1993) Collective mind in organisations: Heedful interrelating on flight decks. "Administrative Science Quarterly", 38(3), 357-381.

Weick, K E, Sutcliffe, K M, and Obstfeld, D (1999) Organising for high reliability: processes of collective mindfulness. In: R.S. Sutton and B.M. Staw (eds.) "Research in organisational behaviour". Volume 1. Stanford: JAI Press, 81-123.

Weick, K E and Sutcliffe, K M (2007) "Managing the unexpected: resilient performance in an age of uncertainty". 2ed. San Francisco: Jossey-Bass.

Yin, R K (2003) "Case study research: design and methods". 3ed. Thousand Oaks, CA: Sage.

HUMAN BEHAVIOUR AND CULTURE

COMPETENCY AND EMPOWERMENT OF PROJECT MANAGERS IN CHINA

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The Agent Construction Management (ACM) system is one of the new measures adopted in government funded projects in China. The main characteristic of the ACM system is the introduction of an independent professional project management firm into the project management process. The ACM system is still in its trial stage in China and there is no unified qualification assessment system for agent construction organizations. While the importance of the project manager's competence is recognized, previous research also shows that project manager's empowerment is conducive to project performance. The definition of competency is confusing as several terms such as competency/competencies, competence/competences, capability and ability are used interchangeably and inconsistently. Competence is the state or quality of being adequately qualified -- the ability to perform a specific role (e.g. PMI's project manager's competency development framework). While empowerment can be viewed as a relational construct and considered within a more general concept of power, it is also a motivational (or psychological) construct. These two perspectives of empowerment are not independent and motivational empowerment may be an outcome of relational empowerment. This research aims to analyze the relationships of motivational empowerment and competency on job performance of the project managers in the ACM organisations. Regression modelling is adopted to analyze the data collected from 203 project managers involved in projects adopting ACM system. Findings support the relationships of competency and empowerment and their effect on project manager's job performance.

Keywords: agent, management system, competency, empowerment, job performance, project manager.

INTRODUCTION

The Agent Construction Management (ACM) system is one of the new measures adopted in government funded projects in China (Zhu et al., 2003) and it is alleged that the performance of ACM is essential for project management success. The main characteristic of the ACM system is the introduction of an independent agent-construction organisation, i.e., the professional project management firm, into the project management process. However, the ACM system is still in its trial stage in China and there is no unified qualification assessment system for the agent

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Chan IYS, Liu AMM, Cao S and Fellows R (2013) Competency and empowerment of project managers in China *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 383-392.

construction organizations. Though the ACM system was thoroughly researched and considered by the Chinese government before its adoption, the majority of research related to ACM focused on introducing the new project management mode, a set of (competency) professional skills requirement of the project manager and its positive effect on project performance. While the importance of project manager competence in their professional skills is recognized, previous research also shows that empowerment of project managers (PM) is conducive to project performance (Liu and Fang, 2006).

ACM presumes a set of PM's functional skills as guided by PMI (Project Management Institution) or other similar institutions for project management training, but the importance of PM's empowerment is not recognised sufficiently in China. Thus, this research aims to analyze the relationships of motivational empowerment and competency on job performance of the project managers in the ACM organisations.

AGENT CONSTRUCTION MANAGEMENT SYSTEM IN CHINA

The ACM system is mainly used in government funded projects in China. The total output value of the Chinese construction industry is about RMB 11.7 trillion in 2011, and its percentage contribution to GDP has increased to 6.8% in 2011 (National Bureau of Statistics of China, 2011). In the ACM system, the employer entrusts construction project management to a professional organization based on an agent relationship (Yin and Yan, 2006), and this system has been adopted in many provinces in China with apparent benefits (Hu and Yan, 2003), so Yin and Yan (2006) assert that it is advisable for all government funded projects to adopt the ACM system.

In ACM, the investor, the agent-construction organization and the end-user are the three principle parties and their respective rights and obligations are defined by contracts between them. The most important contract under the ACM system is the agent contract which defines the relationship between the client and the agent-construction organization. Selection of the agent-construction organisation (i.e., the professional project management organization) is made through tendering and the agent-construction organisation is responsible for construction project cost control and overall quality management.

There is a growing recognition of the centrality of the PM's competency to the performance of projects (Jaselskis and Ashley, 1991) and various efforts have been made to develop evaluative criteria and training needs (Dainty et al., 2003). China has embraced the competency frameworks from Western professional institutions (e.g., PMI and CIOB) as a basis to develop their PM training. However, construction is not a process of purchasing a finished product, but a process to produce a new product (Winch et al., 1998), thus the roles and functions of people, and how they behave, have a significance impact on the construction output. It is, therefore, important to recognise that success of project management is not merely embedded in the PM skills set as stipulated in various PM competency frameworks but also in the informal system of motivation and empowerment.

COMPETENCY

Previous management studies have investigated the impact of competency on performance (e.g., Du, 2010 and Pathirage et al., 2007) and some researchers endeavour to analyze the competencies required by project managers in this dynamic environment (Wysocki and Lewis, 2001; Suikki et al., 2004; Fisher et al., 2005; Muzio et al., 2007). For instance, Dainty et al. (2004) have argued for a competency-

based performance model for construction project managers where managerial behaviour input is appraised and nine performance indicators for PM competency are developed to comprise team building, leadership, decision-making, mutuality and approachability, honesty and integrity, communication, learning, understanding and application, self-efficacy, and maintenance of external relations.

However, the definitions of competence and competency are confusing and often used interchangeably in the literature. Researchers tend to distinguish these terms (Manley and Garbett, 2000; Moore et al., 2002; Westera, 2001; Woodruffe, 1993): i) competence refers to aspects of the job that an employee can perform, ii) competency is defined as behaviours an employee needs to display in order to do the job effectively, such as sensitivity; and iii) competencies refer to the attributes underpinning a behaviour. Competency, from the human resources field, means a standardized requirement for an individual to perform a specific job properly (McCelland, 1998). On the other hand, the UK Employment Department's Standards programme defines competence as a description of something that a person who works in a given occupational area should be able to do (Training Agency, 1988). Practitioners tend to view competency as the state or quality of being adequately qualified -- the ability to perform a specific role, e.g., PMI's project manager's competency development framework. (This research adopts the practitioners' view and with no distinction made between competency and competence).

Professional institutions, such as the Project Management Institution (PMI), the International Project Management Association (IPMA) and the Royal Institution of Chartered Surveyors (RICS project management faculty) establish different sets of competency requirements for their project managers. The Project Management Body of Knowledge (PMBOK) of PMI (2000) involves nine areas of project management, including project integration management, project scope management, project time management, project cost management, project quality management, project human resource management, project communication management, project risk management and project procurement management. The RICS Assessment of Professional Competence (APC) for project management consists of 15 competencies including identifying the client's objectives and priorities, developing the brief, carrying out option or feasibility studies, carrying out risk analysis and management exercise, establishing the budget and management exercises, advising on the project team selection, establishing the lines of communication and managing the information flow, selecting the correct procurement strategy, devising control systems and carrying out value analysis exercises, managing the integration and flow of design information, encouraging productive team working, co-ordinating legal and other consents, conducting tender evaluation and contractor selection, establishing the post contract time, cost and quality control systems, control, monitor and report through to project completion, the ability to 'get things done', developing a vision and strategy, and motivating project team members to achieve that vision and strategy, energizing people to achieve high levels of performance and to overcome barriers to change, conferring with others to come to terms with them or to reach an agreement, and the combination of problem definition, alternatives identification and analysis, and decision-making.

Although behavioural and management competencies of project managers are mostly generic across different industries, their technical /task competencies are highly specific to the context in which they work (Cheng et al., 2005), thus valid sets of competency should be developed specifically for enhancing performance of

professionals in their particular areas. Previous research has paid much attention to PMBOK (e.g., Crawford, 2005; Suikki et al., 2006), which mainly focuses on technical skills, with less emphasis on non-technical 'soft' skills such as leadership, team work and communication. However, 90-95% of PM performance is predicted by 'soft' skills, and only 5-10% is concerned with technical knowledge or ability (Muzio et al., 2007).

EMPOWERMENT

Previous studies have investigated the importance of empowerment in fostering job performance (see Hechanova et al. 2006; Mathieu 2006; Tuuli and Rowlinson, 2009). However, there are generally two schools of thought on empowerment in the literature (Conger and Kanungo, 1988; Spreitzer, 1997). The first group views empowerment as a relational construct and considered within a more general concept of power. The other group focuses on the motivational (or psychological) perspective of empowerment, which has been found to be very important for the behavioural outcomes of practitioners. Spreitzer (1997) points out that these two perspectives of empowerment are not independent and motivational empowerment may be an outcome of relational empowerment.

The relational perspective of empowerment mainly appears in management and social influence literature to describe the perceived power or control that an entity has over others - more specifically, the power to make decisions. Constructs of empowerment in management practice are derived from constructs of power and control (Conger and Kanungo, 1988).

Empowerment can also be viewed from a psychological perspective as motivational empowerment -- Conger and Kanungo (1988) posit that empowerment is, essentially, a motivational concept of self-efficacy. The motivational perspective of empowerment is more psychological in nature and is a comparatively subjective concept, e.g., 'to enable' rather than 'to delegate'. Enabling means creating conditions for improving motivation for task completion by developing a strong sense of personal efficacy. Empowerment can also be explained as a process whereby an individual's belief in his/her self-efficacy is enhanced based on Bandura's (1986) self-efficacy notion. To empower means either strengthening the belief of self-efficacy or weakening the feeling of powerlessness. Empowerment can be enhanced by both task-oriented and person-oriented leadership (Tuuli et al., 2012). It enables individuals to feel that they can perform their work competently, which further influences one's initiation and persistence in task behavior and performance (Liu et al., 2007). According to Thomas and Velthouse (1990), to empower is equal to giving power, and it can also mean 'to energize' when power is explained as energy.

Thomas and Velthouse (1990) operationalize empowerment in terms of intrinsic task motivation defined in four related cognitions in an individual's orientation to work role: impact, meaningfulness, self-determination and competency. While competency is already discussed, impact refers to producing intended effects in one's task environment; meaningfulness concerns the value of the task goal or purpose which is judged in the individuals' own standards, and self-determination involves causal responsibility for an individual's actions.

THEORETICAL MODEL

The importance of empowerment in fostering job performance, including both task and contextual performances, is well recognized (e.g., Hechanova et al., 2006;

Mathieu, 2006; Tuuli and Rowlinson, 2009). Motivational empowerment is predicted to influence one's job performance by affecting behaviours through instrumentality, expectations, and valence of an individual. For individuals who perceive their tasks to be influential, meaningful, achievable and valuable, much effort will be put on achieving the tasks. However, since motivational empowerment and competency are closely interactive, the relationship between motivational empowerment and job performance can be influenced by the competency of an individual (Houtzagers, 1999).

Motivational empowerment is concerned with the fit between an individual, his /her job and the environment. Contingency theory proposes that performance depends on the 'fit' between various individual, job demands and organizational environment factors. Optimized performance depends on the best fit between an individual's characteristics (vision, values, career stages, etc.), job demands (which influence one's performance directly via various tasks, functions, and roles) and the organisational environment (Boyatzis, 1982, 2006a). Organizational environment includes culture and climate, structure and systems, maturity of industry, core competence of the organization, etc. As indicated by Dainty et al. (2002), empowerment alone may not necessarily drive good performance. Factors in implementation and contextual aspects (e.g., power of actors, organizational culture and environment) should also be considered. For instance, work empowerment enhances job performance of construction professionals through motivation and commitment (Liu et al., 2003) and Houtzagers (1999) points out that competency and skill management have been closely linked to the efforts of organizations to empower employees in order to increase organization's competitive advantage and effectiveness. In view of the interaction between motivational empowerment and competency, this study investigates the moderating effect of competency on the motivational empowerment-job performance relationship with the following hypotheses:

Hypothesis 1 : Motivational empowerment is positively associated with job performance of project managers in ACM.

Hypothesis 2 : The relationship between motivational empowerment and job performance is moderated by competency of project managers in ACM.

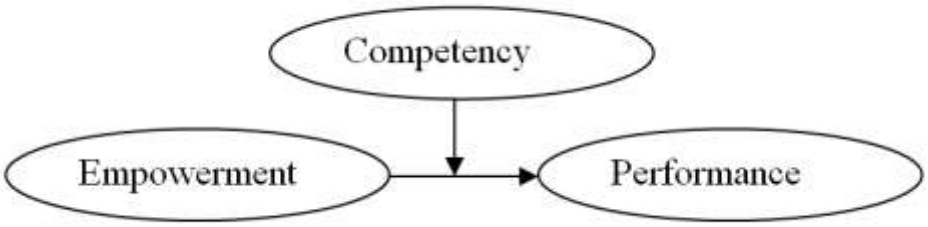

Figure 1 Conceptual Model of Empowerment, Competency and Performance

DATA COLLECTION

A questionnaire survey approach is adopted to investigate the above hypothetical relationships. A questionnaire for competency, empowerment and job performance is designed based on a literature review, and back translation is adopted and tested in a pilot study with 23 project management professionals in China. Based on the qualification assessment criteria, there are 1507 agent construction organizations qualified as class 'A' in 2007 in China, of which 75 organizations (5%) are selected

randomly for distribution of 750 questionnaires with 203 returned (response rate of 27%). Nearly 50% are aged 31-40; 80% are male; 80% with bachelor degrees or above; the majority has accumulated more than 5 years' experience in the industry (69%) and nearly 40% of the respondents have over10 years' experience.

There are three main variables measured in the study: competency, empowerment and job performance. As the APC of RICS does not focus only on professional practice (e.g., control on time, cost and quality) and business (e.g., finance, portfolio, orientation, etc.) aspects, but also denotes the importance of interpersonal and leadership skills, RICS's APC competency list is adopted to measure the professional practice (15 items) and interpersonal skills (6 items). According to the Intentional Change Theory, professionals are stimulated to develop their competencies in accordance to the various core competencies designed in the accredited courses in their professional development process (Boyatzis, 2006b). Measurement is based on Bloom's taxonomy which contains six levels of competency acquirement, including knowledge, comprehension, application, analysis, synthesis and evaluation (Bloom, 1956; Huitt, 2011). Level 0 is added to denote absence of the particular competency.

Motivational empowerment employs a 9-item scale which is developed based on the work of Thomas and Velthouse (1990) by Spreitzer (1997) to define four cognitive determinants of perceived intrinsic motivation for empowerment, including meaning, self-determination, impact and competency. A five-point Likert response format from 1 (strongly disagree) to 5 (strongly agree) is employed, allowing a neutral point.

Successful performance is referred as the accomplishment of task goals and target output levels. The performance scale developed by Riketta and Landerer (2002) is adopted to measure three aspects: i) respondents' self-evaluated performance, ii) their perception on the satisfaction of supervisor towards their performance, and iii) their perception on the satisfaction of colleagues towards their performance. A five-point Likert response format from 1 (strongly disagree) to 5 (strongly agree) is again adopted.

RESULTS AND DISCUSSION

Two tests are carried out; first the influences of empowerment and competency on job performance is analysed by standard regression modelling as shown below in Table 1, and second, the moderating effect of competency on the empowerment-performance relationship as shown in Table 2. Conbrach alpha values lower than 0.6 are considered to be unacceptable in this study (Murphy and Davidshofer, 1988).

Table 1: Base model between motivational empowerment, competency and job performance

Dependent variable	Independent variable	B	S.E.	Sig.	R	R2	Sig.
Job performance	(Constant)	5.187	0.962	0.000	0.618	0.382	0.000
	Motivational Empowerment	0.167	0.023	0.000			
	Competency	0.034	0.007	0.000			

Significant relationships are found between motivational empowerment, competency and job performance. It has been established that empowerment enhances performance of PMs (Liu and Fang, 2006) via power sharing and power amassing. The result in Table 1 validates the claim of the empowerment-performance

relationship and shows that motivational empowerment is a stronger determinant of job performance than competency.

The moderating effect of competency on motivational competency-job performance relationship is investigated next as shown in Table 2. Moderating effects occur when the relationships between two variables (predictor and dependent variable) are affected by a third variable (moderator) (Pallant, 2005).

Table 2: Interaction model between competency, motivational empowerment and job performance

Dependent variable	Independent variables	B	S.E.	Sig.	R	R2	Sig.
Job performance	(Constant)	7.578	1.029	0.000	0.617	0.381	0.000
	Motivational Empowerment	0.115	0.029	0.000			
	Competency x Motivational Empowerment	0.001	0.000	0.000			

To test the moderating effect of competency, the Cohen's effect size (f2) is measured (Chin, 1998) by :

"R2 (interaction model) – R2 (base model) / 1 - R2 (interaction model)"

According to Cohen (1988), f2 values of 0.02, 0.15, or 0.35 indicate the small, medium, or large influences of the particular variables. The moderating effect of competency is found to be medium in the current study.

CONCLUSIONS

The ACM system is a relatively new system for government funded projects in China. In view of the important role of ACM towards project success, this research analysed the association between motivational empowerment, competency and job performance of project managers in ACM organisations. The results indicate that motivational empowerment is a stronger determinant of job performance than competency, and the relationship between motivational empowerment and job performance is moderated by competency. Practitioners tend to put emphases on training of professional competencies but the results recommend leaders to foster motivational empowerment, which 'enables' impact, self-determination and meaningfulness, amongst project managers in ACM.

Although the APC is a list of competency developed by practitioners, these practice based knowledge can be bounded by its contextual nature where practitioners' behaviors can be susceptible to their implicit personal identity and values (Cicmil et al., 2006). Since China is still a developing country, there may be discrepancies between the social and industrial environments between East and West that influence the dimensions of competencies; hence, there is room to develop a more comprehensive competency-based model appropriate in the Chinese context.

REFERENCES

Bandura, A. (1986) Social Foundations of Thought and Action: A Social-Cognitive View. Englewood Cliff, N.J: Prectice-Hall.

Bloom, B.S. (1956) Taxonomy of Educational Objectives Handbook: Cognitive Domain, New York: McKay.

Boyatzis, R.E. (1982) The Competent Manager: A Model for Effective Performance, New York: Wiley.

Boyatzis, R.E. (2006a) Leadership competencies. Inspiring Leaders, In R.J. Burke and C.L. Cooper Ed., London: Routledge Press, 119-126.

Boyatzis, R.E. (2006b) Intentional change theory from a complexity perspective. Journal of Management Development, 25(7), 607-23.

Cheng, M.I., Dainty, A.R.J., Moore, D.R. (2005) What makes a good project manager? Human Resource Management Journal, 15(1), 25-37.

Chin, W.W. (1998) Issues and opinion on SEM. MIS Quarterly, 22(1), vii-xvi.

Cicmil, S., Williams, T., Thomas, J., Hodgson, D. (2006) Rethinking project management: researching the actuality of projects. International Journal of Project Management, 24, 675-686.

Cohen, J. (1988) Statistical Power Analysis for the Behavioural Sciences, Hillsdale, NJ: Lawrence Erlbaum Associates.

Conger, J.A., Kanungo, R.N. (1988) The empowerment process: integrating theory and practice. Academy of Management Review, 13, 471-482.

Crawford, L. (2005) Senior management perceptions of project management competence. International Journal of Project Management, 23(1), 7-16.

Dainty, A.R.J., Bryman, A., Price, A.D.F. (2002) Empowerment within the UK construction sector. Leadership and Organization Development Journal, 23(6), 333-342.

Dainty, A.R.J., Cheng, M.I., Moore, D.R. (2003) Redefining performance measures for construction project managers: an empirical evaluation. Construction Management and Economics, 21(2), 209-218.

Dainty, A.R.J., Cheng, M.I., Moore, D.R. (2004) A competency-based performance model for construction project managers. Construction Management and Economics, 22(8), 877-889.

Du, J. (2010) Does competency decide individual performance? Empirical research taking HR professionals as example. Journal of Beijing Normal University, 05.

Fisher, D.J., Schluter, L., Toleti, P.K. (2005) Project management education and training process for career development. Journal of Construction Engineering and Management, 903-910.

Hechanova, M.R.M., Alampay, R.B.A., Franco, E.P. (2006) Psychological empowerment, job satisfaction and performance among Filipino service workers. Asian Journal of Social Psychology, 9(1), 72-78.

Houtzagers, G. (1999). Empowerment, using skills and competence management. Participation and Empowerment: An International Journal, 7(2), 27-32.

Huitt, W. (2011) Bloom et al.'s taxonomy of the cognitive domain. Educational Psychology Interactive, Valdosta, GA: Valdosta State University.

Jaselskis, E., Ashley, D. (1991) Optimal allocation of project management resources for achieving success. Journal of Construction Engineering and Management, 117(2), 321-340.

Liu, A.M.M., Chiu, W.M., Fellows, R. (2007) Enhancing commitment through work empowerment. Engineering, Construction and Architectural Management, 14(6), 568-80.

Liu, A.M.M., Fang, Z. (2006) A power-based leadership approach to project management. Construction Management and Economics. 24 (5), 497-508.

Liu, A.M.M., Fellows, F., Fang, Z.Y. (2003) The Power Paradigm of Project Leadership, Construction Management and Economics, 21, 819-829.

Manley, K., Garbett, B. (2000) Paying Peter and Paul: reconciling concepts of expertise with competency for a clinical career structure. Journal of Clinical Nursing, 9, 347-59.

Mathieu, J.E., Gilson, L.L., Ruddy, T.M. (2006) Empowerment and team effectiveness: an empirical test of an integrated model, Journal of Applied Psychology, 91(1), 97-108.

McCelland, D.C. (1998) Identifying competencies with behavioral event interviews. Psychological Science, 9(5), 331-339.

Moore, D.R., Cheng, M.I., Dainty, A.R.F. (2002) Competence, competency and competencies: performance assessment in organisations. Work Study, 51(6), 314-319.

Murphy, K.R., Davidshofer, C.O. (1988) Psychological Testing: Principles and Applications, Englewood Cliffs, NJ: Prentice-Hall, pp. 89.

Muzio, E., Fisher, D.J., Thomas, E.R., Peters, V. (2007) Soft skills quantification (SSQ) for project manager competencies. Project Management Journal, 38(2), 30-38.

National Bureau of Statistics of China (2011) National Accounts. China Statistical Yearbook 2011, Retrieved at http://www.stats.gov.cn/tjsj/ndsj/2011/indexeh.htm on 10th Dec 2012.Pallant, J. (2005) SPSS Survival Manual: A Step by Step Guide to Data Analysis using SPSS for Windows, Crows Nest, Allen and Unwin.

Pathirage, C.P., Amaratunga, D.G., Haigh, R.P. (2007) Tacit knowledge and organizational performance: construction industry perspective. Journal of Knowledge Management, 11(1), 115-126.

Riketta, M., Landerer, A. (2002). Organizational commitment, accountability, and work behavior: a correlational study. Social Behavior and Personality, 30 (7), 653-60.

Spreitzer, G.M. (1997) Toward a common ground in defining empowerment. Research in Organizational Change and Development, in Pasmore A. and Woodman W. (Ed), US: Elsevier Science/JAI Press.

Suikki, R., Raija T., Harri H. (2006) Project Management competence development framework in turbulent business environments. Technovation, 26(5-6), 723-738.

Thomas, K.W., Velthouse, B.A. (1990) Cognitive elements of empowerment. Academy of Management Review, 15, 666-681.

Training Agency (1988) The definition of competences and performance criteria, guidance note 3 in Development of Assessable Standards for National Certification, Series, Sheffield Training agency.

Tuuli, M.M., Rowlinson, S. (2009) Empowerment in project teams: a multilevel examination of the job performance implications. Construction Management and Economics, 27(5), 473-498.

Tuuli, M.M., Rowlinson, S., Fellows, R., Liu, A.M.M. (2012) Empowering the project team: impact of leadership style and team context. Team Performance Management, 18(3/4), 149-175.

Westera, W. (2001) Competences in education: a confusion of tongues, Journal of Curriculum Studies, 33 (1), 75-88.

Woodruffe, C. (1993) What is meant by a competency? Leadership & Organization Development Journal. 14(1), 29-36.

Winch, G. (1998) Zephyrs of creative destruction: understanding the management of innovation in construction. Building Research and Information, 26(5), 268-279.

Wysocki, K., Lewis, P. (2001) The World Class Project Manager: a Professional Development Guide, Cambridge, MA: Perseus Publishing.

ORGANIZATIONAL CULTURE, LEADERSHIP STYLE AND EFFECTIVENESS: A CASE STUDY OF MIDDLE EASTERN CONSTRUCTION CLIENTS

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During the last few decades, organizational effectiveness has received a great deal of attention in many industrial sectors. As a result, a variety of models have been formulated which measure organizational performance. In the construction industry, two factors have subsequently captured the imagination and interest of researchers and practitioners alike: the culture of the organization and the leadership style of project managers. This focus places a requirement upon construction organizations to recognize and understand their organizational culture, and equally, to clearly communicate it to their employees as part of their capitalist drive of constantly improving performance, productivity and profit. Traditional ways of conducting construction business require a sound understanding of the technical and managerial demands of executing projects, which in turn, places an increased emphasis upon the management and leadership competencies of individual project managers. The purpose of the research is to explore the relationship between organizational culture, authentic leadership style and effectiveness within the context of a case study investigation centred on Middle Eastern construction clients and their project managers. The outcomes of the investigation, which include the presentation of an explanatory model, indicate that organizational culture is directly and positively related to performance and effectiveness, while project managers' leadership style has an indirect relationship to effectiveness. A strong organizational culture is therefore deemed critical to organizational performance.

Keywords: construction industry, organizational culture, leadership style, organizational effectiveness.

INTRODUCTION

Researchers and practitioners, regardless of their industry focus, have offered a variety of factors that determine effectiveness within an organization: many of which fall beyond the scope of leadership or the culture of the organization (CIOB, 2010; Coffey, 2010). Zehir *et al.* (2011) state that organizational culture and leadership have received notable attention, in management literature, in terms of their relations to various organizational outcomes; e.g., effectiveness, competitive advantage, financial performance or individuals' performance. However, studies that integrate both factors with organizational performance are particularly few.

The construction industry is widely acknowledged as being unstable in its output as a result of its relationship to global economic activity (Ofori, 1990). However, several studies, e.g., Fergusson and Langford (2006), Toor and Ofori (2008), Kefela (2010), have tried to investigate and propose remedies to help alleviate this tendency. Yet, unexpected circumstances continue to emerge and influence construction productivity and output. During the last few decades, the construction industry has moved towards a more globalized mode of operation and, as a result, has had to change its procedures and practices to accommodate its dynamic and fast changing multinational environment. This has led the

Alnasseri N, Osborne A and Steel G (2013) Organizational culture, leadership style and effectiveness: a case study of Middle Eastern construction clients *In*: Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 393-403.

mode of operation and, as a result, has had to change its procedures and practices to accommodate its dynamic and fast changing multinational environment. This has led the industry to pay particular attention to several influencing factors. The current business dynamics of construction companies have driven them to depend more than ever on the concept of organizational culture (Low and Shi, 2001). Traditional ways of conducting construction business depends upon the technical and managerial features of its projects, which require management and leadership skills. Various researchers have shown more interest in leadership studies within the construction industry than other aspects of interest. They have concentrated their efforts on developing an appropriate leadership style for different business contexts, due to the significant influence of leadership on project outcomes, followers and the entire organizational outcomes in the long-term.

The level of organizational culture is associated with the extent that organizations show in four traits, i.e., adaptability, mission, consistency and involvement, and whether they are obvious and understandable for both managers and followers. Several models have evolved to measure the effectiveness of organizational culture (Lewin and Minton, 1986; Smart and John, 1996). In particular, the study focuses its attention on the organizational culture model known as the Denison model (Denison Consulting, 2007). The primary focus of the Denison module is the leadership style of managers and its critical role in helping to influence organizational culture, including the process by which this is transferred to subordinates.

ORGANIZATIONAL CULTURE AND LEADERSHIP

Organizational Culture

Organizational culture and leadership have a significant influence on performance. Influencing people's ideas and understandings, and also dealing with organization's technical issues, is a crucial aspect of a manager's role (Alvesson, 2013). The concept of culture is linked to group environment, where certain things are shared or held in common. For instance, norms, values, behaviour patterns, rituals, traditions, structural ability and integration all contribute to the establishment of an organization's identity (Schein, 1992). Farrell (1993) suggested two conditions to develop organizational culture: formal/informal communication and interaction of values/beliefs/norms. He also emphasized that without verbal, physical or emotional communication and interaction, organizational culture is impossible to exist.

Organizational culture provides an overall image of an organization's identity; this enables it to be categorized among different organization groups. However, an organization is also able to adopt different types of culture within its various departments, i.e., intra-organizational sub-culture. Culture plays a very important role in establishing a business framework and providing a foundation for organizational strategy (Alvesson, 2013). It can also influence management and leadership behaviour at all levels.

Within construction management literature, the publication of cultural-related papers has significantly increased after 1990. Hillebrant (2000) highlighted three main factors for this trend: globalization of construction markets, dynamic environments, and the unique nature of construction business. Changing environments, obstacles and uncertainties have driven organizations to improve their overall organizational performance, but they have faced many challenges along the way. Maloney and Federle (1993) offered poor organizational culture and lack of assessment as the reasoning behind organizational low performance and related difficulties. Later, Harmann (2006) questioned whether organizational culture was indeed capable of influencing the development of the industry in such a manner. However, Brown (1998), somewhat earlier, had provided evidence that some performance factors did attribute

to organizational culture; reduced uncertainty and conflict; provide competitive advantages, coordination, control, commitment, involvement and dedication. It is generally agreed by all parties, that organizational culture helps to clarify and establish behaviour (Steers *et al.*, 1996).

Organizational Culture and Effectiveness – The Link Between Them

There are various dimensions to organizational culture. The main focus within these dimensions is effectiveness measurement, which determines the value/effectiveness of an organization (Cameron and Quinn, 2006). Various indicators for organizational effectiveness have been proposed; e.g., Campbell's (1974) thirty-nine indicators list for all possible measures of effectiveness. Cameron and Quinn (2006) determined two major dimensions: the first dimension distinguishes between effectiveness criteria that are concerned with flexibility and discretion, and criteria that emphasize stability and control; while the second distinguishes between the concept of internal orientation, integration and unity at one side, and on the other, external orientation, differentiation and rivalry. These dimensions are combined to form four quadrants where each one represents organizational effectiveness indicators, which represent an organization's operating features and the approach it believes is most appropriate to its operation. Cameron and Quinn (2006) identified four types of organizational culture: the clan culture, the hierarchy culture, the adhocracy culture and the market culture.

Organizational culture has a strong relationship with organizational performance. It is suggested that it is a key feature in attaining success (Newstrom and Davis, 1993). It has also been linked to several organizational elements, such as high levels of management agreement, employees' productivity attainment, commitment and awareness. Newstrom and Davis (1993) also state that organizational culture determines organizational success. In contrast, Bryman (1984) and Oqbonna and Harris (2000) have mentioned that a strong and coherent culture might negatively affect an organization. Amongst others, they cite the example of dealing with it as a separate concept and disregarding other organizational dimensions may reduce its value in enhancing performance. Difficulties associated with power and politics may prevent the culture of an organization remaining at the same level. The downside of this view is that culture is not easy to change. Thus, strong culture, widely and effectively shared, is not enough to provide effective performance; it must also contain unique qualities, such as flexibility.

Alvesson (2013) states that studies on the relationship between organizational culture and effectiveness are limited by the lack of agreement on the appropriate measurement criteria for effectiveness. Kotter and Heskett (1992) emphasized the importance of adaptability and the fit between an organization and its adopted culture type. Denison Consulting (2007) expanded on this view by exploring four different cultural traits that are associated with several effectiveness criteria (see Table 1 below), where adequate attention must be paid to the internal and external business, long- and short-terms, and factors that provide flexibility and focus. Hence, among different organizational culture types, when an organization is strong in these culture traits, including its leaders and employees at all managerial levels, effective and efficient performance is expected to occur within its business operation.

Table 1: Denison model's cultural traits and effectiveness criteria

	Profitability	Innovation & customer satisfaction	
External Focus	Mission	Adaptability	Growth
Internal Focus	Consistency	Involvement	Quality & employee satisfaction
	Stability	Flexibility	

Leadership

Yukl (2010) raises several controversial leadership issues. For example, why do some leaders perform well-perform in certain organizations while not in others. Also, can a good leader positively influence business operations? As a result, several leadership theories appeared examining leaders-followers relationships, leadership dimensions and evaluation (Daft, 2008). Leaders and managers are essential within organizations: they must effectively coordinate and communicate together in order to achieve organizational goals and visions (Northouse, 2010). Limsila and Ogunlana (2008) explained that organizational effectiveness, subordinates satisfaction and extra working effort were to be expected from good leadership and management practices, which are the key theories behind most leadership models. Over the years, several attempts have been made to develop various leadership theories that tried to explain the relationship between particular styles in different contexts and explore the most effective or appropriate style. Regrettably, this is an apparent lack of lack of empirical evidence which focuses on project-based industries (Giritli and Oraz, 2003).

Debates have emerged about the ability to create leaders that can make a real change and deal with construction culture, multinational members, cultural backgrounds, globalization, changing environment and economic growth (CIOB, 2010). Studies have identified that construction firms and educational institutions continue to produce leaders or managers which lack the required leadership skills for such a complex environment (Toor and Ofori, 2008). This has led to a general misunderstanding of the construction industry requirements in terms of leadership and its impact on performance.

Bresnen *et al*. (1986) justified that the construction project cycle plays an important role in changing the leadership styles of managers and leaders: for example, from people to task-oriented. Leaders may have a dominant leadership style but it should be adjusted or be combined with elements of different styles over the development of a project: in other words, a transformational approach. Rowlinson *et al.,* (1993) agreed and offered supportive and directive styles for pre- and construction stages, respectively. Project managers are often blamed when projects encounter obstacles or problems. Indeed, some organizations have leaders that are incompetent or have insufficient leadership styles that do not help them in dealing with followers (Limsila and Ogunlana, 2008). This emphasizes the need for a leader to adopt an appropriate style and cope with unexpected circumstances, e.g., the contingency approach. The CIOB (2010) argued that leaders' traits and qualities required in the construction industry are different when compared with other industries. They suggested a re-assessment of leadership style, along with leaders' qualities and skills are required in order for the industry and organizations to succeed. It also emphasized that greater focus on particular traits is needed, such as relationship management, emotional factors and develop working cultures.

Authentic Leadership Style in Construction

Leadership in construction is facing more challenges than ever before, along with increasing demands of new and future leadership styles. Indeed, the traditional construction focus tends

to be on authority and power. This is due to the managerial and technical features and complexities of construction projects. However, modern construction conditions and their associated challenges – fast changing and unstable environments – place an increasing emphasis upon changing the traditional perception of the leadership styles, abilities, competencies and behaviours for project managers. Suffering from poor record achievement, moral and ethical practices, poor social image is a perpetual industry concern (Toor and Ofori, 2008). Accordingly, a unique leadership style is needed for the construction industry: managers/leaders need to have a coherent style with their own traits, personalities, values, visions and motivations. Several leadership researchers, e.g., Avolio and Gardner (2005), George (2003), George and Sims (2007), Toor and Ofori (2008), offered the authentic approach as a new leadership style for the new environment and solution for various challenges, crisis and issues. Authenticity study has aimed to increase awareness, significantly enhance organizational behaviour and develop authentic leaders who are not only skilled but also lead projects by authenticity traits.

Authentic leaders have unique characteristic and traits, which include morality and self-discipline, personal integrity, positive energy, transparency, confidence, clear purpose. This enables them to lead with concern about others and to establish connected relationships (George, 2003; Toor and Ofori, 2008). Gardner *et al.* (2005) note that there are no individuals who are completely authentic or inauthentic, but they are more or less authentic or inauthentic. Toor and Ofori (2008) found several studies that show a relation between authenticity principles and organizational performance and outcomes, whereby the more evident the authentic leadership is, the better employees' performance will be. Authentic leaders have the ability to influence and inspire their followers in order to follow organizational goals and visions, along with motivating them to attain an effective working environment.

The Relationship Between Leadership and Organizational Culture

Numerous studies have investigated the link between leadership or organizational culture and organizational effectiveness. However, few studies have examined them together (Giritli *et al.*, 2013; Ogbonna and Harris, 2000). The relationship between leaders and their organizational and environmental context has almost been ignored by past researchers. Instead, attention has been paid to the relationship between leaders and their subordinates. Indeed, leadership style and organizational culture play a crucial role in determining effectiveness: they are therefore dependent upon each other (Giritli *et al.*, 2013). In contrast, they highlight the view that culture has not been permanently related to leadership, particularly in the context of contingency leadership theories. Kefela (2010) states that effective leadership processes start from influencing others in terms of skills, knowledge, ethics, values and beliefs in order to accomplish missions and goals. It is these dimensions that create the culture of an organization.

RESEARCH THEORETICAL MODEL

Due to globalization, massive changes and difficulties that relate to the current condition of the construction industry, multicultural environment have increased significantly (Akiner and Akiner, 2009). Employees and industry practitioners are now working within a diverse culture in terms of its main traits, attitudes, beliefs, values, roles and different relationship perceptions. Accordingly, they need strong organizational culture, along with an appropriate style of leadership and leaders that fit the nature of this culture. A review of the literature, which draws from different agenda evident in management research, (along with the evaluation of the current cultural and organizational leadership demands in the construction industry) enables a conceptual model to be formulated (see Figure 1 below). The model is

comprised of two fields: organizational culture and authentic leadership characteristics. Its development leads to two main observations: firstly, organizational culture and authentic leaders should interact with individuals and project processes, in which those skilled and competent leaders understand their culture and effectively deliver its strategies to subordinates; and secondly, the interaction of these variables provides an effective working environment that will enhance chances of success (see Figure 2).

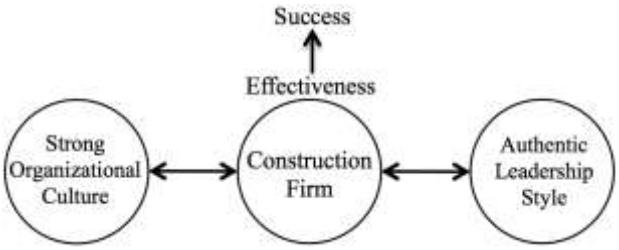

Figure 1: The effectiveness model of construction firm

Figure 2: Components and mechanism of the model

RESEARCH METHOD

Sampling and Data Collection

The study centered on a large construction Middle East-based organization and randomly selected employees holding various managerial positions. A total of 120 respondents from 6 different construction projects participated in the investigation; this gave a response rate of 66%. The work experience of the participants (22 at line, 26 at middle and 12 at senior management level) typically ranged between 2 to 10 years, with a few holding over 10 years' experience. Almost half of the respondents had 6 to 9 years' experience. The sample was divided into six categories: A to F, each representing specific construction project and client.

A mixed method approach was used to elicit data from respondents through two sets of structured questionnaire surveys. This provided data to enable an investigation of the level of organizational culture and the identification of leaders' roles in relation to their organizational culture within each project environment.

Organizational Culture Measures

There are various models which propose different classifications and measures of organizational culture. Giritli and associates (2013) have explained that they each provide insight into an overall understanding of organizational culture. However, as mentioned above, the research adopted model during this study was the Denison Culture Model (Denison Consulting, 2007). This model involves the collection of data via a questionnaire consisting of four different clusters of questions. These are relevant to the key cultural dimensions of the theoretical model: involvement, consistency, adaptability and mission. These traits break down into 12 indices: 3 indices for each trait. Each cluster of questions has 12 statements: four for each index, making a total of 48 questions. The model is divided into horizontal and vertical axes: internal/external focuses and stability/flexibility respectively.

A closed statement tool, based on four-point Likert scale structure, was adopted to design the questionnaires. Respondents were asked to select the most appropriate category, i.e., strongly agree, agree, disagree and strongly disagree; for each statement. Calculating the average score of the participants' responses derived the overall cultural profile of each project. The organization's cultural profile was obtained by calculating the average score of all respondents within each organization.

Authentic Leadership Measures

The research included items from Toor and Ofori's (2007) study on leadership ethic and authenticity. It is potentially the largest study on authentic leadership development within construction project professionals. Respondents were asked to evaluate their leaders using 16 statements based on a four-point Likert scale structure. A score of 1-4 was assigned, where 1= strongly agree and 4=strongly disagree. The statements were designed to measure each organization's level of adoption of the authentic leadership principle. The mean score of the respondents was derived as a measure of the level of project leadership authenticity.

Findings

Research findings were derived following two inter-related stages of data handling: firstly, descriptive data were collated and presented for each variable; and secondly, the relationship between organizational culture and leadership was evaluated using this collated data to highlight correlations between key themes within the analysis matrix for each project. Project data were analysed independently in order to evaluate the individual context; followed by cross-project case analysis, which involved both organizational culture and leadership traits.

The analysis reported strong levels of organizational culture associated with projects A, E and F, and their leaders' authenticity practices increased accordingly. The results for projects C and D contrasted dramatically: they indicated very low levels of culture and authenticity practices. Project B, on the other hand, received a low level of organizational culture with a high level of employees' satisfaction toward their leaders' authenticity. Figure 2 and 3 illustrate the overall organizational culture scores and the mean scores and standard deviations for organization authentic leadership style, respectively. The overall level of culture within the organization is medium, with a low level of adoption of the authenticity principle among its leaders.

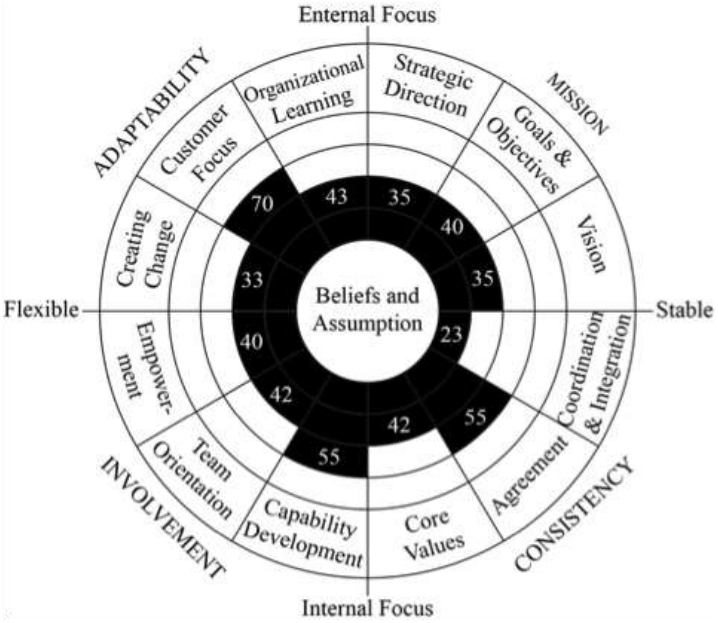

Figure 2: Cross-project Report of the Middle East-based Organization - Organizational Culture (%)

No.	My Leader …	M	SD
1.	Act in the best interest of my organization.	2.83	0.89
2.	Has a good ability to understand different situations and contexts.	2.83	0.90
3.	Is trustworthy and transparent.	2.33	0.99
4.	Has a strong vision.	2.83	1.09
5.	Gives me freedom in my job.	2.55	1.17
6.	Optimistic and looks forward to positive outcomes of team effort.	2.50	0.90
7.	Leads from heart and soul.	2.66	1.19
8.	Has the ability to say "no" when necessary.	2.50	1.09
9.	Well deserves to be in the leadership position.	2.50	1.09
10.	Makes me feel that my contribution is important for the organization.	2.50	1.09
11.	Has a good balance between his work/task and people/ relationship orientation.	2.66	1.19
12.	Helps me to develop my personal strengths.	2.66	1.19
13.	Is fair in decision-making.	2.50	1.09
14.	Admits when mistakes are made by him.	2.50	1.09
15.	Make efforts to establish strong and positive relationships.	2.33	0.99
16.	Makes personal sacrifices for the benefit of others.	2.66	1.19

Figure 3: Cross-project Report of the Middle East-based Organization - Authentic Leadership

DISSCUSION AND CONCLUSION

Existing theory suggested that organizational culture and leadership style are the major dimensions of effectiveness within the construction industry: in particular, strong organizational culture and authentic leadership style. Although the investigation was undertaken within the same context, i.e. the Middle-Eastern construction company, the traits and norms and level of organizational culture varied from project to project. The strong influence of organizational culture on authenticity level was obvious in the five projects studied. Respondents appeared to be dissatisfied with the authenticity practice of their leaders. This seems to be consistent with earlier research undertaken by Weese (1996),

Ogbonna and Harris (2000) and Kefela (2010), in which appropriate leadership within an organization is not directly related to its effectiveness but needs strong organizational culture that is widely shared in order to achieve high performance and employees' satisfaction.

The study has indicated that construction leaders tend to perform using a wide range of leadership behaviour, even within the same organizational environment. Thus, organizational culture and its various traits are directly linked to organizational performance, where positive cultural change in a single division will obviously influence that unit and have impacts on its effectiveness and efficiency. The research has suggested that organizational culture is a key to firm performance regardless of the organization's appropriate style of leadership. Organizations should pay an adequate attention to their culture in order to achieve positive outcomes. Meanwhile, leadership has to receive its importance.

Some caution must be noted, however: this study is limited to a specific Middle Eastern construction firm; furthermore, although the Denison culture model is generally well-supported, it may well lack a comprehensive understanding of all cultural components in relation to Middle-Eastern culture.

REFERENCES

Akiner, I and Akiner, M E (2009) Evaluation of Turkish Construction Industry Through the Challenges and Globalisation. "An International Journal", 1(2), 64-71.

Alvesson, M (2013) "Understanding Organizational Culture". 2ed. London: Sage Publication Ltd.

Avolio, B J and Gardner, W L (2005) Authentic Leadership Development: Getting to the Root of Positive Forms of Leadership. "The Leadership Quarterly", 16(3), 315–38.

Bresnen, M J, Bryman, A E, Ford, J R, Beardsworth, A D and Keil, E T (1986) The Leader Orientation of Construction Site Managers. "Journal of Construction Engineering and Management", 112(3), 370-386.

Brown, A D (1998) "Organizational Culture". Hall: Financial Times Pitman.

Bryman, A (1984) Leadership and Corporate Culture: Harmony and Disharmony. "Personnel Review", 13(2), 19-23.

Cameron, K S and Quinn, R E (2006) "Diagnosing and Changing Organizational Culture: Based on the Competing Values Framework". Revised ed. Reading: Addison-Wesley Publishing Company Inc.

Coffey, V (2010) "Understanding Organisational Culture in the Construction Industry". United States of America: Spon press.

Daft, R L (2008) "The Leadership Experience". 4ed. United State of America: South-Western.

Denison Consulting (2007) "The Denison Model". [online] available from <http://www.denisonconsulting.com/home.aspx>.

Farrell, S M (1993) "Organizational Cultures and Values As they Impact on Job Satisfaction and Organizational Commitment". Unpublished Dissertation, Wright State University.

Fergusson, H and Langford, D A (2006) Strategies for Managing Environmental Issues in Construction Organisations. "Engineering, Construction and Architectural Management", 13(2), 171-185.

Gardner, W L, Avolio, B J, Luthans, F, May, D R and Walumbwa, F (2005) Can You See the Real Me? A Self-Based Model of Authentic Leader and Follower Development. "The Leadership Quarterly", 16(3), 343-372.

George, B (2003) "Authentic leadership: Rediscovering the Secrets to Creating Lasting Value". San Francisco: Jossey-Bass.

George, B and Sims, P (2007) "True North: Discover Your Authentic Leadership". San Francisco: Jossey-Bass.

Giritli, H, Oney-Yazici, E, Topçu-Oraz, G and Acar E (2013) The Interplay Between Leadership and Organizational Culture in the Turkish Construction Sector. "International Journal of Project Management", 31(2), 228-238.

Giritli, H and Oraz, G T (2003) Leadership Styles: Some Evidence from the Turkish Construction Industry. "Construction Management and Economics", 22(3), 253-262.

Harmann, A (2006) The Role of Organisational Culture in Motivating Innovative Behaviour in Construction Firms. "Construction Innovation: Information, Process, Management", 6(3), 159-172.

Hillebrant, P M (2000) "Economic Theory and the Construction Industry". 3ed. London: Macmillan.

Kefela, G T (2010) Understanding Organisational Culture and Leadership – Enhance Efficiency and Productivity. "PM World Today", XII(I), 1-14.

Kotter, J and Heskett, J L (1992) "Corporate Culture and Performance". New York: Free Press.

Lewin, A Y and Minton, J W (1986) Determining Organizational Effectiveness: Another Look, and An Agenda for Research. "Management Science", 32(5), 514-538.

Limsila, K and Ogunlana, S O (2008) Performance and Leadership Outcome Correlates of Leadership Styles and Subordinate Commitment. "Engineering, Construction and Architectural Management", 15(2), 164-184.

Low, S P and Shi, Y (2001) Cultural Influences on organizational Processes in International Projects: Two Case Studies. "International Journal of Productivity and Performance Management", 50(6), 267-85.

Maloney, W F and Federle, M O (1993) Practical Models for Organizational Assessment. "Journal of Management in Engineering", 9(1), 64-81.

Newstrom, J W and Davis, K (1993) "Organizational Behavior: Human Behavior at Work". 9ed. New York: McGraw-Hill Inc.

Northouse, P G (2010) "Leadership Theory and Practice". 5ed. California: SAGE Publication Inc.

Ogbonna, E and Harris, L C (2000) Leadership Style, Organisational Culture and Performance: Empirical Evidence from UK Companies. "The International Journal of Human Resource Management", 11(4), 766-788.

Ofori, G (1990) "The Construction Industry: Aspects of Its Economics and Management". NUS Press, Singapore.

Rowlinson, S, Ho, T K K and Po-Hung, Y (1993) Leadership Style of Construction Managers in Hong Kong. "Construction Management and Economics", 11(6), 455-465.

Schein, E H (1992) "Organisational Culture and Leadership". 2ed. San Francisco: Jossey-Bass Inc.

Smart, J C and John, E P S (1996) Organizational Culture and Effectiveness in Higher Education: A Test of the Culture Type and Strong Culture Hypotheses. "Educational Evaluation and Policy Analysis", 18(3), 219-241.

Steers, R, Porter, L and Bigley, G (1996) "Motivation and Leadership At Work". 6ed. United States of America: McGraw-Hill.

The Chartered Institute of Building (2010) "A Report on the Leadership in the Construction Industry". United Kingdom: CIOB. [online] available from <http://www.ciob.org/node/16583>.

Toor, S R and Ofori, G (2008) Leadership for Future Construction Industry: Agenda for Authentic Leadership. "International Journal of Project Management", 26(6), 620–630.

Toor, S R and Ofori, G (2007) Ethics and Authenticity of Leadership in the Construction Industry. “Proceeding of the 17th CIB World Building Congress: Construction for Development”. 4-17 May 2007, Cape Town. In-house Publisher, 322-334.

Weese, W J (1996) Do Leadership and Organisational Culture Really Matter?. “Journal of Sport Management”, 10(2), 197-206.

Yukl, G (2010) “Leadership in Organizations”. 7ed. Upper Saddle River, New Jersey: Pearson Prentice Hall.

Zehir, C, Ertosun, O G, Zehir, S and Muceldili, B (2011) The Effect of Leadership Style and Organizational Culture over Firm Performance: Multi-National Companies in Istanbul. “Procedia Social and Behavioral Sciences”, 24, 1460-1474.

DEVELOPMENT OF A CONCEPTUAL MODEL FOR ORGANIZATIONAL LEARNING CULTURE AND INNOVATION DIFFUSION IN CONSTRUCTION

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Driven by vigorous competition and continuously escalating demands of clients in construction, innovation is increasingly important for enhancing performance of contractors and designers in design, planning and management of construction projects. Instead of intra-organization innovation, innovation in construction often diffuses across inter-organization boundaries. Influenced by various organizational learning and culture, innovation diffusion may be problematic. This paper aims to develop a conceptual framework of the relationships between organizational learning culture, learning and innovation diffusion in the construction industry via systematic review. Seven learning culture variables were identified, including creating opportunity, communication, collaboration and teamwork, knowledge sharing, collective vision, connection with the environment and leader support and reward system. There are six stages of innovation diffusion, namely acquisition, decision, assimilation, transformation, exploitation and confirmation. The resulted model provides preliminary support on the propositional relationship between organizational learning culture and innovation diffusion, and that this relationship can be mediated by organization learning. The model provides researchers and practitioners a foundation for further validations by empirical studies.

Keywords: learning, innovation diffusion, organizational culture.

INTRODUCTION

Innovation has found to be essential in enhancing financial performance, competitiveness of an organization and quality of life of employees (Blayse and Manley, 2004). Driven by vigorous competition and continuously escalating demands of clients in construction, innovation is increasingly important for enhancing performance of contractors and designers in design, planning and management of construction projects. The definition of innovation is widely discussed in different disciplines. There are generally two schools of thought, namely outcome school and process school. The first considers innovation as a new idea, product or process that can create value (e.g. Rogers 1962); while the second considers it as successful implementation of creative ideas within an organization, from the conceptualization to the utilization stage of a new item of economic or social value (e.g. Amabile 1996). Innovation in construction often refers to new technology or system adopted by an organization, so innovation is defined as any new things which brings value to an organization in this study, which follows the outcome school.

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Hua YY and Chan IYS (2013) Development of a conceptual model for organizational learning culture and innovation diffusion in construction In: Smith, S.D and Ahiaga-Dagbui, D.D (Eds) Procs 29th Annual ARCOM Conference, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 405-414.

There are not many traditional research and development activities in the construction industry. Lots of innovation is resulted from the diffusion of external knowledge within an organization. The recent spread of a novel and effective computer-related technologies, Building Information Model (BIM), in construction implies that the future of construction industry may depend on the rapid diffusion and successful utilization of new technologies in workplace. Damanpour and Wischnevsky (2006) distinguished two types of innovation - primarily generated innovation and primarily adopted innovation. A construction firm plays an important role as innovation-adopting organization, which undertakes an innovation diffusion process. Innovation diffusion is "a process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers 1962: 79). Although innovation diffusion can be competence-enhancing for a firm, depending on it complicated diffusion process, it can also be competence-destroying (Tushman and Anderson 1986).

Many researchers have investigated how innovation process is influenced by various organizational contexts (e.g., organizational culture and context and climate). However, due to the unitary view of innovation generation and adoption in previous research studies, there are comparatively fewer studies conducted to specifically investigate the impact of organizational culture on innovation diffusion process.

Innovation diffusion is highly dependent on organizational learning (Attewell 1992). Organizational learning refers to as a continuous testing of experience and its transformation into knowledge available to whole organization and relevant to their mission (Senge 1997). It may be an outstanding feature which distinguishes the successful innovation diffusion from successful innovation generation. Since learning culture of an organization can facilitate learning outcomes (Buckler 1998; Buhler 2002), the aim of this paper is to explore the relationship between organizational learning culture and innovation diffusion process in the construction industry.

INNOVATION DIFFUSION

The term "diffusion" was firstly adopted by physicians and chemists as the movement of particles from an area of high concentration to an area of low concentration at the beginning. This concept was then introduced into other disciplines, like biology, sociology, communication, management, and so on. Rogers (1962) divided diffusion into five stages based on his investigation on diffusion process, including knowledge, persuasion, decision, implementation and confirmation. Rogers's model contains individual adoption process, but it does not include the processes of learning and assimilation. These learning stages were later revealed in the absorptive capacity model. Absorptive capacity is defined as a firm's "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1989). The absorptive process thereby includes three stages: recognition, assimilation and application. Based on the absorptive capacity model developed by Cohen and Levinthal (1989), Zahra and George (2002) added a transformation stage in their innovation diffusion model and redefined the absorptive capacity as "a set of organizational routines and processes by which firms acquire, assimilate, transforms and exploit knowledge to produce a dynamic organizational capability" (p.186).

Different models have different focuses. This study adopts a comprehensive approach, which develops an innovation diffusion model by integrating the different stages included in different models. Table 1 summarizes seven stages, including acquisition, decision, assimilation, transformation, exploitation and confirmation. Definitions of these stages mainly follow the works conducted by Rogers (2003) and Zahra and George (2002).

Table 1: Definition of Innovation Diffusion Stages

Diffusion stages	Definition
Acquisition	Recognize, value, and acquire external knowledge that is critical to a firm's operations (Rogers 2003)
Decision	Weigh the advantages/disadvantages and decide whether to adopt or reject the innovation (Rogers 2003)
Assimilation	Routines and processes that allow it to analyze, process, interpret and understand the information obtained from external sources (Zahra and George 2002).
Transformation	Develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge (Zahra and George 2002)
Exploitation	Apply new external knowledge and to create new ones by incorporating acquired and transformed knowledge into its operations (Zahra and George 2002)
Confirmation	Finalize decision to continue using the innovation (Rogers 2003)

ORGANIZATIONAL LEARNING CULTURE

Culture is defined as the collective programming of human mind which distinguishes members of one human group from those of another (Hofstede, 1981). According to Hofstede (1990), there are four layers of culture, including values, rituals, heroes, symbols, and symbols, heroes, and rituals can be subsumed under the term “practices” because they are visible to an observer. Therefore, the definition of organization culture includes both shared values and perceived common practices that carry a specific meaning within the organizational unit. There are two basic approaches of studying organizational culture, the typological approach and the trait approach (Liu et al. 2006). Amongst these two approaches, researchers adopting trait approach believe that culture can be measured as a multidimensional set of values and practices embraced by an organization (Hofstede et al. 1990). The Hofstede model of organizational culture includes several key dimensions, namely means oriented versus goal oriented; internally driven versus externally driven; easy going work discipline versus strict work discipline; local versus professional, open versus closed; employee oriented versus work oriented. This does not only serve as a tool to map organizational culture, but also provide a better way to measure and manage culture.

Following the Hofstede model of organizational culture, researchers tried to investigate organizational learning from different cultural levels, such as shared values or practices. The majority of these studies focus on the practice aspects. For instance, Watkins and Marsick (1993) defines seven dimensions of organizational learning culture, such as creating continuous learning opportunities, encouraging teamwork and empowering people towards a collective vision. Gephart et al. (1997) defines three dimensions of organizational learning culture, including facilitating knowledge sharing and transferring, sharing a common goal, and encouraging independent thinking and trying new ideas. Bishop et al. (2006) established a framework of organizational learning culture and identify four possible features of a learning-supportive culture, such as easy access to knowledge resources, collaborative working, and encourage and reward the acquisition and sharing of knowledge. The similarities and differences of these models are summarized in Table 2. These dimensions have been verified by later empirical studies under different organization contexts (e.g., Ellinger et al. 2003; Hernandez 2003; Bates and Khasawneh 2005; Alzawahreh 2012).

Table 2: Dimensions of Organizational Learning Culture

Dimensions \ Authors	(Watkins and Marsick (1993)	Gephart et al (1997)	Bishop et al. (2006)
Creating opportunities	Create continuous learning opportunities	-	Easy access to knowledge resources
Promote communication	Promote inquiry and dialogue	-	-
Collaboration and teamwork	Encourage collaboration and team learning	-	Collaborative working
Knowledge sharing	Create systems to capture and share learning	Facilitate knowledge sharing and transferring	-
Collective vision	Empower people toward a collective vision	Share a common goal	-
Connection with the environment	Connect the organization to its environment	-	-
Leader support and reward system	Provide strategic leadership for learning	Encourage independent thinking and trying new ideas	Encourage and reward the acquisition, sharing and exploitation of knowledge

INNOVATION DIFFUSION AND ORGANIZATIONAL LEARNING

Adopting new process technologies is a process of "learning by doing" (Arrow 1962). As verified by empirical study, organizational learning is the core of innovation diffusion (Attewell 1992).In order to successfully assimilate a new process technology, an organization must reach a state where its bundles of knowledge and skills encompass those needed to apply the new technology effectively (Fichman and Kemerer 1997). In the case of BIM, for example, successful diffusion requires understanding of its technical features, discerning of any potential problems in application, and accommodation of this new technology to the new work procedure and standards. Organizational learning, similar to innovation, is a very elusive concept due to the variety of perspectives that come under scrutiny in the academic literature. Senge (1997) defines organizational learning as a continuous testing of experience and its transformation into knowledge available to whole organization and relevant to their mission.

When talking about organizational learning, the important role of individual learning in organization cannot be ignored. Individual learning involves the distillation of an individual's experiences regarding a technology into understandings that may be viewed as personal skills and knowledge. An organization learns when individual insights and skills become embodied in organizational routines, practices, and beliefs that outlast the presence of the originating

individual (Attewell 1992). Organizational learning emerges when an organization acquires information (knowledge, understandings, know-how, techniques and procedures) of any kind by any means (Argyris and Schön 1996). It can be achieved by both formal (training programs, seminars and workshops) and informal methods (experience and mistakes) (Suggs 2003). Informal learning happens in various situations and relies on interactions among people, which is highly associated with the innovative culture of an organization (Bishop et al. 2006). Bishop et al (2006) consider an organizational learning culture is one that values the creation, sharing and application of new knowledge, and manifestation of such values in different aspects of an organization. Hence, this study aims to develop a conceptual model associating organizational learning culture and innovation diffusion.

RESEARCH METHOD

To develop a conceptual model for organizational learning and innovation diffusion, systematic review was conducted to summarize the outcomes of various relevant research studies based on a systematic plan and search strategy. Since research studies covering both organizational learning and innovation diffusion in construction are rare, both construction-related and non-construction studies covering dimension(s) of the above two concepts are included in this paper. The study aims to develop a conceptual framework regarding the impact of various learning culture dimensions on the innovation diffusion process. Studies were selected by identifying keywords such as “innovation”, “diffusion”, “learning” and /or “culture” in paper title, abstract and /or keywords. To ensure quality of studies, only papers listed in the Academic Journal Quality Guide (ABS version 4, 2010) (general management) and the top-ten ranking list developed by Chau (1997) (construction management) are included.

CONCEPTUAL MODEL DEVELOPMENT

Based on the literature review, a preliminary conceptual model was developed to illustrate the relationships between organizational learning culture, learning and innovation diffusion revealed by previous studies. Organizational learning culture has impact on various innovation diffusion stages through the mediating role of organization learning.

As illustrated in Figure 1, there are seven identified dimensions of learning culture, which was found to have different influences on the six innovation diffusion stages.

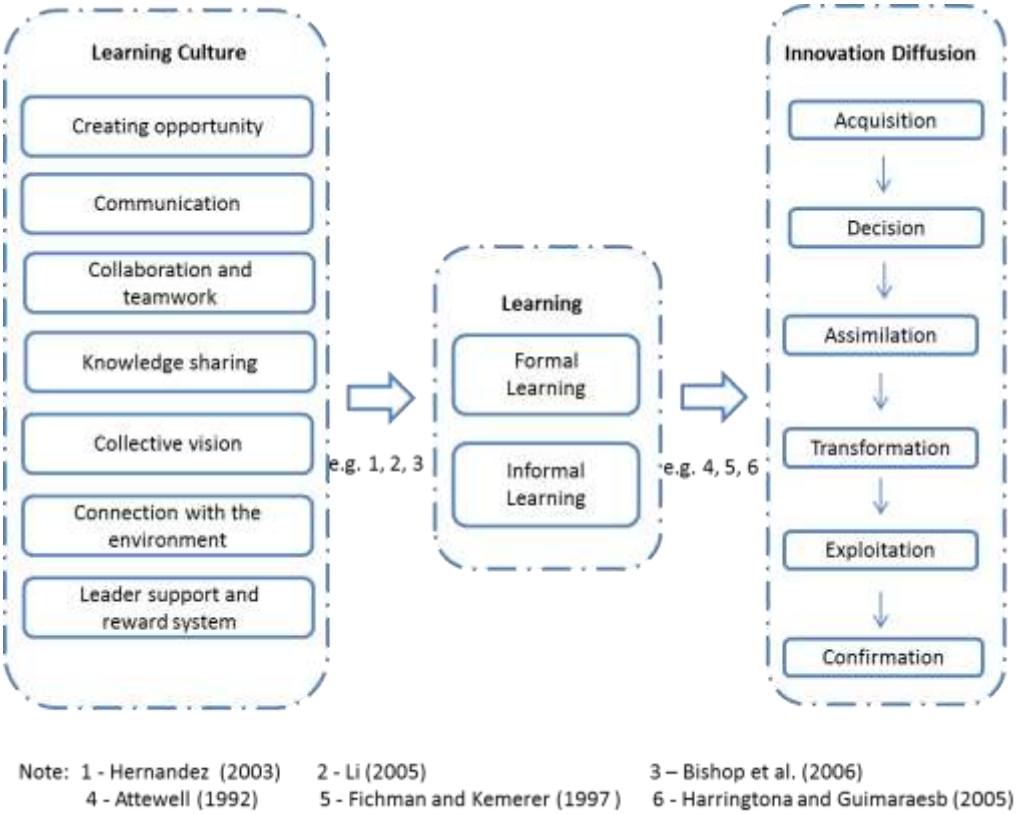

Figure 1: A Conceptual Model for Organizational Learning Culture and Innovation Diffusion

Creating opportunities for learning provides platform for employees to acquire innovative knowledge. Without adequate learning and understanding about an innovative technique, it is hard to assimilate and incorporate it into traditional work tasks. Creating opportunities for learning has thus found to enhance success of innovation implementation (Fichman 1997; Meyers et al. 1999). It can be achieved by considering and incorporating learning opportunities at work design stage. Another approach is providing opportunities for on-going education and growth, such as training and rotation. On the other hand, effective communication broadens sources of innovation acquirement, provides support for decision making and decreases inconsistency and mistakes in implementation stage. An organization learning culture which facilitates communication can be fostered by providing sufficient and effective questioning and feedback channels. Effective communication can be enhanced by equipping employees with productive reasoning skills for expressing and exchanging individual views (Boer et al. 1999; Meyers et al.1999). Moreover, adopting and implementing a new technology in an organization involves participation of different departments and individuals, in which collaboration between these parties is essential (Gambatese and Hallowell 2011; Kosine 2003). Effective collaboration and teamwork can be achieved by providing platforms for multi-departmental groups to access different modes of thinking, learning and working together, and by providing proper rewards for collaboration with fruitful outcomes.

Knowledge sharing is the cornerstone of innovation diffusion. This is especially important for the confirmation stage. After exploitation, the confirmed innovative knowledge /technique should be transferred and promoted to other parties in an organization, so as to facilitate effective implementation. To foster knowledge sharing, both high and low technology systems, such as using internet based communication technology and stimulating conversation between colleagues, should be created and integrated with work (Jones 2004;

Kearns 2003; Liao 2007). On the other hand, collective vision refers to the setting, owning, and implementation of a joint vision by employees in an organization. Responsibility is distributed for decision making so that employees are motivated to learn toward what they are held accountable to do. Shared values and understandings between parties in an exchange relationship facilitate meaningful communication that is essential in both the exchange and combination required for knowledge creation (Bates 2005; Gyampah 2004; Li 2005). Moreover, cultural dimensions regarding external environment (Harringtona and Guimaraesb 2005) and network ties (Abrahamson and Rosenkopf 1997; Singh 2005) are also found to be related to innovation diffusion. To enable access to innovative knowledge from the external environment, organizations may collect documents describing new developments in the industry, encourage personal contacts with knowledgeable individuals outside the organization, and use other external communication channels. Lastly, Politis (2005) found that coercive and referent power is likely to have a negative influence on employees' knowledge acquisition and knowledge sharing processes. Leadership for innovation can be demonstrated by behaviour (e.g., providing vision, organizing feedback, rewards, Jong and Hartog 2007) and personal characteristics of individual leaders (e.g., manager's tenure, education background, pro-innovation attitude, Damanpour and Scheider 2009).

Innovation Diffusion and Learning Culture in the Construction Industry

Researchers in the construction management field mainly concentrate on the positive effects of collaboration and team work, connection with the environment and leader support on innovation diffusion (Gambatese and Hallowell 2011; Linderoth 2010; Larsen 2011; Park et al. 2004). This may due to the project-oriented and multi-stakeholder natures in construction. Practitioners are thus suggested to put emphases on promoting collaboration, building network with other companies and increasing support for R&D, in order to facilitate innovation diffusion. Comparatively, opportunity to learning, communication, knowledge sharing, and collective vision attract less attention. One of the possible reasons may be that innovation diffusion is a new research area in construction management. The conceptual model sheds light on the knowledge gap for further comprehensive studies investigating the associations between organizational learning culture and various innovation diffusion stages in these aspects of construction.

Limitation and Future Study

The resulted model was developed based on literature review, in which it only acts as a preliminary conceptual model for further research studies. Although the propositional organizational learning culture - innovation diffusion relationships have been tested by various studies, these results are fragmented. Validation by a comprehensive study supported by data collected from the construction context is necessary. Further research studies are suggested to test the model by an in-depth case study. The diffusion of BIM amongst construction organizations can be adopted as a proxy for innovation in construction.

BIM was recognized as an innovation in the construction industry to improve the efficiency in the late 1980s and early 1990s (Linderoth 2010). However, the process and outcomes of adopting BIM differ greatly across different construction enterprises. Researchers have started to investigate the success factors of BIM diffusion in construction, including BIM proficiencies of team members, communication of project team (Barlish and Sullivan, 2012) and technical tool functional requirements and needs (Gu and London, 2010). Although some of the researchers acknowledged the importance of non-technical strategic issues in the innovation diffusion process (Gu and London, 2010), studies concerning the impact of culture on innovation diffusion are still rare. Hence, the proposed further case study is essential for the development of innovation diffusion theory in the construction industry.

CONCLUSION

The conceptual model reveals that organizational learning culture generally includes opportunities and access to learning, promote communication, collaboration and teamwork, knowledge sharing, collective vision, connection with the environment, and leader support and reward system, which may have indirect impact on the innovation diffusion process covering acquisition, decision, assimilation, transformation, exploitation and confirmation through the mediating role of organization learning. Although only limited construction-related research is found, the literature review provides partial support to the comprehensive model. The preliminary results provide researchers a platform for further empirical studies to investigate how to facilitate innovation diffusion by fostering an effective organization learning culture.

ACKNOWLEDGEMENT

The work described in this paper was fully supported by a grant from the General Research Fund (Project No. HKU715111).

REFERENCES

Abrahamson, E and Rosenkopf, L (1997) Social network effects on the extent of innovation diffusion: a computer simulation. “Organization Science”, 8(3), 289-309.

Amabile, T M, Conti, R, Coon, H, Lazenby, J, and Herron, M (1996) Assessing the work environment for creativity. “Academy of Management Journal”, 39(5), 1154-1184.

Arrow, K (1962) The economic implications of learning by doing. “Review of Economic Studies”, 29, 166-170.

Attewell, P (1992) Technology diffusion and organizational learning: The case of business computing, “Organization Science”, 3(1), 1-19.

Barlish, K and Sullivan, K (2012) How to measure the benefits of BIM-A case study approach. “Automation in construction”, 24, 149-159.

Bates, R and Khasawneh, S (2005) Organizational learning culture, learning transfer climate and perceived innovation in Jordanian organizations. “International Journal of Training and Development”, 9(2), 96-109.

Bishop, D (2011) The importance of being an insider: how networks influence the small firm's engagement with formal training. “Journal of European Industrial Training” 35(4), 326 -344.

Bishop, D, Felstead, A, Fuller, A, Jewson, N, Lee, T, and Unwin, L (2006) Connecting culture and learning in organisations: a review of current themes. Learning as Work Research Paper 5.

Blayse, A M, and Manley, K (2004) Key influences on construction innovation. “Construction Innovation”, 4(3), 143-154.

Boer, M, Bosch, F A J V, and Volberda, H W (1999) Co-evolution of firm absorptive capacity and knowledge environment: organizational forms and combinative capabilities. “Organization Science”, 10(5), 551-568.

Buckler, B (1998) Practical steps towards a learning organization: applying academic knowledge to improvement and innovation in business. “The Learning Organization”, 5(1), 15-23.

Buhler, P M (2002), Managing the new millennium: building the learning organization for the 21st century: a necessary challenge. “Supervision”, 63(12), 20-23.

Chau, K W (1997) The ranking of construction management journals. “Constr. Manage. Econom”, 154, 387-398.

Cohen, W M and Levinthal, D A (1989) Innovation and learning: the two faces of R&D. “The Economic Journal”, 99(9), 569-596.

Cohen, W M and Levinthal, D A (1990) Absorptive capacity: a new perspective on learning and innovation. “Administration Science Quarterly”, 35(1), 128-152.

Damanpour, F and Scheider, M (2009) Characteristics of innovation and innovation adoption in public organizations: assessing the role of managers. “J Public Adm Res Theory”, 19(3), 495-522.

Damanpour, F and Wischnevsky, J D (2006) Research on innovation in organizations: distinguishing innovation-generating from innovation-adopting organizations. “Journal of Engineering and Technology Management”, 23, 269-291.

Ellinger, A D, Ellinger, A E, Yang, B and Howton, S H (2003) Making the business case for the learning organization concept. “Advances in Developing Human Resources”, 5, 163-172.

Fichman, R G and Kemerer, C F (1997) The assimilation of software process innovations: an organizational learning perspective. “Management Science”, 43(10), 1345-1363.

Gambatese, J A and Hallowell, M (2011) Enabling and measuring innovation in the construction industry. “Construction Management and Economics”, 29(6), 553-567.

Gephart, M A, Holton, E F, Marsick, V J, and Redding, J C (1997) Assessing strategic leverage for the learning organization-group and organizational outcomes, Climate and Support Systems. Unpublished Manuscript.

Gluch, P, Gustafsson, M, Thuvander, L. (2009) An absorptive capacity model for green innovation and performance in the construction industry. “Construction Management and Economics”, 27(5), 451-464.

Gu, N, and London, K (2010) Understanding and facilitating BIM adoption in the ACE industry. "Automation in Construction", 19(8), 988-999.

Gyampah, K A and Salam, A F (2004) An extension of the technology acceptance model in an ERP implementation environment. “Information and Management”, 41(6), 731-745.

Harringtona, S J and Guimaraesb, T (2005) Corporate culture, absorptive capacity and IT success. “Information and Organization”, 15(1), 39-63.

Hernandez, M H (2003) Assessing tacit knowledge transfer and dimensions of a learning environment in Colombian businesses. “Advances in Developing Human Resources”, 5, 215-221.

Hoecklin, L (1996) “Managing cultural differences: strategies for competitive advantage”, Addison-Wesley, Wokingham.

Hofstede, G (1981) Culture and organization. “International Studies of Management and Organization”, 10(4), 15-41.

Hofstede, G, Neuyen, B, Ohayv, D D and Sanders, G (1990) Measuring organisational cultures: a qualitative and quantitative study across twenty cases. “Administrative Science Quarterly”, 35 (6), 286-316.

Jong, J P J and Hartog, D N D (2007) How leaders influence employees' innovative behaviour. “European Journal of Innovation Management”, 10(1), 41- 64.

Kearns, G S and Lederer, A L (2003) A resource-based view of strategic IT alignment: how knowledge sharing creates competitive advantage. “Decision Sciences”, 34(1), 1-29.

Larsen, G D (2011) Understanding the early stages of the innovation diffusion process: awareness, influence and communication networks. “Construction Management and Economics”, 29(10), 987-1002.

Li, L (2005) The effects of trust and shared vision on inward knowledge transfer in subsidiaries’ intra- and inter-organizational relationships. “International Business Review”, 14(1), 77–95.

Linderoth, H C J (2010) Understanding adoption and use of BIM as the creation of actor networks. “Automation in Construction”, 19(1), 66-72.

Meyers, P W, Sivakumar, K, and Nakata, C (1999) Implementation of industrial process innovations: factors, effects, and marketing implications. “Journal of Product Innovation Management”, 16(3), 295-311.

Park M, Nepal M P, and Dulaimi M F (2004) Dynamic modelling for construction innovation. “Journal of Management and Engineering”, 20(4), 170-177.

Politis, J D (2005) The influence of managerial power and credibility on knowledge acquisition attributes. “Leadership & Organization Development Journal”, 26(3), 197-214.

Rogers, E M (1962) “Diffusion of innovations”, Glencoe, Free Press.

Roper, S, Hales, C, Bryson, J R and Love, J (2009) Measuring sectoral innovation capability in nine areas of the UK economy. (Available on line (http://www.nesta.org.uk/publications/reports/assets/features/measuring_sectoral_innovation_capability_in_nine_areas_of_the_uk_economy [accessed on 24/8/2010])

Senge, P M (1997) The fifth discipline. “Measuring Business Excellence”, 1(3), 46 - 51.

Singh, J (2005) Collaborative networks as determinants of knowledge diffusion patterns. "Management Science", 51(5), 756-770.

Suggs, S (2003) More than one way to learn. “Information Outlook”, 7(5), 42-3.

Tushman, M and Anderson, P (1986) Technological discontinuities and organizational environments. “Administrative Science Quarterly”, 31 (9), 439-465.

Watkins, K E and Marsick, V J (1993) “Sculpting the learning organization”, San Francisco, Jossey-Bass.

Zahra, S A and George, G (2002) Absorptive capacity: A review, re-conceptualization, and extension. “Academy of Management Review”, 27(2), 185-203.

A META-ANALYSIS OF OPPORTUNISTIC BEHAVIOUR IN PUBLIC-PRIVATE PARTNERSHIPS: MANIFESTATIONS AND ANTECEDENTS

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Public-private partnerships (PPP) are increasingly popular around the world. A number of studies have been conducted on the risk factors and risk allocation in PPP, but they ignored the underlying forces which drive project stakeholders' behaviour when transferring risks. This paper addresses this gap by investigating the manifestation and antecedents of opportunistic behaviour in PPP projects. Using delinquency theory, transaction cost economics and agency theory, a conceptual model of antecedents of opportunistic behaviour in PPP is developed. A meta-analysis of 20 PPP case is conducted. It is found that self-interest seeking and asset specificity are the most important factors in motivating parties' to act opportunistically. Superordination and externalization are the two significant forces in justifying opportunistic behaviours in PPPs. In addition, risk occurrences have a direct relationship with opportunistic behaviour.

Keywords: public-private partnership, risk transfer, risk allocation, opportunistic behaviour.

INTRODUCTION

Collin and Hansson (2000) define PPPs as “an arrangement between a municipality and one or more private firms, where all parties share risks, profit, utilities and investments through a joint ownership of an organization”. The definition and concept of partnership place the principles of cooperation, joint ownership and risk sharing at the centre of the 'partnership' approach. However, in many projects, evidence indicates that the reality does not match the rhetoric? There is considerable research which shows that in practice, PPP projects are less ideal and that, as in all business transactions, the public and private sector engage in opportunistic behaviour with the intent of furthering their own interests at the expense of the other party's. For example, sometimes the more powerful public parties force their private partners to take risks (Guasch 2004, Jin and Zhang 2011), sometimes the public parties don’t have expertise to see the risks they are taking and sometimes the risks are hidden from them by unscrupulous business partners (Vazquez and Allen 2004, Chang 2013). A recent report by the Australian Contractors Association (ACA 2012) shows that contractors feel that they are exploited at various points along the PPP negotiation process and that many risks are unfairly and inappropriately transferred to them without their knowledge, consent and agreement. In transaction cost theory, this type of behaviour is described as 'opportunistic' and is defined as "self-interest seeking with guile"(Williamson 1985, p.47).

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Qu Y and Loosemore M (2013) A meta-analysis of opportunistic behaviour in public-private partnerships: manifestations and antecedents *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 415-424.

Given the centrality of open, fair and appropriate risk allocation to the PPP approach, a number of studies have been conducted to explore how to achieve it (Li et al 2005, Singh and Kalidindi 2006, Xiao and Zhang 2011). However, these studies either focus on the problems associated with poor risk allocation or the mechanics by which parties should be allocated each risk or the nature of the risks each should take. The underlying forces which drive project stakeholders' behaviour when negotiating risks in PPP projects has been largely ignored, leaving us with little understanding of the reasons 'why' risk allocation is often less than optimal in PPP projects. This study fills this gap by investigating causes of opportunistic behaviour in PPP projects. By better understanding the basis of opportunistic behaviour, managers of PPP projects will be better equipped to ensure that PPP projects exhibit the positive behaviours which are the characteristics of a true partnership.

MANIFESTATIONS OF OPPORTUNISTIC BEHAVIOUR IN PPP

In the context of risk allocation in PPP project, the opportunistic behaviour come from transferring risk, with the intent of pursuing their interests at the expense of the other party's. The key elements of opportunism are lack of commitment and self-interest seeking. There are numerous examples of opportunistic behaviour that have been identified in the PPP literature. For example, ‘underbidding’ occurs when the private contractor quotes a price for a piece of work put out to tender which is lower than that which would cover costs (Korczynski 1994). Underbidding is considered opportunistically in PPP project if (1) the bidders engage in misleading and deceptive behaviour by making unrealistic or even false promises to the public sector to win PPP contract and; (2) The winner bidder breaks the promise once wining the contract and refuses to fulfil the contract unless additional conditions are satisfied and the public sectors bear the extra risks (Vazquez and Allen 2004, Chang 2013). Free riding refers to people obtaining benefits from their partners but not bearing a proportional share of the costs of providing the benefits (Albanese and van Fleet, 1985). There is evidence that some governments used ‘free riding’ strategy in cooperation with their private partners in PPP project, by transferring of all risks to the private sector and trying to create public infrastructure at little or no cost (Jin and Zhang 2011). For example, in the Taiwan electronic toll collection (ETC) program, PPP was even defined as ‘government zero investment’, which means the private sector is willing to carry out, and the public sector do not need to invest a penny (Chen 2007). Consequently the private consortium had to take all the risks including commercial and technical operation and maintenance, even though this was not the most efficient allocation of risks (Guasch 2004, Boardman et al 2005). ‘Hostile Takeover’ allows a suitor to take over a target company whose management is unwilling to agree to merger or takeover (Davis 1988). A takeover is considered "hostile" if it is against the willingness of the private partner. For example Spiller (2008) described a project where the government took over a project which directly led to private consortium bankruptcy. ‘Power Misuse’ refers to the government deliberately and unilaterally changed the rules via the use of formal and informal powers to meet its own interest (Guasch 2004). For example, governments may issue legislation making a particular type of contract illegal (Spiller 2008). Finally, ‘social Surplus Capture’ is judged on the ground whether the public or private sector or both disobeyed the principle of public interest and equity (Chen 2007). For example, there is evidence of some occasions when PPP projects only serve a political purpose to help government win an election, leaving taxpayers to pay the cost of the project (Engel et al 2006).

ANTECEDENTS OF OPPORTUNISTIC BEHAVIOUR IN PPP

The three main theories which provide a conceptual understanding of opportunistic behaviour are: transaction cost economics, agency theory and delinquency theory.

Transaction Cost Economics Theory

In PPP projects parties can find themselves locked-in to relationships with their partners and consequently vulnerable to opportunistic behaviour. The idea of the lock-in relationship has been discussed by transaction cost economics (Williamson 1985). In transaction cost economics the following elements help to explain opportunistic behaviour: asset specificity, environmental uncertainty and imperfect control.

Asset Specificity

Asset specificity refers to a situation in which resources necessary to carry out a transaction involve "durable transaction-specific investments" that cannot be used for another purpose without significant financial loss (Fligstein and Freeland 1995). It provides a barrier for parties to exit a relationship. The bigger the size of asset specificity, the more disadvantage for one partner if the other behaves opportunistically (Kapmeier 2008). For example even if a government knew the truth that their private partners were collecting profits at the expense of their own interest, they may not be able to determine the contract because the termination cost will be even higher for the public sector than carrying on (Guasch 2004, Boardman et al 2005). If one partner knows the other is committed to continuing this relationship regardless of escalating cost, it has an opportunity to behave opportunistically (de Brux 2010)

Environmental Uncertainty and Imperfect Control

One assumption of transaction cost economics theory is bounded rationality. It is defined as a semi-strong form of rationality, but limited to the uncertainties (Williamson 1985). Burnes (2000:75) comments that “uncertainty arises because of our inability ever to understand and control events fully, especially the actions of others, whether outside or inside an organization”. Thus, with high degree of environmental uncertainty and imperfect control, the opportunism occurred. In PPP project, the environment uncertainties included political risks, construction risks, legal risks, economic risks, operation risks and so on (Li et al. 2005, Xiao and Zhang 2011). Imperfect control refers to questionable criteria for selecting bidder (Abdul-Aziz 2001), lack of transparency in bidding or renegotiation process (Chen 2007, Engel et al 2006), parties’ non-professional judgment, and incomplete contract (Vazquez and Allen 2004). If the environmental uncertainties are high and complex, the contract will be difficult to specify and cover every potential problem that may occur, which create space for opportunism (de Brux, 2010).

Agency Theory

Contrary to transaction cost economic theory, agency theory assumes that contracts are complete (Akerlof, 1970). Agency theory assumes that both the agent and principal are rational and self-interested, but the rationality is bounded to information asymmetry between the parties, which may lead to opportunism, adverse selection or moral hazard (Arthurs and Busenitz 2003).

Information Asymmetry

Asymmetric information assumes a situation in which one party involved in a transaction has more or superior information than another (Bahli and Rivard, 2003). When the motive to deceive exists, relative advantage to information in an exchange relationship provides an excellent opportunity to do so. For example in the bidding stage of PPP project, the public would consider bidder’s qualifications and details of the bidding documents (Vazquez and Allen 2004, Chang 2013). The private would consider the government’s credibility and willingness to provide guarantees (Boardman et al 2005, Chen 2007). ‘Underbidding’ occurs when the private partners take advantage of the public’s lack of information (Guasch 2004, Boardman et al 2005).

Delinquency Theory

Transaction cost economics theory and agency theory provide useful concepts to explain the conditions which can lead to opportunistic behaviour. It helps provide answers to questions like - will people act opportunistically if they know they are wrong and their actions will be punished? How do they justify their opportunistic behaviours? Neutralization plays an important role in justifying wrongdoings. Sykes and Matza (1957) described three dimensions in justification: externalization, normalization and superordination.

Externalization

Externalization refers to the situation where the delinquent acts are due to forces outside of individual and beyond his control (Sykes and Matza, 1957). The individuals usually justify their responsibilities of opportunistic behaviour by blaming environmental uncertainty, the other party's imperfect control, information asymmetry or the other party's asset specificity. The responsibility of the wrongfulness can be waived if the injury occurred because of the environmental uncertainty, information asymmetry between parties or the injured party's asset specificity, because it couldn't be the evidence that the opportunistic party conducted the wrongdoings deliberately. For example parties needn't to bear extra risks if they break the relationship, but they choose to keep in the relationship, because the millions of dollars investment made him held up to their partners (Boardman et al 2005, Spiller 2008). In this regards, parties justify their opportunistic behaviour by externalization.

Normalization

Normalization is described as people justifying their wrongdoing as normal (Sykes and Matza, 1957). For example, construction industry has bad reputation in commitment (Korczynski 1994), so it is normal to lack of commitment in PPP projects. In case of Chile highway projects, the project was valued at $3.4 billion and increased another $1.27 billion in renegotiations. This action usually cannot be accepted, but in Chile it is common. Many contracts in Chile were renegotiated after construction to include additional works. 12 out of the 16 highway projects awarded by 1998 had been renegotiated by May 2002 (Engel et al 2006). In this sense, parties justify their opportunistic behaviour by normalization.

Superordination

Superordination is to justify revenge. Sometimes even if the parties admit their actions involve an injury or hurt, but the moral indignation of themselves may be insistence that the injury is not wrong (Sykes and Matza, 1957). In this regards, the injury is a form of rightful punishment. For example the government took over the project after the private contractor Covanta invested millions of dollars, which leads Covanta to bankrupt in Tampa Bay seawater desalination project (Boardmans et al 2005). However, in government view of point, this is a form of punishment for the private contractor's constant delays in completion of the project. Another example shown in Taiwan ETC project (Chen 2007), the private sector transfers risks to customers and government, because the government treated the PPP as free lunch and tried to transfer all the risks to private contractors at first. In private contractor's opinion, this is a punishment to the public sector for their wrong attitude and wrong doings. In this regards, parties justify their opportunistic behaviour by superordination.

Table 1 summarises the instruments of antecedents and manifestations of opportunistic behaviour in PPP projects under the theoretical constructs discussed above.

Table 1: Instruments of Antecedents and Manifestation of Opportunistic Behaviour in PPP

Antecedents of Opportunistic Behavior						Manifestation of Opportunistic Behavior [MOB]
Externalization				Normalization	Superordination	
Environmental Uncertainty [EU]	Imperfect Control [IC]	Information Asymmetry [IA]	Asset Specificity [AS]	Lack of Commitment [LOC]	Self-interest Seeking [SS]	
[EU1] economic risks [EU2] construction risks, [EU3] operation risks, [EU4] political risks [EU5] legal risks [EU6] management risks	[IC1] questionable criteria for selecting bidders [IC2] parties' non-professional judgment [IC3] lack of transparency in bidding/renegotiation process [IC4] incomplete contract	[IA1] bidder's qualifications and details of the bidding documents [IA2] government's credibility and willingness to provide guarantees [IA3] customers' right to know the bidding and renegotiation process, the parties' decision making process, the project charges	[AS1] PPP project [AS2] government reputation [AS3] private investment [AS4] private willingness to get the job [AS5] customers payment [AS6]tax payment	[LOC1] make unrealistic promises and break the promise once wining the contract [LOC2] transfer risks, and refuse to assume even when the other party is overloaded [LOC3] deliberately work slowly and claim extra payment to overtime [LOC4] deliberately deliver pooter quality of work and claim extra payment for maintenance [LOC5] takeover PPP project against the willingness of private partner [LOC6] deliberately and unilaterally changed the rules via the use of formal and informal powers [LOC7] unilaterally transfer the risks to customers or taxpayers	[SS1] private gain benefits at the expense of public [SS2] public gain benefits at the expense of private [SS3] public/private gain benefits at the expense of customers/taxpayers	[MOB1] underbidding [MOB2] free riding [MOB3] sitting on the job [MOB4] poor quality of performance [MOB5] hostile takeover [MOB6] power misuse [MOB7] social surplus capture

The conceptual model is developed in Figure 1 to illustrate of the social forces that shape and sustain of opportunistic behaviour in PPP projects, as well as the patterns of interaction that underpin them.

Figure 1: Conceptual Model of Antecedents and Manifestations of Opportunistic Behaviour in PPP

METHOD

To demonstrate the conceptual model, the papers relevant to PPP published in the following leading construction management journals were used: International Journal of Project Management (IJPM), Journal of Construction Engineering and Management (JCEM), Construction Management and Economics (CME), as well as ARCOM conference papers, NBER working papers and books. Additionally, the author employed the following phrases in subjects, titles, keywords, or abstracts in paper searching: ["Public–Private Partnership" OR "Private Finance Initiative" OR "Build–Operate–Transfer"] AND ["Failure" OR "Conflict" OR "Dispute" OR "Renegotiation"]. The author scaled down the search by focusing on the papers published from 2001 to 2013. Finally the following 20 PPP cases from 15 countries are selected in Table 2.

Table 2: Meta-analysis of 20 PPP Cases

No.	Author	Case	Stage	Antecedents						Manifestation Opportunistic Behavior [MOB]
				Externalization				Normalization	Superordination	
				EU	IC	IA	AS	LOC	SS	
1	Boardman et al 2005	Dulles Greenway	Operate	[EU3]			[AS3] [AS4]	[LOC7]	[SS3]	[MOB7]
2	Boardman et al 2005	Tampa Bay Seawater Desalination Project	Build 14-day acceptance test after construction	[EU2]	[IC4]	[IA1] [IA2]	[AS3] [AS4]	[LOC3] [LOC4] [LOC5]	[SS1] [SS2]	[MOB3] [MOB5]
3	Boardman et al 2005	The Alberta Special Water Management System	Operate				[AS3] [AS4]	[LOC7]	[SS3]	[MOB7]
4	Boardman et al 2005	The Highway 407 Express Toll Route	Bidding	[EU2] [EU3]	[IC4]	[IA1] [IA2]	[AS3] [AS4]	[LOC2]	[SS2]	[MOB2]
5	Engel et al 2006	Chile Highway Projects	Renegotiation after bidding	[EU4]	[IC3] [IC4]	[IA3]	[AS3]	[LOC7]	[SS3]	[MOB7]
6	Spiller 2008	Venezuelan Oil Project	Operate	[EU3] [EU4]			[AS3] [AS4]	[LOC5] [LOC6]	[SS2]	[MOB6] [MOB5]
7	Kumaraswamy and Zhang 2001	The Ngone Bridge Project, LAO PDR	Operate	[EU3]			[AS3]	[LOC7]	[SS3]	[MOB7]
8	Chang 2013	Channel Tunnel Rail Link Project	Bidding			[IA1]	[AS1] [AS2]	[LOC1]	[SS1]	[MOB1]
9	Chen 2007	Taiwan Electronic Toll Collection (ETC) Program	Pre-tendering	[EU3] [EU5]	[IC3]	[IA2]	[AS3] [AS4]	[LOC2]	[SS2]	[MOB2]
10	Spiller 2008	Water and Sanitation Project in Tucuman	Operate	[EU3] [EU4]			[AS3] [AS4]	[LOC10]	[SS2]	[MOB6]
11	Abdul-Aziz 2001	Malaysia's Sewerage System	Build Operate	[EU6]	[IC1] [IC3]	[IA1] [IA3] [IA3]	[AS1] [AS3] [AS5]	[LOC3] [LOC7]	[SS1] [SS3]	[MOB4] [MOB7]
12	Vazquez and Allen 2004	Highway infrastructure in Central America and Mexico	Bidding Build Operate	[EU1] [EU3]	[IC2] [IC4]	[IA1]	[AS1] [AS2]	[LOC1] [LOC2] [LOC3]	[SIS1] [SS3]	[MOB1] [MOB4] [MOB7]
13	Guasch 2004	Mexican Highway	Bidding	[EU1]	[IC1] [IC3] [IC2] [IC4]	[IA1]	[AS1] [AS2]	[LOC1]	[SS1]	[MOB1]
14	Guasch 2004	Mexican National Railways	Bidding			[IA1]	[AS1] [AS2]	[LOC1]	[SS1]	[MOB1]
15	Guasch 2004	Airport Project in Lima	Bidding		[IC2]	[IA1]	[AS1] [AS2]	[LOC1]	[SS1]	[MOB1]
16	Guasch 2004	Buenos Aires Water and Sanitation Project	Bidding Build	[EU1] [EU2] [EU3]	[IC3] [IC4]	[IA2] [IA1]	[AS3] [AS4] [AS1]	[LOC2] [LOC3]	[SS1] [SS2]	[MOB2] [MOB4]
17	Guasch 2004	Colombia Airport Concession		[EU3] [EU1]	[IC4]		[AS3]	[LOC7]	[SS3]	[MOB7]
18	Guasch 2004	Samana Highway Project in the Dominican Republic	operate	[EU1] [EU3]	[IC4]		[AS3]	[LOC7]	[SS3]	[MOB7]
19	Guasch 2004	Port Concession in Peru	Pre-Bidding		[IC4]		[AS3] [AS4]	[LOC19]	[SS2]	[MOB6]
20	Guasch 2004	Water and Sanitation Concession in Bolivia	Operation	[EU3] [EU4]	[IC2]	[IA1]	[AS1]	[LOC7]	[SS3]	[MOB7]

DATA ANALYSIS AND DISCUSSION

Risk Occurrences and Opportunistic Behaviour

Previous PPP researches either focus on the mechanics by which parties should be allocated each risk or the nature of the risks each should take (Li et al. 2005, Xiao and Zhang 2011). They ignored the underlying forces which drive project stakeholders' behaviour when negotiating risks in PPP projects. This has left us with little understanding of the reasons 'why' risk allocation is often less than optimal in PPP projects. This study fills this gap by investigating the relationship between risk occurrences and opportunistic behaviour in each stage of PPP projects (see Figure 2). At the stage of 'Pre-tendering', the government has dominant power in the partnership, thus the opportunistic behaviours are driven by the public party. With the involvement of the private partners in 'Bidding' stage, the power changes in the partnership and sometime the opportunistic behaviour is driven by the private party, i.e.

'underbidding'. It is found that with more opportunistic behaviours conducted in 'Build' period, the number of risk occurrences reaches peak. After the completion of construction, the power of the partnership changes again, and the private weakens, thus the risks begin to transfer to the private.

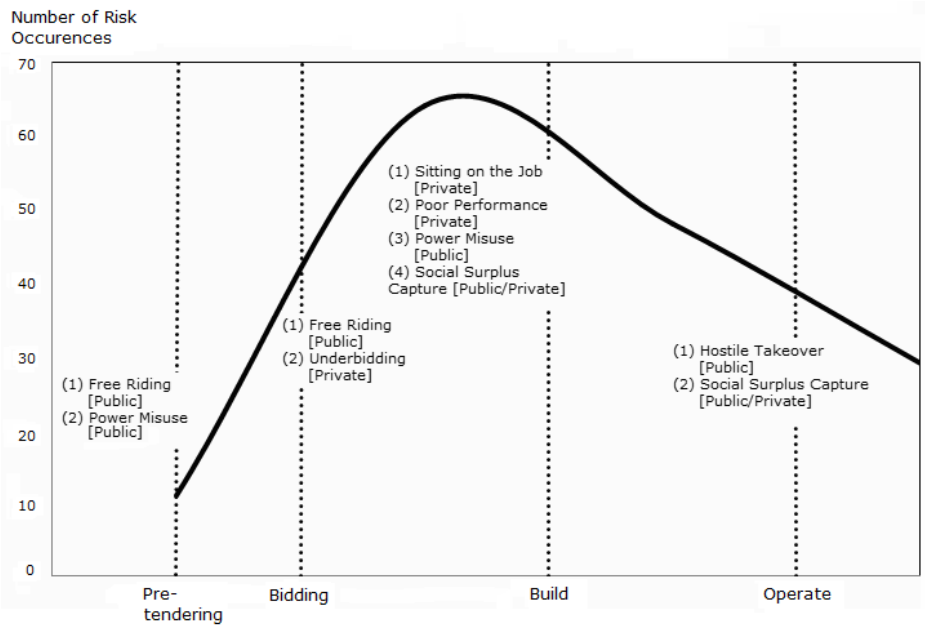

Figure 2: The Number of Risks Occurrences and Opportunistic behaviour in each Stage

Motives and Justifications of Opportunistic Behaviour

From the manifestation of opportunistic behaviour and transaction cost economics theory and agency theory, it is identified that environmental uncertainty, imperfect control, asset specificity, information asymmetry, lack of commitment and self-interest seeking are six determinants which lead to opportunistic behaviours. But nobody will act opportunistically if their wrongdoings definitely break the contract or the law, since they will pay the price for that. So the problem is how people doing the wrongfulness can survive themselves as well. How can they justify their opportunistic behaviours? In this paper, the author combined these two perspectives to better understand the antecedents of opportunistic behaviour in PPP projects.

The mean value for the six determinants of the opportunistic behaviour from 20 PPP cases was calculated: environmental uncertainty (4.17), imperfect control (5), information asymmetry (5.67), asset specificity (6.17), lack of commitment (3.86), self-interest seeking (8). It is found from Figure 3 that self-interest seeking and asset specificity are the most important factors in motivating parties' opportunistic behaviours. It is consistent with the transaction cost economics theory that self-interest seeking is the fundamental assumption of opportunistic behaviour. Asset specificity is a key factor in power changes and risk allocation in partnerships. The bigger the size of asset specificity, the more vulnerable the party in the partnership, and thus have to bear more risks.The mean value for the three dimensions of justifications for oopportunistic behaviour were: externalization (5.25), normalization (3.857), superordination (8). It is found in Figure 4 that superordination and externalization are the two important forces in justifying opportunistic behaviours. Revenge is the main source for opportunistic behaviour in PPP projects, and people usually justify their opportunistic behaviour by externalization.

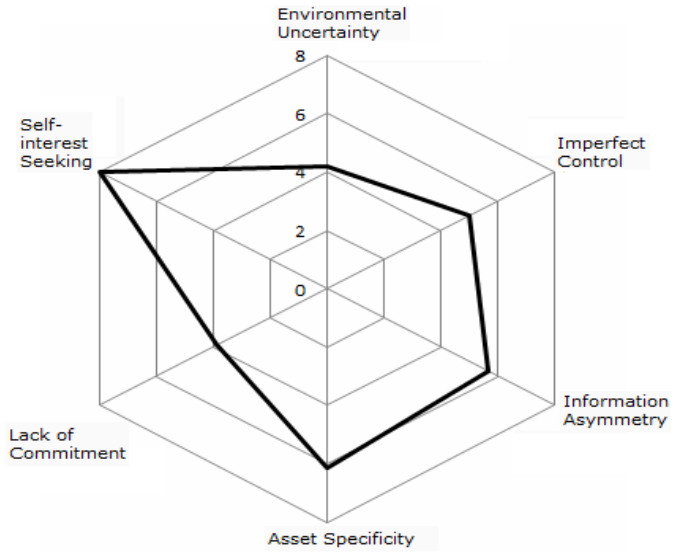

Figure 3: Six Elements of Antecedents of Opportunistic Behaviour in PPP

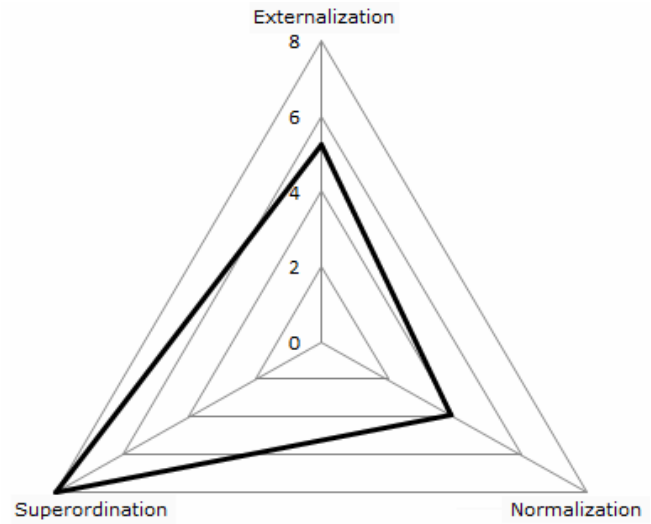

Figure 4: Externalization, Normalization and Superordination in Opportunistic Behaviour in PPP

CONCLUSIONS

Previous researches in PPP have been conducted either on the nature of risks or the mechanics of risk that each party should take. Nobody mentioned the underlying forces which drive project stakeholders' behaviour when transferring risks. This paper fills this gap by investigating the opportunistic behaviour in PPP projects. The author first identified 7 types of opportunistic behaviour in PPP projects. After reviewing of transaction cost economics, agency theory and delinquency theory, a conceptual model of antecedents of opportunistic behaviour in PPP is developed, with combination of both motivations and justifications of opportunistic behaviours in PPP. Six determinants of motivations in opportunistic behaviour in PPP are identified as environmental uncertainty, imperfect control, asset specificity, information asymmetry, lack of commitment and self-interest seeking. Three justification techniques for opportunistic behaviour in PPP are defined as externalization, normalization and superordination. A meta-analysis of 20 PPP case is conducted. It is found that self-interest seeking and asset specificity are the most important

factors in motivating parties' to act opportunistically. It is consistent with the transaction cost economics theory that self-interest seeking is the fundamental assumption of opportunistic behaviour. Asset specificity is a key factor in power changes and risk allocation in partnerships. The bigger the size of asset specificity, the more vulnerable the party in the partnership, and thus have to bear more risks. Superordination and externalization are the two significant forces in justifying opportunistic behaviours in PPP. Revenge is the main source for opportunistic behaviour in PPP projects, and people usually justify their opportunistic behaviour by externalization. In addition, it is more interesting to find that risk occurrences do have a relationship with the opportunistic behaviours. With the more opportunistic behaviours conducted, the number of risk occurrences can reach to peak.

REFERENCES

Abdul-Aziz, A. (2001). Unrevealing of BOT Scheme: Malaysia's Indah Water Konsortium, Journal of Construction Engineering and Management, 457-460.

ACA (2012). Scope for Improvement 2012, Australian Constructors Association.

Akerlof, G. (1970). The market for lemons: quality uncertainty and the market mechanism. Quarterly Journal of Economics 84 (3), 488–500.

Albanese, R., van Fleet, D. D. (1985). Rational Behaviour in Groups: The Free Riding Tendency, Academy of Management Review, Vol, 10, No. 2, 244-255

Arthurs, J. D., Busenitz, L. W. (2003). The Boundaries and Limitations of Agency Theory and Stewardship Theory in the Venture Capitalist/Entrepreneur Relationship, Entrepreneurship Theory and Practice, pp. 145-162.

Bahli, B. and Rivard, S. (2003). The information technology outsourcing risk: a transaction cost and agency theory-based perspective, Journal of Information Technology, 18, 211–221.

Boardman, A. F., Poschmann, F. and Vining, A. R. (2005). North American infrastructure P3s: examples and lessons learned, in Graeme Hodge and Carsten Greve (Eds.) The Challenge of Public-Private Partnerships: Learning from International Experience, Edward Elgar: Cheltenham, UK., pp. 162-189.

Burnes, B. (2000) Managing change, Harlow: Pearson.

Chang, C. Y. (2013). Understanding the hold-up problem I the management of megaprojects: The Case of the Channel Tunnel Rail Link project, International Journal of Project Management, 31: 628-637.

Chen, C. (2007) Institutional barriers to private participation in infrastructure: the case of electronic toll collection in Taiwan. In Boyd, D (Ed) Procs 23rd Annual ARCOM Conference, 3-5 September 2007, Belfast, UK, Association of Researchers in Construction Management, 673-682.

Collin, S. and Hansson, L. (2000). The propensity, persistence and performance of public-private partnership in Sweden' in Stephen P. Osborne (ed.) Public-Private Partnership: Theory and Practice in International Perspective, London: Routledge, pp.201-218.

Davis, K. B. (1988). Epilogue: The Role of the Hostile Takeover and the Role of the States, Wis. L. Rev. 491-525.

de Brux, J. (2010). The Dark and Bright Sides of Renegotiation: An Application to Transport Concession Contracts, Utilities Policy 18: 77–85.

Engel, E., Fischer, R., Galetovic, A. (2006). Renegotiation without holdup: anticipating spending and infrastructure concessions. NBER Working Paper, No. 12399.

Fligstein, N., Freeland, R. (1995). Theoretical and Comparative Perspectives on Corporate Organization, Annu. Rev. Sociol. 21:21-43.

Guasch, J. L., (2004). Granting and Renegotiating Infrastructure Concessions: Doing it Right. The World Bank, Washington DC.

Jin, X. H., Zhang, G. (2011). Modeling optimal risk allocation in PPP projects using artificial neural networks, International Journal of Project Management 29, 591–603.

Kapmeier, F. (2008). Common Learning and Opportunistic Behaviour in Learning Alliances, Systems Research and Behavioural Science, 25, 549-573.

Korczynski, M. (1994), Low Trust and Opportunism In Action, Journal of Industry Studies, 1:2, 43-64.

Li, B., Akintoye. A.Edwards, P.J. Hardcastle C. (2005), "The allocation of Risk in PPP/PFI Construction Projects in the UK", International Journal of Project Management 23 (1), pages: 25-35

Singh,L.B., Kalidindi, S.N., (2006), "Traffic revenue risk management through Annuity Model of PPP road projects in India", International Journal of Project Management Vol 24, pages: 605–613.

Spiller, P., 2008. An institutional theory of public contracts: Regulatory implications, NBER Working Paper 14152.

Vazquez, F., Allen, S. (2004). Private sector participation in the delivery of highway infrastructure in Central America and Mexico, Construction Management and Economics, 22, 745-754.

Williamson, O. E., (1985). The economic institutions of capitalism, The Free Press, New York.

Xiao, H.J., Zhang, G. (2011) "Modelling optimal risk allocation in PPP projects using artificial neural networks", International Journal of Project Management Vol 29, pages: 591–603.

Sykes, G. M., Matza, D. (1957). On neutralizing delinquent self-images. American Sociological Review, 22, 667-670.

A PHENOMENOLOGICAL STUDY OF PRIVATE HOMEBUILDERS' PERCEPTIONS ON THE EMPLOYMENT OF PROFESSIONAL SERVICES

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Owner-built housing projects are the most common construction projects undertaken in Ghana. A notable feature of the projects is the limited engagement of professional services of construction professionals. Previous studies indicate a negative attitude of clients toward consultancy services on such projects, with the consequent impact on project performance. Even on the same project, clients and consultants view issues in different ways. Thus to get a fuller understanding of clients' attitudes, they have to be observed through their own eyes. This paper explores the phenomenon of low utilisation of otherwise extensively available highly trained professionals, from the client's viewpoint. Previous studies have identified certain negative preconceptions of clients, among a broad range of causes, for their unwillingness to engage professionals on private housing projects, but do not explore the bases for the perceptions of clients. This study develops an in-depth description of homebuilder clients' perceptions on the employment of professional services, and what feeds those perceptions. The study adopts a phenomenological approach, using in-depth interviews and constructivist abstraction to define clients' perceptions on professional services in homebuilding. The portraits of four clients' experiences are synthesised into a composite description of their perceptions and consequent effects on their relationship with consultants. The results revealed clients to perceive consultants' services as inaccessible, inconvenient, expensive and as a second resort. The factors that have led to these perceptions include client prejudice, social conditions, construction industry conditions, consultants' actions and clients' experience of living in the houses they build. Clients' perceptions lead them to mostly engage non-professionals. The findings should enable consultants to have a better understanding of homebuilder clients.

Keywords: client, Ghana, perceptions, relationships.

INTRODUCTION

Many clients are known to consistently deny consultants a free hand to operate (Alinaitwe 2008). They lack basic understanding of professional practices (Boyd and Chinyio 2006), are inconsistent in their payments, and have the habit of executing projects in bits over a very long period of time (Alinaitwe 2008). The awareness of these problems and the need for dealing with it has been highlighted by some past studies (Alinaitwe 2008; Siva and London 2012). However, many of the studies have focused on contractors' and consultants' viewpoints (ref). and on large commercial developers and corporate bodies (Vennström 2008; Nuamani and Tsegay 2011).

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Frimpong S and Dansoh A (2013) A phenomenological study of private homebuilders' perceptions on the employment of professional services *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 425-433

Nevertheless, many key questions still remain unanswered or partially investigated. For instance how do private homebuilding clients perceive the relevance of professional services? What factors have influenced clients' perceptions? How have professionals contributed to client perceptions? The fundamental proposition of this research is that clients' attitudes toward the engagement of consultants on homebuilding projects are largely due to their perceptions on the need for construction consultancy services.

METHODOLOGY

The purpose of this study was to develop a composite description of homebuilders' perceptions on the relevance of the services of construction consultants. Such studies are consistent with strategies of inquiry such as case study, ethnography, phenomenological studies, and grounded theory. The phenomenological research method was adopted as it generally deals with people's perceptions, attitudes, beliefs, feelings, and emotions associated with everyday life, thereby offering the prospect of authentic accounts of complex phenomena from the perspective of those actually involved (Denscombe, 2010, p 93). Non-probability (purposive) sampling was chosen because of its potential to yield the most relevant information (Hansemark and Albinsson 2004) for a phenomenological study like this. Each of the client units were expected to have unique characteristics and that themes and categories would emerge from comparing the different experiences. There were thus two units of analysis. The first one comprised clients who were in a position to build a house but had not yet done so and had never engaged the services of a consultant. The second unit comprised clients who had engaged the services of consultants on a house project. A total of 4 participants (see Table 1) were chosen for the study as Giorgi (2008a) recommends a minimum of three cases for such studies. In order to achieve "geographic diversity" (Nitta et al., 2010), respondents were drawn from two regions in Ghana with the highest number of private home building projects (Greater Accra and Ashanti Region).

Table 1: Summary of client characteristics

CLIENT	REGION	OCCUPATION	AGE (YRS)
UNIT ONE			
Ann	Ashanti	Banker	30 - 40
Kay	Greater Accra	Cement Retailer	20 - 30
UNIT TWO			
Joe and April	Greater Accra	Computer Engineer	30 – 40
Kate	Ashanti	Clothes Seller	20 -30

Note: Names are all pseudonyms to protect anonymity.

Sixty to ninety minute recorded interviews were conducted with clients. Interview questions were open-ended to afford respondents the opportunity to express themselves freely with minimal influence from the interviewer. Specific guiding questions were also used to seek answers to pertinent questions that were not addressed during open-ended discussions (Yin 1994). The analysis of data adopted in

this research involved a "repeated reading" of transcripts and field notes (Morrissey and Higgs, 2006). Following the procedures recommended by Giorgi (1985; cited in Morrissey and Higgs, 2006), and Creswell (2006) key statements and words providing insight into clients perceptions were highlighted. These were then grouped into clusters and common themes were identified. A "textural and structural description" of clients' experiences and the factors influencing their perceptions were respectively produced based on the emergent themes. The final step involved producing a "composite description" of client perceptions based on the structural and textural descriptions.

RESULTS AND DISCUSSIONS

Themes of client perceptions

Five themes emerged (see Table 2): 1) competence and capabilities, 2) cost of engagement, 3) roles and responsibilities, 4) relationships, and 5) rules of engagement.

Table2: Themes of client perceptions

THEME	SUB-THEMES
Competence and capabilities	Performance, age, availability/accessibility, improvement, service/business quality
Cost of engagement	Fees, convenience, differentiation, standardisation
Roles and responsibilities	Need, expectation, scope, differentiation
Relationships	Learning, essence, communication, treatment, autonomy, age
Rules of engagement	Need, benefits, enforceability, appeal, effects

Competence and capabilities

Homebuilders perceive consultants' competence and capabilities differently. Generally, consultants are perceived to possess the competence and capabilities outlined by the past studies (Boyd, 2011; Kurrer, 2008). However, homebuilders feel that local consultants are inaccessible, making their presence not being felt. They feel that consultants are responsible for their own inaccessibility and therefore think finding a consultant is a difficult task. As a consequence, homebuilders rate Ghanaian consultants' competence and capabilites to be just above average.

"…Well for now, I will give them 6 out of 10…It is a fifty-fifty situation." (Joe and April)

"…And sometimes we have the perception that we cannot always approach them…" (Ann)

Clients also perceive consultants to be poor businessmen. They feel that consultants are only interested in the technicalities of construction and not the business aspects of their engagement.

"...Consultants should be able to separate the business side of their work from the technicalities. They should be two different things..." (Joe and April)

Cost of engagement
Clients perceive fees paid to engage consultants to be too high. Interestingly, such perceptions were shared by all the clients interviewed. Past studies on consultancy fees (Drew et al., 2002a) intimate that many clients put undue emphasis on fees paid to consultants during their selection process. The data analysis revealed this finding to be the same in the case of clients interviewed.

"…They should have sympathy on us… You charge us fat cash." (Kate)

Clients feel that the best time for them to engage consultants is when they have money. This was revealed in the statements made by Joe and April:

"You look at your budget and because you don't have money you are forced to go to the other side. But when the finances are good, you can get a professional..."

Drew et al., (2004) found that most clients in their selection of consultants look to obtain the highest quality of service at the lowest price possible. However, when it comes to professional services, there is a positive correlation between cost and quality (Drew et al., 2002a). Thus, in many cases, clients are torn between making a choice in favour for cost or quality. The fact that homebuilders find this situation to be inconvenient is revealed in Ann's statements:

"…the other people will charge cheaper and the surplus will be used for something else."

Roles and responsibilities
The roles and responsibilities of consultants in themselves are perceived by clients as key to the construction process. However consultants per se are not perceived as indispensable. This perception was recurrent in the statements made by all the respondents.

"Really necessary? Well, I was just thinking. I think it was necessary, but really necessary, no…" (Kate)

Clients perceive consultants to want to do all their work upfront. This perception cut across both groups of clients.

"The thing is, what will stop you from going to the consultant is that we don't know that we can tell them that we want to do the house from this part and then move on that part…We think that the consultants would want to complete the work all at once,..We want to do the work bit by bit. We don't think you will be ready to do that." (Kate)

Relationships
All clients shared the perception that engaging a consultant was an avenue for "client learning" (Siva and London, 2012). In contrast to the findings of some previous studies on professional practice (Cuff, 1991), when it comes to the issue of 'learning opportunities, clients do not perceive consultants as people who "just do" things. To clients, the best people to learn from are construction professionals.

"The architects however take their time to work for you… They don't just build…They also teach you a lot of things. Anything they do, they will talk to you about it." (Kay)

Generally, clients perceive a relationship with a consultant as the "best for their building". To many clients, engaging a consultant on a project is a sign of prestige.

"At least, it adds some prestige to the project but that won't be the main influence." (Ann)

Previous studies on client-consultant relationships revealed clients to have negative perceptions on how consultants treat their clients (RIBA, 1992, 1993, and 1995). The results confirmed this.

"…we deserve a lot of respect from them." (Kate)

Clients perceive that it would be difficult for them to maintain their autonomy when working with an older consultant. Clients' statements indicated that they would feel comfortable working with relatively younger consultants.

"I personally will like to deal with a younger person... If you insist, they (older consultants) see you to be disrespectful whereby in the real sense you were just insisting on your preference." (Ann)

Rules of engagement
All clients, irrespective of their background, have the perception that although there are statutory regulations, they are not being enforced and as such it is "not compulsory" to seek professional help when building houses. Some clients perceive the non-enforceable nature of statutory regulations as the cause of poor quality construction works. Clients hold the perception that adopting formal rules of engagement would necessarily mean that consultants will demand higher fees and vice versa. This perhaps could explain the reason why some of them are apprehensive toward adopting formal rules of engagement on their projects.

"But I think signing a contract is good because it comes with seeing to it that the work gets done well. I am sure I will be charged extra for that." (Kate)

Factors influencing clients' perceptions

Five factors that influence clients' perceptions were identified. In addition to revealing the factors the findings also confirm the fact that clients' perceptions are not totally under the direct influence of consultants (Mahon and Watrick, 2003). This study has not only confirmed the findings of past studies but has also revealed specific characteristics about clients that account for the subjectiveness of their self-generated perceptions. Majority of the clients indicated that they have very little knowledge and understanding of the technicalities involved in construction.

Client prejudice
Some perceptions that clients hold of consultants are self-generated. For instance, asked about how they get to know that it is expensive to seek professional services, Kate replied:

"Uhm, I just guessed...Consultants go to school; they acquire degrees, so obviously their services are going to be expensive. I needn't ask anybody"

Formal and education curriculum at the basic level interestingly falls short when it comes to the issue of shelter. For this reason, many people, apart from those with specialized training in construction, demonstrate a lack of knowledge of the proper processes required to provide shelter for themselves. This was confirmed by analysis. Among clients who had been to school, apart from those who had taken practical steps to know more about construction, the closest the rest had come to design and construction was pre-technical skills and drawing they studied in Junior High School.

Social factors
Social factors account for the perceptions that clients hold of the construction industry and its workforce. Some past studies confirm this finding. According to Vaid (1999; cited in ILO, 2001), many people including construction workers do not want their children to work in the construction industry; "they wish for better things for their children". Thus, to many people, the construction industry is not presented in an appealing way.

"…And at the basic level, the construction industry is not presented in a palatable way." (Ann)

Clients' perceptions are also borrowed from those they have social ties with. This was evident in the stories of all clients interviewed.

"I had a friend who wanted to build and that is how he went about the whole thing. He is the one who told me that it is expensive to engage a consultant." (Ann)

Construction industry conditions
The global construction industry is characterized by the collapse of buildings, poorly constructed building, widespread corruption, political interference, and unqualified workforce undertaking shoddy works (ILO 2001). Nevertheless, the construction industry also has to some extent a positive image. Internationally and locally, all of these conditions affect clients' perceptions of the industry. The results of the analysis confirm this fact. It is evident that where the industry conditions are good, clients tend to have a positive perception and vice versa.

"Something that affected me very much was the collapse of the Melcom building…I realized that it was a very critical thing. You can't just entrust your life into anyone's hands." (Ann)

In both developed and developing countries a greater percentage of the labour force in construction is made up of those with little or no education (ILO 2001). These are the people that the relatively few highly skilled and educated consultants compete with.

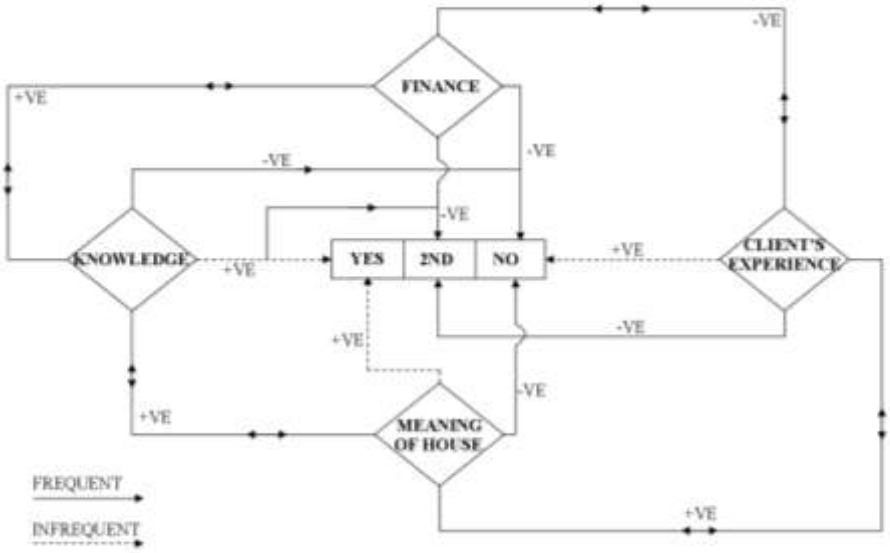
"The fact that consultants are good does not mean that the others are not good...Others also use laypeople and their houses are nice. It is a matter of finding the right laypeople to do the work." (Ann)

The consultant
The actions of the consultant during the project relationship also account for the perceptions of clients. They can either reinforce clients' existing perceptions or change them. By working in a systematic manner to help clients understand the nature of professional work (RIBA 1992; Crafford 1997) consultants can change clients' negative perceptions. The findings in this study confirm this fact.

"Yes. We didn't have money to finish all the work in a year or six months. But now I know that it's possible to get the consultant to do the work in stages even if I want to do it small. The consultant told me that." (Kate)

The house
"Looking at our house and the kind of problems we are having right now, if we used consultants, we would have gotten everything right…" (Kate)

Clients interviewed had developed perceptions through their contact with the house. Past studies on client learning found that through living in the house which was a product of a consultant's work or not, clients acquired a better appreciation of the



work done by consultants (Siva and London, 2012). This indicates that another avenue where consultants can influence the perceptions of their clients is the house.

Effects of perceptions on clients' attitude toward engagement of consultants

The Perception Effect Model (see Figure 2) explains the existence of the phenomenon of low-utilization of consultants on house projects.

The Yes

The perceptions of some clients on the need to engage the services of consultants on house projects has resulted in their being more determined to engage consultants on their projects. This effect is the "Yes" on the Perception Effect Model.

Figure 2: The perception effect model

"They are not being imposed on us. This boils down to the individual's opinion and what they want. In my own perspective, I think engaging consultants will be the best for me." (Kay)

From the model, there are two direct routes to the "Yes". First, clients had adequate knowledge of construction issues that made them generate positive perceptions about consultants. Second, some clients had either come into contact with a house that had caused them to generate positive perceptions of consultants or the house they wanted to have a house meant a lot to them (the dream house) that it had led them to develop positive perceptions of the need for consultants. The model also reveals an indirect route to the "Yes". A positive financial standing alone was not enough to lead a client to the "Yes". It had to be combined with a positive perception of consultants that had been fuelled by the client's adequate knowledge on construction issues.

The No

The perceptions of some clients on the need to engage the services of consultants on house projects had led them to see the engagement of a consultant on their house project as unnecessary. This is the "No" on the Perception Effect Model.

"…Unfortunately at that time, we did not have an overbloated budget to spend the building. Whatever we would have paid the consultant could have comfortably been used to do other things…" (Joe and April)

There are three direct routes to the "No". First, clients perceived consultants not to be "the only good people to" help them on house projects. This gives the indication that if a client has a positive experience dealing with non-professionals, they would make an outright decision not to engage consultants. Second, the house that these clients wanted to build did not mean anything to them. They felt that it was "just a house" and so this engaging a consultant on such a project was a "waste of time and money". Third, the clients perceived engaging a consultant to be expensive and so since their financial standing was negative, they could not see themselves engaging a consultant. There is one indirect route to the "No". When clients' financial standing was positive, it had to be combined with a perception of consultants that had been fuelled by the client's knowledge on issues pertaining to construction. In this instance, clients who did not have adequate knowledge of issues pertaining to construction and consultancy services, even though they were "rich" headed for the "No". This might explain why among clients who do not engage consultants on their project are people who are in a position to afford the cost of engaging consultants. The clients who fell into this category were influenced by at least one of these factors.

The second resort

Some clients see the engagement of a consultant on their house project as second resort if they undergo a change in circumstance or their initial decision not to engage consultants becomes unsuccessful.

"Yes, we were very angry...We know that now so maybe if we are building a new house we will fully engage a consultant right from the start… Never again will I use the local people." (Kate)

There are two direct routes to the "2nd". First, all clients had been through negative experiences working with non-professionals. Second, the clients perceived engaging a consultant to be expensive and so since their financial standing was negative, they could not see themselves engaging a consultant. However, two indirect routes were also identified. The first indirect route to the "2nd" indicated that when the clients' financial standing changed from negative to positive, clients who had developed positive perceptions due to their adequate knowledge of issues pertaining to construction and consultancy services headed for the "2nd". Alternatively, clients whose financial standing remained negative chose consultants as a second resort when their perceptions were positively affected by the knowledge they had acquired. This might explain why among clients who engage consultants on their projects are people who are not in a position to afford the cost of engaging consultants.

CONCLUSIONS

The research involved determining the extent to which clients' clients' perceptions affected their attitude toward engaging consultants on house projects. Four in-depth phenomenological interviews were conducted with homebuilding clients. The data collected from the interviews was analyzed by using the phenomenological research approach. This study has built on existing research to refine the understanding of the consultant-client relationship on house projects by exploring in much detail client perceptions and how it impacts on client-consultant relationships on house projects. The five key themes of clients' perceptions that were derived are Competence and Capabilities, Cost of Engagement, Roles and Responsibilities, Relationships, and Rules of Engagement. This study has also revealed five factors that influence clients' perceptions; client prejudice, social factors, construction industry conditions, the consultant, and the house. The study identified the actions of the consultant as well as

the house that has been built as a product of the consultants work as the two main means through which consultants can help clients to develop positive perceptions about the need for engaging professionals on house projects. This study focused only on the client-consultant engagement on single a single house project as well as on the homebuilding (owner-occupier) client. The models developed from this study can be applied to the investigation of the client-consultant engagement on other project types as they are also common and offer a variety of circumstances and challenges to client-consultant relationships.

REFERENCES

Alinaitwe, H. M. (2008), "An assessment of clients' performance in having an efficient building process in Uganda", Journal of Civil Engineering and Management, 14(2): 73-78

Boyd, D. and Chinyio, E. (2006), "Understanding the Construction Client", Blackwell, Oxford.

Boyd, D and Kerr, E (1998), "An analysis of developer-clients' perception of consultants", in: Hughes, W (Ed.), 14th Annual ARCOM Conference, 9-11 September 1998, University of Reading, Association of Researchers in Construction Management, Vol. 1, 88-97.

Chen, J. (2008), "The development of a habitus shock model for architect-client relationships on house projects", Master's dissertation, School of Architecture and the Built Environment, University of Newcastle, Newcastle

Creswell, J. W. (2006),"Qualitative inquiry and research design". London: Sage Publications.

Cuff, D. (1991), "Architecture: the story of practice", Cambridge: MIT Press Cambridge, MA.

Denscombe, M. (2010), "The good research guide for small-scale social research", Open University Press, McGraw-Hill Education, 4e, pp. 93-105

Giorgi, A. (2008a). "Concerning a serious misunderstanding of the essence of the phenomenological method in psychology", Journal of Phenomenological Psychology, 39, 33-58.

International Labour Organization (2001), "The construction industry in the twenty-first century: Its image, employment prospects and skill requirements", tripartite meeting on the construction industry in the twenty-first century: its image, employment prospects and skill requirements, Geneva

Mahon, J.F. and Wartick, S.L. (2003), 'Dealing with Stakeholders: How Reputation, Credibility and Framing Influence the Game', Corporate Reputation Review, Vol.6 (1); p.19.

Morrissey, G. and Higgs, J. (2006), "Phenomenological research and adolescent female sexuality: discoveries and applications". The Qualitative Report Vol. 11, No. 1, pp. 161-181

Nitta, K., Holley, M., and Wrobel, S. (2010), "A phenomenological study of rural school consolidation", Journal of Research in Rural Education, 25(2), 1-19

Royal Institute of British Architects (RIBA) (1993),"Strategic Study of the Profession: Phase 2: Clients and Architects", London: RIBA Publications

Siva, J. and London, K. (2012), "Client learning for successful architect-client relationships", Engineering, Construction and Architectural Management, 19(3): 253-268.

Yin, R. (1994), "Case Study Research – Design and Methods", Applied Social Research Method Series 5, 2nd ed., Newbury Park, CA: Sage

HOW TO BUILD WHAT BUYERS WANT – UNVEILING CUSTOMER PREFERENCES FOR PREFABRICATED HOMES

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An increasing number of buyers demand houses that are configured according to their personal needs and wants. However, in order to be effectively responsive and to control variety, it is important to determine what buyers wish to customise and to what degree. The prioritisation of customised attributes in house design still remains an unknown by builders. This indicates the importance of developing an appropriate model to determine customer preferences that can be adapted to different house building methods. This research identifies buyer preferences in prefabricated house building projects through the application of a modified Analytical Hierarchy Process approach, using a paired comparison-based preference measurement. This method considers changing attribute positions in a survey, which compels respondents to continuously reconsider the importance of a feature. This paper contributes by applying a preference measurement method in order to prioritise and identify what buyers of prefabricated homes really focus on when configuring a house. This is important as only knowledge of the preferences will enable practitioners to be effective in customisation efforts and also ensuring operational efficiency.

Keywords: customer preference measurement, customization, design and build, marketing, prefabrication.

INTRODUCTION

Over recent years the house building industry has seen a radical change in market requirements. Modern lifestyle trends have introduced unprecedented competition that calls for a change in operations of the house building sector. As a consequence house builders have tried to increase customisation efforts so as to deliver exactly what clients require. But much more is needed than simply redesigning existing standard house types. There has to be a supporting revolution in the house building sector (Barlow, 1999). This involves the construction of houses from a mixture of standardised components and consequently requires the housing supply chain to be changed radically but will finally grant customers access to the design activity of their houses. Hence, there needs to be a rapid development of custom-made houses while still imposing the rule of economies of scale. This positions economies of scale in direct conflict with economies of scope (Kooii and Situmdrang, 2003).

Lessons learnt from other sectors (e.g. automotive, clothing) show how important it is to exactly know clients' preferences in order to deliver new product variety at a price that is acceptable to house buyers (Hofman et al, 2006 and Stäblein et al, 2011). There

Schoenwitz M, Gosling J, Naim M and Potter A (2013) How to build what buyers want – unveiling customer preferences for prefabricated homes *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 435-444.

is therefore a need to find out how potential customers assign priorities to the different elements in a house that can be customised. If house building companies knew customer's preferences in advance, they could increase variety where it is really necessary and offer standardised solutions where individualisation is not needed, taking advantage of economies of scale.

With this research we aim to present a preference measurement method in order to prioritise and identify what buyers of prefabricated homes really focus on when configuring a house. This will enable practitioners to be effective in customisation efforts and ensure operational efficiency accordingly. However, determining the appropriate level of choice is difficult and insight into the nature of choice is sparse within the literature. Collecting and analysing empirical data in this area is also a complex undertaking, meaning the evidence base is thinner than would be expected. Hence, we empirically investigate the question: How do we determine buyers' preferences for mass customised homes? In doing so, we focus on Germany, the leading country for self-build housing in Europe.

THE IMPORTANCE OF CUSTOMER PREFERENCE

To successfully compete in the long term, a company has to make sure that customers are satisfied. One way of achieving customer satisfaction in the house building industry is to build houses that reflect the personal preferences of the buyer. Ozaki (2003) presents two empirical studies in the UK speculative house building industry. Her conclusion starts with the sentence: "Overall, UK housing customers do not seem to be very satisfied customers." (p. 562). She continues and states that the industry lacks customer-focus and that customer requirements are not sufficiently considered.

Japanese companies have successfully implemented manufacturing principles derived from the car industry in order to produce attractive, affordable and, above all, customized houses through prefabrication (Towill, 2001). In this regard, clever product architecture is vital and can give the impression of a fully customized house although in reality it involves standard operating procedures in production (Halman et al., 2008). More specifically, as Gibb (2001) writes, the whole product design, although consisting of standardized components, must provide variation: i.e. 'customized solutions from standardized components' (p. 312).

Leishman and Warren (2006) present research on housing design customisation. They highlight the importance of capturing user requirements and suggest that wider choice of internal specification is associated with greater consumer demand. However, the house is a complex product and consists of a large sub-system with many different components and subcomponents. These are then partially available in many different attributes which increases the options that can potentially be offered to a customer. Thus companies wanting to provide houses that are built according to customers' needs must develop strategies on how to identify customer preferences and consequently configure the supply chain in a way that can cope with the degree of choice that needs to be provided (Barlow et al, 2003). In this regard it is also important to know how customers prioritise their preferences. Only then will it be possible to identify elements with the need and degree of variety.

RESEARCH METHOD

Selecting the appropriate preference measurement method

Customer preference measurement in general is problematic as many customers are not able to exactly specify the importance of product attributes. Moreover the perception of an attribute independently from others may be completely different compared to the perception of the same attribute in combination with others. Eggers and Sattler (2011) categorise preference measurement techniques as:

1. Compositional approaches. Evaluation of product attributes and levels separately. The perceived utility of the entire product is then composed of the importance allocated to its specific attributes and levels.
2. Decompositional approaches. Evaluation of products by considering the attributes and levels jointly. Preferences can then be decomposed using statistical methods.
3. Hybrid approaches. Combination of compositional and decompositional approaches.

Although there is no clear recommendation in the literature, Conjoint Analysis (CA) has become the most frequently used method for measuring customer preferences. However, this decompositional approach uses a ranking procedure to assign customer priorities to product attributes. This means that the CA cannot be first choice when it comes to measuring customer preferences for complex products as the questionnaire length increases considerably with growing numbers of attributes and attribute levels resulting in information overload for respondents (Green and Srinivasan, 1990).

The analytic hierarchy process (AHP) has also been used as a customer preference measurement tool (Scholl et al, 2005). Although this is an effective method to identify respondents' priorities for products with a normal architecture, as the number of attributes increases, more comparisons become necessary thus risking that the respondents are overburdened.

In general compositional tools have been used more frequently to analyse customer preferences. This is mainly due to the fact that these approaches are cognitively less demanding than decompositional tools. Recently Scholz et al (2010) recommended the paired comparison-based preference measurement (PCPM) as a preference measurement tool for complex products. PCPM is a modified version of the AHP method and differs from the latter in some important aspects (Meißner et al, 2010). It has a simple three layer hierarchy; static two-cyclic designs are used to reduce the number of paired comparisons needed in the data collection process; and a bipolar equidistant scale is shown.

One advantage of the PCPM approach is that it takes into account the Number-of-Levels Effect. In PCPM the average preference weight is reduced when further attributes are included in the sub-problem. With increasing numbers of attribute levels the range in the preference weights between the most and the least preferred levels is thus reduced. The PCPM approach tries to balance this effect by multiplying the respective preference weights by the number of attributes being compared. As a consequence the average preference weights stay constant even if additional elements are included (Scholz et al, 2010).

The PCPM is used in this study as it has a proven track record of successful application in complex product environments (e.g. Scholz et al, 2010) and an appropriate software tool is readily available to conduct the online survey.

Attributes included in the survey

Previous empirical research (Schoenwitz et al., 2012) yielded a product architecture overview showing all the components and attributes a house typically consists of, as shown in Figure 1. The set-up of the questionnaire followed this product architecture but not all components and subcomponents were included as otherwise the questionnaire would have been too long. The above mentioned empirical research, also from the German prefabricated house industry, identified subcomponent options taken up by customers on a regular basis. The highest ranked subcomponents for each component have been considered in the preference measurement task.

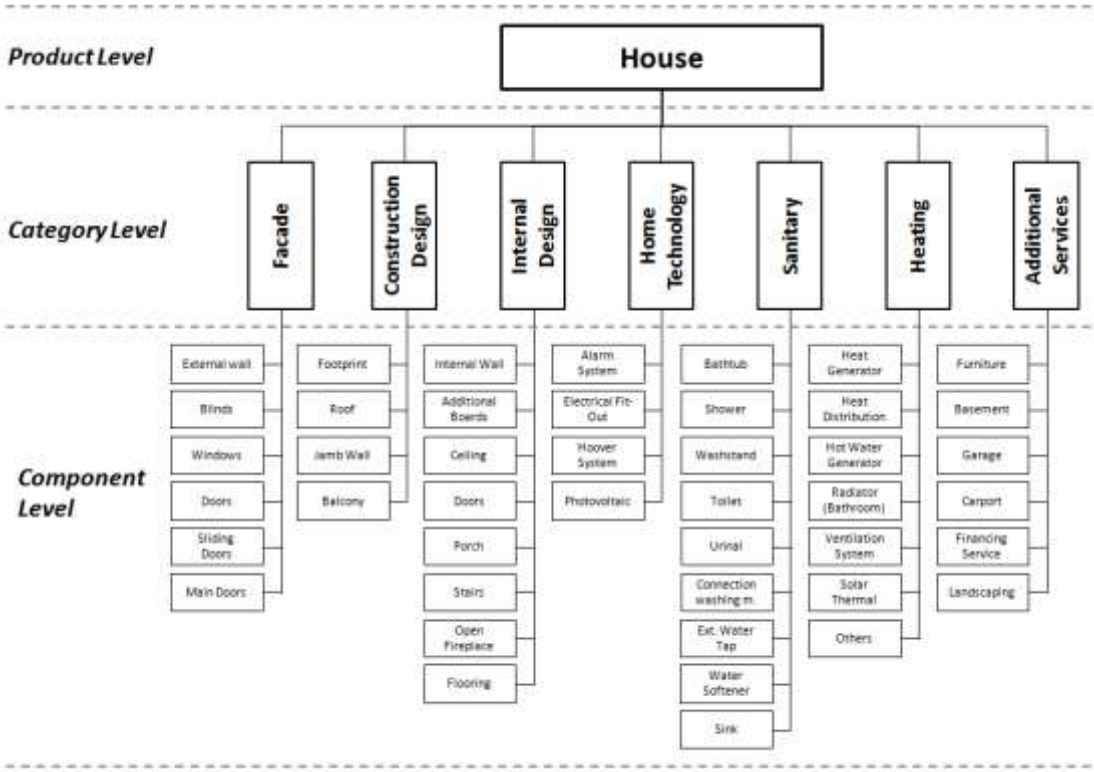

Figure 1: Product architecture matrix of prefabricated house

Data collection and analysis

An online survey was the chosen data collection method for this study. This type of survey has become very popular recently, due to the ever increasing number of internet users and the availability of improved and more sophisticated online survey software. The latter was decisive for this study as it is important for a preference measurement using pairwise comparisons to have software that visualizes the questions effectively. This survey method is also cost effective, an important advantage as it enables the researcher to collect a lot of data in a short period of time (Brandenburg and Thielsch, 2009). The advantages and disadvantages of online surveys are illustrated in Table 1.

In order to set up the online questionnaire and conduct the survey a software tool (AHPlab version 2.2.6) was used. This tool supports the data input and weights preferences according to the PCPM approach. Furthermore the questionnaire can be designed in a way that appeals to respondents. As the survey was conducted in Germany the questionnaire was set up in German language.

As is good practice in questionnaire design easy introductory questions were asked first and the most important questions were asked in the first half of the questionnaire when concentration and focus is still high (Burns and Bush, 2008). In total the respondent had to respond to twenty questions. Some were dual- and others multiple choice. Expected time to complete the questionnaire was twenty minutes which was indicated on the start page so that each respondent knew exactly what the associated expenditure of time was.

Table 1: Methodological advantages and disadvantages of online surveys (adapted from Brandenburg and Thielsch, 2009).

Advantages	Disadvantages
Time efficiency during data collection, analysis and presentation of data.	The programming of the online questionnaire needs more time. There may be a dependency on third parties
Time and effort as well as expenses for print, distribution and coding of questionnaire do not apply. No interviewee and data transfer is needed.	Additional training on the software may be necessary.
Automation and with this increased objectiveness: no error sources through data transfer, no test supervisor effects, no group effects.	The conditions of the data collection cannot be controlled, which results in problems with the objectivity.
More heterogeneous sample formation compared to offline studies. Online surveys will never be able to represent the total population.	Online surveys will never be able to represent the total population.
Availability of the medium: some groups of people can be better reached online.	Not all target groups go online and not all computers are up to date with current soft- and hardware.
Higher data quality, well programmed online questionnaires avoid “missing data” and consistency checks through time protocols are possible.	Multiple participation cannot be ruled out completely. Questions a respondent may have can only be answered asynchronous and on the initiative of the respondent.
Higher acceptance due to voluntariness, flexibility and anonymousness.	Problems with acceptance if the respondents suspect a marketing campaign or data abuse.
Ethical transparency: online surveys are much more transparent as they are easier accessible than offline surveys.	The database of the online survey needs to be protected against unauthorized access. Data protection in general more difficult.

Having finalised a draft version of the questionnaire, a pilot was tested with a group of three experts and two non-experts. This was important to ensure that the questionnaire is suitable for people with and without specific knowledge of the house building industry. The group was asked to evaluate each question and pairwise compare attributes with regard to clarity, relevance and preciseness. Following this, small improvements were made before the questionnaire was finalised.

Initially, people particularly interested in prefabricated housing were targeted for data collection. The Association of German Premanufactured Building Manufacturers (BDF) represents nearly 90% of the German prefabrication industry (BDF, 2013) and runs over 20 show home 'villages', which are usually the first contact points for those interested in such houses. Hence, the BDF was contacted to enquire whether a survey could be conducted in one of the centres. A new show house centre in Cologne was chosen as it had 5,228 visitors per month on average from January - July 2012, making it the most frequently visited centre. Two computer stations were set up for

one day (Saturday) for visitors to complete the questionnaire. Although the centre was very well visited, only five respondents agreed to complete the questionnaire in over eight hours. Most of the visitors on that day were families or groups who wanted to visit the show house centre together, and none of these visitors were prepared to complete the questionnaire and delay the whole group. Furthermore it was difficult to convince people that the survey was for academic purposes.

Given this low completion rate, a conventional online survey approach was adopted. A random sample of available email addresses was taken and the link to the questionnaire was forwarded to these recipients. The sampling frame consisted of 397 potential respondents who received an email explaining the purpose of the research and giving reassurance that the survey would be anonymous. After four weeks 62 responses were received and a reminder was sent to the above mentioned potential respondents. Following another four weeks the survey was closed and the link was deactivated. 33 responses had to be removed from the result spread sheet due to biased responses. These included unrealistic responses to questions where for example postcodes or figures were not indicated in a correct way. Furthermore data sets were removed where a response pattern was identifiable. This happens when respondents always activate the same field and do not specifically respond to the question. In total 82 valid responses were received from the online survey. This means that a response rate of 20.65% was achieved. Braun Hamilton (2009) indicates that a typical response rate for online surveys is 26%. Hence, the response rate of the survey conducted in this research can be classified as acceptable.

The software used recorded the respondents input in a data format that enabled an export of the data into an Excel spreadsheet. This facilitated further analysis of the data. First, the biased data sets were removed. Following this the raw data was formatted and decoded so that figures could be derived from the data. These activities involved mainly the conversion of the system data into usable information. For example if a respondent indicated that he is male, the system recorded a 1. In the spreadsheet the 1 was then substituted by the word 'male'.

A first analysis showed that 68% of the respondents were male and the majority was between 31 and 40 years old. Respondents were from throughout Germany, although particularly concentrated in the west of the country.

RESULTS

One of the first questions was whether respondents think that it is important to have a certain degree of choice when configuring a house. Nearly 90% of the respondents thought that it is rather important or very important to have a certain degree of choice. However, this can only indicate that house buyers actually appreciate choice. But it is much more relevant for companies offering prefabricated houses to know exactly where choice is required and where options can be reduced.

Respondents were asked to rate the importance of the categories in Figure 1. This is the first real pointer with regard to customer preferences in the prefabricated house building industry. As can be seen in Figure 3 the respondents indicated particular customisation interest in the following categories: construction (18.31%), home technology (16.94%) and heating (18.01%). In categories like internal design (12.84%) or facades (12.60%), the need to customise is rather low. Often, prefabricated houses have specific design traits that are common to all, and many of the components for this are within these categories. However, this does not mean that

within these categories customers do not wish to have a high degree of choice for certain components. Hence it is important to consider all layers of the product architecture in the preference measurement exercise. Only then can the option list be set up according to customer preferences and needs.

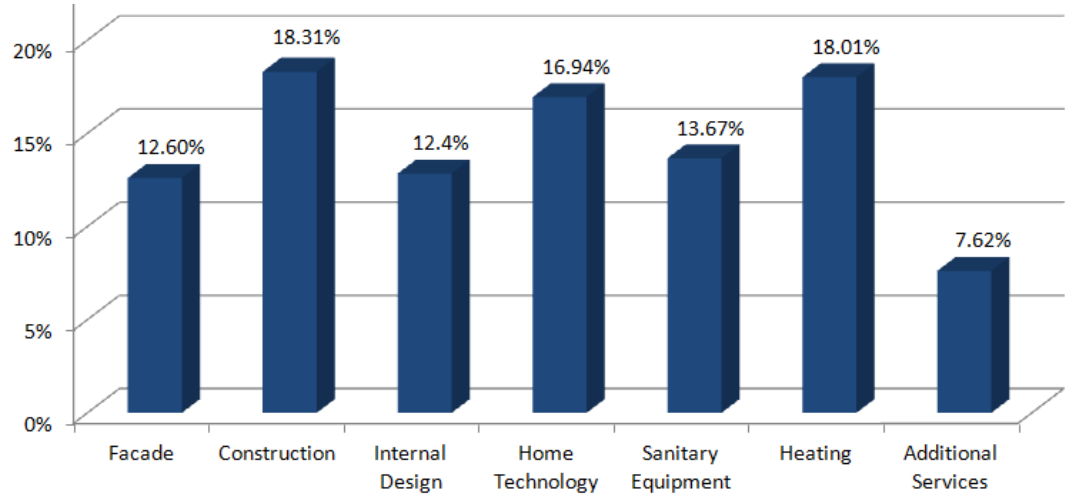

Figure 3: Importance of categories

Figure 4 shows the appropriate results on a subcomponent level. Focussing on components that have been rated as very important in terms of choice being offered, it emerges that flexibility of construction and security seemed to be particularly important for potential house buyers.

It becomes apparent that the possibility to change the footprint of the building is more important than choice for the other attributes. It needs to be adaptable to the appropriate family situation and/or life style of the house buyer. Related to this is the design and construction of the ceiling. An opening in the ceiling for example influences the overall footprint of the building and this seems to be highly relevant for respondents. Figure 4 also confirms that security of the facade (building shell) seems to be very important for respondents. This is even more important than the design of the main door in the same category which has more of an impact on visual appearance.

The results of the survey differ from results of a case study presented by Schoenwitz et al (2012). In their study, subcomponents which signify lifestyle and design of the house are much more important than others. Furthermore choice in the electric fit-out (e.g. switches and sockets) was extensive. The latter is in line with the results of this survey. However, in contrast to the case study results lifestyle and design issues do not seem to be as important for respondents. More important are practical issues concerning the construction of the building. The differences between options actually taken up by customers when configuring a house and the results of this survey further confirm assumptions from researchers that customisation is made only because choice is available and not necessarily because it is really needed (Huffman and Kahn, 1998).

The results presented above already give some guidance for prefabricated house builders on where to focus customisation efforts at a component level. However, not all prefabricated house builders offer a one-stop-shop-solution to their customers. This means that not all the categories highlighted as being important to potential house buyers are relevant. However, even if the components and subcomponents contained

in an important category are not offered to customers, it may be a sensible decision to at least offer support and consultation in these areas.

The results not only show where choice needs to be offered but they also show which attributes and categories can be neglected. This is probably more important than to know what needs to be offered as every option that does not need to be offered any more reduces variety and complexity. Features like a central vacuum cleaner, photovoltaic system or furniture can be identified as not being high in demand.

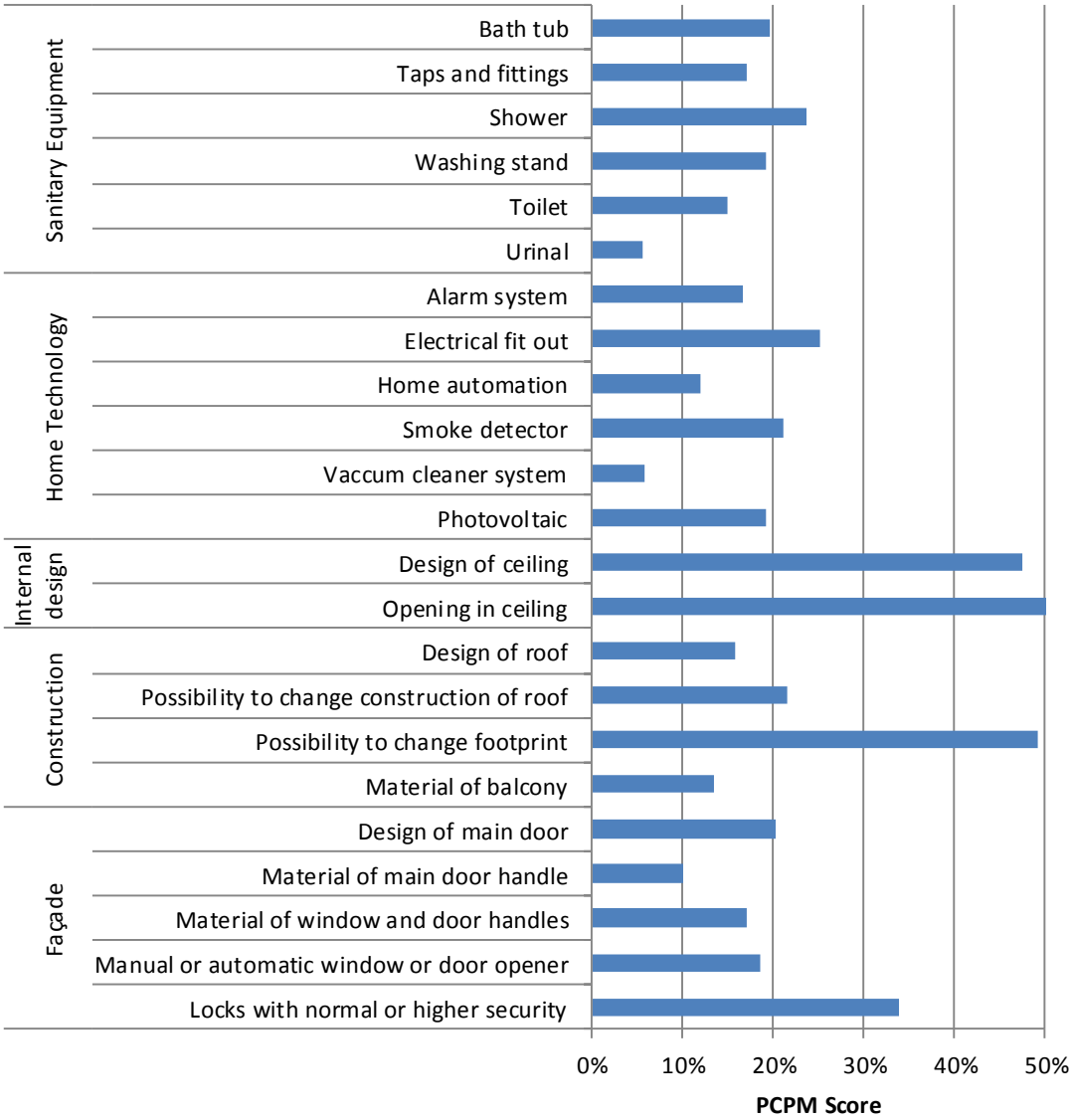

Figure 4: PCPM results for sub components, grouped by category

CONCLUSIONS AND MANAGERIAL IMPLICATIONS

This empirical research contributes by applying a preference measurement method for multi-attribute products (PCPM) in order to prioritise and identify what buyers of prefabricated homes really focus on when configuring a house. This is important as only knowledge of the preferences will enable practitioners to be effective in customisation efforts and ensuring operational efficiency accordingly.

There are two main outcomes of this study. First, a procedure has been developed that prioritises categories and components in a prefabricated house design. This procedure

can be adopted by building companies interested to offer customised houses. Second, results of an online survey have been presented which can help prefabricated house building companies to make the right decisions about the level of variety to offer.

The results of the online survey clearly show that attributes associated with flexibility and security have significant higher impact on the overall product preference compared to others. However, one has to be careful with the interpretation of the results as these can be biased by current trends influencing respondents. Furthermore due to the multi-layer product architecture and the many different alternatives, the possible preference orders can be very long and thus respondents have to make a lot of difficult decisions.

Differences between Schoenwitz et al. (2012) and this survey indicate that although customers have other interests and preferences, customisation in certain areas is considerable when customers configure their house. A reason for this could be that they only take up options because these are made available. If this can be confirmed then there would be considerable potential for house builders to reduce variety and hence costs in order to align options offered with potential buyers' preferences.

There are some limitations to this research. First, the survey was conducted in Germany, thus there may be cultural differences influencing preferences and requirements when building a house. Second, an online survey excludes all nonusers of the internet. The latter could have different preferences when it comes to technological issues. Hence, any conclusions drawn from the above mentioned results cannot rely exclusively on the internet sample. Third, house building companies need to decide who their target customer is and any sample needs to be constituted on this basis, rather than the random sample used above.

Further research is necessary to analyse the collected data in more depth. In particular we are interested to look at the influence of demographics on preferences.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Martin Meißner from the University of Bielefeld for his support in successfully using the PCPM and providing access to the survey software.

REFERENCES

Barlow, J. (1999) From craft production to mass Customisation. Innovative Requirements for the UK Housebuilding industry, “Housing Studies”, 14(1), pp. 23

Barlow, J., Childerhouse, P., Gann, D., Hong-Minh, S., Naim, M. and Ozaki, R. (2003), Choice and delivery in housebuilding: lessons from Japan for UK housebuilders, “Building Research & Information”, 31(2), pp. 134–45.

BDF (2013). Der Verband. Available: http://www.bdf-ev.de/german/verband/index.html. Last accessed 29th April 2013.

Brandenburg, T. and Thielsch, M. T. (2009) “Praxis der Wirtschaftspsychologie“, Münster: MV Wissenschaft

Braun Hamilton, M. (2009) Online Survey Response Rates and Times - Background and Guidance for Industry, available: http://www.supersurvey.com/papers/supersurvey_white_paper_response_rates.pdf

Burns, A. C. and Bush, R. F. (2008) "Basic Marketing Research - Using Microsoft Excel Data Analysis", Pearson Education: New Jersey

Eggers, F. and Sattler, H. (2009) Hybrid Individualized Two-level Choice-based Conjoint (HIT-CBC): A New Method for Measuring Preference Structures with Many Attribute Levels, “International Journal of Research in Marketing”, 26, pp. 108-118

Gibb, A. G. F. (2001) Standardization and pre-assembly – distinguishing myth from reality using case study research, Construction Management and Economics, 19, 307-315

Green, P. E. and Srinivasan, V. (1993) Conjoint Analysis in Marketing: New Developments with Implications for Research and Practice, “Journal of Marketing”, 54(4), pp. 3-19

Hofman, E., Halman, J. I. M. and Ion R. A. (2006) Variation in Housing Design: Identifying Customer Preferences, “Housing Studies”, 21(6), pp. 929-943

Huffman, C. and Kahn. B. E. (1998) Variety for Sale: Mass Customization or Mass Confusion?, "Journal of Retailing", 74 (4), pp. 491-513

Kooii, L. P. and Situmdrang, T. D. (2003) Solving the assembly configuration problem for modular products using an immune algorithm approach, “International Journal of Production Research”, 41(15), pp. 3419-3434

Leishman, C. and Warren, F. (2006) Private housing design customization through house type substitution, "Construction Management and Economics", 24, pp. 149-158

Meißner, M., Decker, R. and Scholz, S.W. (2010), An Adaptive Algorithm for Pairwise Comparison-based Preference Measurement. “Journal of Multi-Criterion Decision Analysis”, 17, pp. 167–177

Ozaki, R. (2003) Customer-focused approaches to innovation in housebuilding, "Construction Management and Economics", 21, pp. 557-564

Schoenwitz, M., Naim, M. and Potter, A. (2012), The nature of choice in mass customized house building, "Construction Management and Economics", 30, pp. 203-219

Scholl, A., Manthey, L., Helm R. And Steiner, M. (2005) Solving Multiattributive Design Problems with the Anlaytic Hierarchy Process and Conjoint Analysis: An Empirical Comparison, “European Journal of Operational Research”, 164(3), pp. 760-777

Scholz, S. W., Meissner, M. and Decker, R. (2010) Measuring Consumer Preferences for Complex Products: A Compositional Approach Based on Paired Comparisons, “Journal of Marketing Research”, XLVII (August 2010), pp. 685-698

Stäblein, T., Holweg, M. and Miemczyk, J. (2011) Theoretical versus actual product variety: how much customisation do customers really demand? “International Journal of Operations & Production Management”, 31(3), pp. 350-370

Towill, D. R. (2001), The idea of building business process: the responsive housebuilder, "Construction Mangement and Economics", 19, pp. 285-293

ANALYSING THE DISCOURSES SURROUNDING CHANGE AND REFORM IN THE CONSTRUCTION SECTOR: THE NEED FOR A MARRIAGE BETWEEN CRITICAL THEORY AND A SOCIO-HISTORICAL CULTURAL PERSPECTIVE

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Attempts to drive change and reform of the UK construction industry have been an on-going concern for numerous stakeholders, both in government and across industry, for years. The issue is a seemingly perennially topical one which shows little sign of abating. The current UK coalition government has recently ordered a wide ranging review of building standards and regulations, including health and safety and energy efficiency, in an attempt to cut 'red-tape', reduce costs, get industry moving and provide a boost to the flagging economy. Scholarly analyses of the reform agenda have tended to adopt a Critical Theory perspective. Such an approach, however, lacks a certain nuance and perhaps only reveals one layer of social reality. That various social actors in competition for scarce resources vie with each other for power and control reveals only a partial insight. What is arguably lacking is a more fundamental exposition concerning the historical, social and cultural explanatory forces at play. Whilst it is illuminating to expose vested interests, ideology and power, what has led to the development of various views? How have they come to achieve such high accord in discussions? Drawing on the works of Max Weber, Georg Simmel and Barbara Adam, this paper seeks to develop a broader theoretical lens in order to gain an appreciation of the forces influencing the development of the motivations and normative views of key stakeholders of the policy-making process. It considers the wider socio-cultural structures and forces that influence behaviour, shape and constrain these views. This approach will contribute to a much needed broader philosophical and theoretical debate within the construction management community (and beyond) on the need to better engage with and understand the cultural sources influencing the perennial issue of policy formulation and diffusion in the built environment that consistently fails to deliver expected reforms.

Keywords: culture, construction, money, policy, time

INTRODUCTION

The recently ordered wide ranging review of building standards and regulations, including health and safety and energy efficiency, is stated to be an attempt to cut 'red-tape', reduce costs, get industry moving and provide a boost to the flagging economy (Jowit: 2012). The industry is arguably being treated once more as an

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Smiley J, Dainty A and Fernie S (2013) Analysing the discourses surrounding change and reform in the construction sector: the need for a marriage between critical theory and a socio-historical cultural perspective *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 445-454.

economic regulator, with government expenditure responding to a precarious political and monetary milieu. (Ball: 1988). This is in some ways understandable in an era of austerity ushered in by the current financial crisis with global markets continuing to lack confidence and fiscal security looking continuously uncertain, particularly across Europe. Previous discourse(s) surrounding change and reform drew from the Latham and Egan reports (among others) to develop a series a recommendations for change and reform. These have been complemented and reinforced by the 'Technology Foresight Report' (1995), 'Modernising Construction' (2001), 'Accelerating Change' (2002) and the Wolstenhome report (2009). Notably, 'Sir Michael Latham's proposals were warmly supported by all political parties throughout the country' (Cahill and Puybaraud in Murray and Langford: 2003: p. 150) and this has arguably been the case with proposals arising from all reports mentioned above. That there is wide consensus across the political spectrum for these proposals and recommendations is perhaps indicative of a more fundamental underlying cultural predisposition. This paper suggests that hidden beneath the rhetoric of discourses for change and reform in construction are a multitude of power relations, vested interests, taken-for-granted norms, values, assumptions and cultural attitudes which are rarely articulated, let alone challenged. To address this, research that adopts Critical Theory coupled to a broad socio-historical cultural perspective is argued to form a robust theoretical and analytical lens through which to explore afresh construction discourses and explain the cultural predispositions which influence them. These arguments and lenses are initially developed through a brief examination of research that has sought to explore two pivotal industry reform recommendations; Building Information Modelling (BIM) and Partnering. The arguments are then further sharpened by turning attention towards that spectre of social science; the 'Iron Cage'.

BIM

According to Davies and Harty (2012) exploring BIM via issues of control, surveillance and power exposes an assumption by researchers that diffusion is considered to be largely, '…unproblematic technical activities…positioned as politically neutral and generally beneficial…' (Davies and Harty: 2012: p. 24). They argue, quite convincingly, that prescriptions flowing from such assumptions are too readily accepted by a multitude of stakeholders without due thought or critical examination. But, whilst useful, their research offers little insight into the cultural predispositions of those with vested interests in developing and diffusing BIM to explain the assumptions adopted. In other words, why do they hold the particular cultural interests they do? If we consider the diffusion of BIM to be a social endeavour and not a neutral, value free technological prescription, then immediately we are faced with a question of how and why this has come into being? What does this reveal about social relations in the particular cultural milieu in which it has emerged? How has the prescription referred to as 'BIM' come to be seen as a 'rational' course of action? Why has it emerged at this particular time? Why has it been so 'persuasive' to so many and why are 'control' and 'surveillance' deemed necessary and desirable components in construction projects? Perhaps more importantly, to what end?

It is also interesting to consider the role of time and its absence from much literature. Though BIM is alluded to in terms of reducing time (which interestingly has come to be linked historically with 'efficiency'), time is an all too often taken for granted aspect of culture. It is often reified and treated as an unalterable, objective aspect of our reality. The differences, for example, between the uniform, commodified,

decontextualized nature of the time inherent in BIM and other ICT prescriptions that employers attempt to impose on their workforce and the variable, contextualised nature of time as humans actually experience it are rarely explored (Adam: 1995; Chan: 2012). Whilst Summerfield and Lowe (2012) highlight the connection between culture and BIM, variances in time perceptions between those of different cultural backgrounds are rarely discussed and an understanding of such would seem important in a world where companies have ever increasingly diverse workforces. Indeed, the importance of, and need to engage with a more holistic appreciation of time is all too often missing from construction management literature (Chan 2012). That such a narrow perception of time has come to be predominant and that an arguably increasingly homogenous discourse surrounding construction 'improvements' is emerging worldwide is a point that shall be developed later on. What is needed, however, is a description and knowledge of the primordial soup from which various cognitive frames and discourses emerge, without which no understanding of said discourses, values, attitudes and behaviours can be complete.

To adequately understand the development and diffusion of BIM prescriptions then, and their relationship with and impact upon human thought and behaviours, we arguably need to attempt a genealogy of time, values, belief and culture.

PARTNERING

The discourse(s) surrounding partnering offer an interesting theoretical departure point in which to consider calls for change and construction 'improvement'. Bresnen and Marshall (2000) problematize the issue of partnering and highlight its contested definitional and conceptual nature and the role of power and vested interests (both between and within organizations) that shape partnering practice. In the absence of a wider cultural perspective to complement their critical approach, however, their research, and others drawing from the discourse of partnering, arguably offers an incomplete picture. For example, they do not explain why values such as reduced time, lower costs, greater speed and efficiency have come to dominate partnering discourse(s) and appear to be privileged over other potential values?

With its calls for long-term relationships and stability, the rhetoric of partnering arguably mirrors wider societal norms and values and calls for stable, monogamous relationships as a way for a healthy, productive, stable life. This can be contrasted with the increasing liquidity and fluid nature (which some might pejoratively label as promiscuous) of interpersonal relationships in modern life, (see Bauman: 2000, for example). From this perspective, calls for partnering could perhaps be seen as conservative endeavours, reflecting societal norms which seek to maintain or perhaps reintroduce prevailing traditional societal norms and values and bring a modicum of perceived morality to business practices with the sector. Or, perhaps more cynically, partnering could be characterised as marriages of convenience, based solely on desires for financial security and stability, rather than other, nobler notions. But, either way, there are still questions as to how and why these particular discourses of morality have come to be so dominant within the industry reform discourse.

Using an institutional theory perspective, Gottlieb and Jensen (2012) also consider the rise of partnering discourse, this time in the Danish context:

> 'The following analysis takes its starting point in 1990 and continues to the present day. It focuses exclusively on the development of partnering in Denmark and does not consider the development in other Nordic or European

> countries, neither when discussing international influences on Danish development, nor in relation to the 'cultural traffic' of change principles and recipes across nations' (Gottlieb and Jensen: 2012: p. 162).

Whilst they argue that the study's findings should only be thought of as applicable to the Danish context in particular, it is arguably limited in even providing that, without the wider and deeper insights required. As such they call for future studies to explore, '…how and why different variants of partnering emerge over time and place and how to understand the relationship between macro-level industrial change and local project practices' (Gottlieb and Jensen: 2012: p. p. 168). Such studies are arguably understood as necessary to provide a broader understanding of the transnational historical and cultural influences at work. Research of this nature would also concede that neither the Danish construction industry nor the concept of partnering have emerged from a vacuum and that, as a result, an understanding of the historical and cultural antecedents are essential to deepening any contextual understanding of change and reform recommendations.

POWER, HISTORY, AND CULTURE – AN INSEPARABLE MIXTURE

Drawing inspiration from the Frankfurt School and Critical Theorists such as Horkheimer, Adorno, and Habermas, a Critical Theory approach to organization and management research in the built environment has sought to, '…interrogate and challenge received wisdom about management theory and practice' (Alvesson and Willmott: 2003: p. 1). But whilst such critical perspectives have previously been adopted to highlight the importance of ideology, vested interests and power struggles inherent in calls to reform, they are limited to revealing only partial insights framed around the obvious – that social actors in competition for scarce resources vie with each other for power and control. The use of dialectical thinking in this body of research, so typical of a Critical approach, whilst informative is arguably overly simplistic and rests upon a hidden taken-for-granted teleology. Highlighting the role of the ideologies which lay behind the rhetoric surrounding 'improvement' is a valid yet incomplete contribution. This is because, ideology and power, as Lawson (2006) notes, are, '…important, but alone merely represent the locally mediated expression of underlying networks of social relations' (Lawson: 2006: p. 21). Sage et al (2010) further warn of dialectics becoming, '…an un-reflective way of generating new concepts; driving forward closed syntheses of unexamined binary oppositions', within critical projects thinking (Sage et al: 2010: p.545). This is not meant to dismiss a Critical approach at all, as there is great value in it as a theoretical lens. Critical Theory offers a valuable piece of the puzzle, so to speak, but only a piece. It does not adequately reveal how and why behaviours, vested interests and power struggles evolve or explain their development into particular shapes and forms. It is almost as if such circumstances are to be treated as an inevitable and inalienable part of human existence. But such an assumption arguably rests on an unwarranted view of human nature, one which makes of central importance the presence of competitive urges and conflict at the expense of other, differing conceptions, for example, that of mutual aid and cooperation (Kropotkin: 1902). Furthermore, such assumptions neglect the idea that the various actors involved, even dominant ones, are themselves humans influenced and shaped by the prevailing discourses and social milieu of their times. After all, how is it determined that someone represents a 'powerful' or 'dominant' actor in the first place? And why do the powerful seek the particular interests they do, as opposed to others?

Whilst some scholars (for example, McCabe: 2007, who very usefully traces the historical developments which influenced the current 'Respect for People' agenda) have recognised the importance of history in the formation of reform policies, there is still little discussion of the wider cultural dimensions at work. For example, the idealizing and prioritizing of efficiency, rationality and the desire for speed is arguably specific to a particular time and space/place in human history and the result of human artifice. It has not always been this way and need not always be in the future. To engage with and understand reform at a deeper level, it is necessary to develop views concerning the historical, social and cultural explanatory forces at play (Hempel: 1942). Such research would inevitably reveal wider and more profound insights into vested interests, ideology and power by explaining what led to the development of such views; how they had come to achieve such high accord in discussions and; why certain discourses (and related policies) have emerged at the expense of others at particular times. Central to this is an acceptance that actors are subjects embedded in particular historical periods and influenced by a prevailing socio-cultural milieu of their times. Or, as Marx observed,

> 'Men make their own history, but they do not make it just as they please; they do not make it under circumstances chosen by themselves, but under circumstances directly encountered, given and transmitted from the past. The tradition of all the dead generations weighs like a nightmare on the brain of the living' (Marx: 1852/1970: p. 15 in Ritzer and Goodman: 2003: p. 44).

In summary, a deeper understanding of improvement discourses in the UK construction industry must engage with and explore the various socio-historical cultural factors and forces at play.

THE 'IRON CAGE REVISITED', AGAIN

Thirty years ago, DiMaggio and Powell (1983) wrote of the increasingly homogenous nature of organizational discourse and sought to, '…explain homogeneity, not variation' (DiMaggio and Powell: 1983: p. 148). Thirty years on and arguably the relentless march towards increasing homogenization has continued with the uncritical acceptance of various improvement prescriptions with repeated emphases on 'efficiency', 'value' and 'productivity'. Such characteristics, as Ness and Green (2012) have commented, '…have become naturalised; they are seen as commonsense by all or almost all the participants and thus not seen as ideological or as representing the position of those with most power' (Ness and Green: 2012: in Dainty and Loosemore [eds] p. 25). But how has this come to be the case? An appreciation of this subject only becomes more visible through a more thorough, critical examination with history, culture and the social. It is especially interesting to consider the roles of Weber, Simmel and Adam. For although it is essential to consider discourse, rhetoric and the power relations enshrined in them, there is little insight into the way said relations come about. A tentative theoretical premise then will be that the development of a papered moneyed economy (Simmel: 1907), along with the standardization and decontextualization of time from the 1800s onwards (Adam) have led to an increasing predominance of instrumental rationality at the expense of other competing forms of rationality (Simmel: 1903; Weber: 1904). This has, in turn, been spread globally through a combination of both the diffusion of new technologies and the collapsing of space and time that said new information technologies has afforded (Castells: 2004) and by the spread of neoliberalism thought and practices by the leading actors of our times (neatly characterized by Green (2011) as the 'Enterprise

Culture'). In fact, the discourse referred to as 'Neoliberalism' could only arguably have come about as a result of the above combination of forces and events. Critically, the varied combination of processes commonly referred to as 'globalisation' can themselves be considered as, '…an ideological assertion rather than a description of inevitable economic and cultural processes' (Faulks: 1999: p. 70). This particular combination of events, like a slow-setting cement mixture, has gradually began to harden, with discourses surrounding construction 'improvements' becoming ever more intractable, unmoveable, and unimaginative as a result.

The political philosopher Michael Oakeshott, himself a staunch critic of the turn to Rationalism, stated,

> 'But what, at first sight, is remarkable, is that politics should have been earlier and more fully engulfed by the tidal wave [of rationalism] than any other human activity. The hold of Rationalism upon most departments of life has varied in its firmness…but in politics it has steadily increased and is stronger now than at any earlier time' (Oakeshott in Callahan: 2008: p. 26).

It is through the socio-historical theoretical lens stated above that we may arguably hope to begin to make sense of the ever increasing tendency for this particular type of rational thought to dominate policy development, construction debates and, indeed, everyday contemporary existence. The potential for humans to cognitively perceive differing perspectives is constrained by a particular combination of biological, historical and cultural forces. Indeed, could it not be considered that an individual's psychological frames, predictions, habits and preferences are a causal result of cultural forces? Or that they are a result of mutually constitutive forces which interact with, shape, and constrain each other against a backdrop of culture which limits the potential variety and plasticity of any user experiences? From this perspective, it is not so remarkable that this specific type of instrumental rationality would begin to be privileged over other, competing forms of knowledge, for, as Simmel stated,

> 'Money economy and the dominance of the intellect are intrinsically connected…it reduces all quality and individuality to the question: How much? All intimate emotional relations between persons are founded in their in individuality. Whereas in rational relations man is reckoned with like a number…' (Simmel: 1903: p. 3).

The abstract, impersonal nature of money (particularly papered money) alters social and exchange relations, impacts psychological frames and, combined with the advent in 1913 of 'Global time', with the first wireless time-signal sent from the Eiffel Tower, and the increasing decontextualisation and commodification of time (Adam: 1995), has meant the stripping of, '…both work and time from their contextual meanings…' (Adam: 1990: p. 116). This has led to an increasing predisposition to an instrumental means-end rationality that prioritizes the efficient maximization of monetary gains at the expense of other competing values. This cultural predisposition, spread and perpetuated by the dominant wealth possessors of our times, has become our very own 'Iron Cage'. That is, a dominant cultural intellectual discourse so engrained that many social actors (intellectuals and lay-persons alike) have difficulty even imagining 'viable' alternatives. To borrow a turn of phrase from the economist J. K. Galbraith (1958), a new 'conventional wisdom' is born. This has led to a situation where, 'Each individual's opportunity to create and develop becomes increasingly restricted by intellectualization, rationalization (including the sphere of law), and the "calculating exactness" of modern times' (Capetillo-Ponce: 2005: p. 117). Notions of

‘Best practice’ must be seen as reflective of and linked to more fundamental philosophical assumptions regarding what actors conceive to be the ‘Good life’. And these visions of the ‘Good life’ have not emerged in a vacuum but are the result of a combination of numerous cultural, historical and biological factors.

An appreciation of this helps to place into context the repeated emphases by those calling for reform and change in construction on value for money (for both business and clients alike) in successive reports ranging from Banwell through to Latham and Egan and the National Audit Office’s (2004) Getting Value for Money from Construction Projects Through Design. This is a sentiment so stubbornly entrenched that the Royal Institute of Chartered Surveyors (RICS) recent (2013) publication simultaneously reports that, ‘…the Coalition Government…need to make efficiencies and reductions in the cost of the construction they procure’, whilst proudly proclaiming their creation of a new standard which can, ‘…help reduce spending on individual projects and allow for more projects to be delivered within restricted budgets’ (RICS 2013: p. 10). The more things change the more they seemingly stay the same! It also goes some way to understand the currently booming ‘business of BIM’ with a plethora of expensive workshops and courses increasingly being offered for this ‘essential’ prescription; arguably prioritizing money at the expense of workers’ health and safety and ability to balance life and work more generally. Interestingly, from a sociological perspective, we can link the calls for ‘Respect for People’ with the moral discourses surrounding ‘clean’ and ‘dirty’ money (Baker and Jimerson: 1992). Monies are inextricably embedded within the wider social milieu in which they emerge and how they are exchanged, distributed, and accumulated matters to the social actors involved, with debates reflecting the prevailing moral discourses prevalent at the time. So, ‘Respect’, in this context, is linked to both practices and remuneration which are perceived to be fair (however ‘fair’ is defined by the various actors involved). And debates, both within the Human Resource Management literature and illustrated in the actions of unions, fighting for perceived improvements in working conditions, must be considered as competing discourses which represent a negotiation of contemporary morality. But what has led to the emergence of these particular discourses in the first place? How have these specific moral sentiments amongst the various actors present evolved? It is important to ask such questions as a much needed corrective measure for a great deal of the academic and policy literature which does, ‘... not provide explicit reflection on the values or interests such ‘policy implications’ are meant to advance (Bartram: 2010: p. 355).

CONCLUSION

It is not enough to shine a light on inequalities, power differentials, and vested interests. In attempting to understand the various calls for change and reform in construction, it is important to understand the numerous forces which have led to both past and current discourses. By combining a Critical approach with a more fundamental socio-historical cultural lens, a more detailed, nuanced and sophisticated understanding can be achieved. There is arguably a moral imperative for us, as a community of researchers, to critically examine the genealogy of norms, values, attitudes, and behaviours, including our own. Why do we esteem certain values at the expense of others, how has this come to be the case historically? How have we arrived at the particular cultural milieu we currently experience? By even attempting to answer such questions, by fostering this sort of reflexive, hyper-critical attitude, assumptions and taken for granted attitudes can be challenged, made explicit, and transparent. A more honest and humble debate, informed by knowledge of the sources

and influences of various discourses is essential. Without such an effort, the unreflective majority will continue to aimlessly stumble on and even well-meaning critics will have difficulty finding inventive solutions to perceived problems. After all, attempts to think outside the box necessarily depend on the contours and characteristics of the box. But,

> 'Since such forces of life have grown into the roots and into the crown of the whole of the historical life in which we, in our fleeting existence, as a cell, belong only as a part, it is not our task either to accuse or to pardon, but only to understand' (Simmel: 1903: p. 10).

REFERENCES

Adam, B. (1990) Time & Social Theory, Cambridge: Polity Press.

Adam, B. (1995) Timewatch: the social analysis of time, Cambridge: Polity Press.

Alvesson and Willmott [eds] (2003) Studying Management Critically, London: SAGE Publications

Baker, W., and Jimeson, J. (1992) 'The Sociology of Money', American Behavioral Scientist, Vol. 35, No. 6, pp. 678 – 693.

Ball, M. (1988) Rebuilding Construction: Economic Change in the British Construction Industry, London: Routledge Press.

Banwell, Sir Harold (1964) The Placing and Management of Contracts for Building and Civil Engineering Work. HMSO, London.

Bartram, D. (2010) 'The normative foundations of 'policy implications': reflections on international labour migration', Work, Employment, Society, Vol. 24, No, 2. pp. 355 – 365.

Bauman, Z. (2000) Liquid Modernity, Cambridge: Polity Press.

Bresnen, M. and Marshall, N. (2000) 'Partnering in construction: a critical review of issues, problems and dilemmas', Construction Management and Economics, Vol. 18, pp. 229-237.

Cahill, D and Puybaraud, M C 'Constructing the Team: The Latham Report' in Murray, M. and Langford, D. [eds] Construction Reports – 1944-98, pp 145 -160, Oxford: Blackwell Publishing.

Callahan, G. (2009) 'Michael Oakeshott on Rationalism in Politics', The Freeman-Ideas on Liberty, Vol. 59, No. 1, Foundation for Economic Education.

Capetillo-Ponce, J. (2004/5) 'Contrasting Simmel's and Marx's Ideas on Alienation', Human Architecture: Journal of the Sociology of Self-Knowledge, Vol. III, Nos. 1&2, Fall 2004/Spring 2005.

Castells, M (2004) The Power of Identity, The Information Age: Economy, Society and Culture Vol II, Oxford: Wiley-Blackwell Publishing.

Chan, P (2012) 'Constructing a sense of time in projects: Implications of a Bergsonian view of time', In: Smith, S.D (Ed) Procs 28th Annual ARCOM Conference, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 497-507

Davies, R and Harty, C (2012) Control, surveillance and the 'dark side' of BIM In: Smith, S.D (Ed) Procs 28th Annual ARCOM Conference, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 23-32.

DiMaggio, P J and Powell, W W (1983) 'The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields', American Sociological Review, Vol. 48, No. 2, pp. 147 -160.

Egan, Sir John. (1998) Rethinking Construction. Report of the Construction Task Force to the Deputy Prime Minister, John Prescott, on the scope for improving the quality and efficiency of UK construction. Department of the Environment, Transport and the Regions, London.

Faulks, K. (1999) Political Sociology: A Critical Introduction, Edinburgh: Edinburgh University Press.

Fernie, S., Leiringer, R., and Thorpe, T. (2006) 'Rethinking change in construction: a critical perspective', Building Research and Information, Vol. 34, No. 2, pp. 91 – 103.

Galbraith, J. K. The Affluent Society, London: penguin Books Ltd.

Gottlieb, S.C., and Jensen, J.S. (2012) 'Making sense of partnering: discourse, governance and institutional change', Engineering Project Organization Journal, Vol. 2, No. 3, pp. 159 – 170.

Green, S. D. (2011) Making Sense of Construction Improvement, Oxford: Wiley-Blackwell Publishing.

Hempel, C. G. (1942) 'The Function of General Laws in History', in Martin, M and McIntyre, L. [eds], Readings in the Philosophy of Social Science, London: MIT Press.

Hollis, M. (1994) The philosophy of social science: An introduction, Cambridge: Cambridge University Press.

Jowitt, J. (2012) 'Government orders building standards review', The Guardian [online], 26th October 2012. Available online at: www.guardian.co.uk/politics/2012/oct/26/government-building-standards-review-regulation [Accessed on the 26th October 2012]

Kropotkin, P. (1902/1989) Mutual aid: a factor of evolution, Montreal: Black Rose Books.

Latham, Sir Michael (1994) Constructing the Team. Final report of the Government/industry review of procurement and contractual arrangements in the UK construction industry. HMSO, London.

Lawson, J. (2006) Critical Realism and Housing Research, London: Routledge.

McCabe, S. (2007) 'Respect for people – The dawn of a new era or mere rhetoric?', in Dainty, A., Green, S. and Bagilhole, B. [eds] People and Culture in Construction – A Reader, London: Taylor and Francis Group.

NAO (2001) Modernising Construction. Report by the Comptroller and Auditor General of the National Audit Office, The Stationary Office, London.

NAO (2004) Getting Value for Money from Construction Projects through Design. Report prepared by Davis, Langdon & Everest, National Audit Office, London.

Ness, K and Green, S. D. (2012) 'Human resource management in the construction context: disappearing workers in the UK' in Dainty, A and Loosemore, M [eds] Human Resource Management in Construction – Critical Perspectives – 2nd Edition (2012) pp. 18 – 50.

OST (1995) Technology Foresight: Progress Through Partnership, Office of Science and Technology, London.

RICS (2013) RICS Construction Policy. Report prepared by the Royal Institute of Chartered Surveyors, March 2013, London.

Ritzer, G. and Goodman, D. J. (2003) Sociological Theory – Sixth Edition, London: McGraw Hill Publishing.

Sage, D.J., Dainty, A.R.J. and Brookes, N.J. (2010), A Consideration of Reflexive Practice Within the Critical Projects Movement, *International Journal of Project Management*, Vol.28, No.6, pp539-546.

Simmel, G. (1903) 'The Metropolis and Mental Life', Available online at: www.altruists.org/static/files/The Metropolis and Mental Life (Georg Simmel).htm

Simmel, G. (1907) The Philosophy of Money, Third Edition – Edited by David Frisby (2005), London: Routledge.

Strategic Forum (2002) Accelerating Change, Rethinking Construction, London.

Summerfield, A.J., and Lowe, R (2012): Challenges and future directions for energy and buildings research, Building Research & Information, 40:4, 391-400.

Weber, M (1904/2011) The Protestant Ethic and the Spirit of Capitalism, Oxford: Wiley-Blackwell Publishing.

Wolstenhome, A. (2009) Never Waste a Good Crisis, Constructing Excellence in the Built Environment, London.

PRIDE AND PREJUDICE – IDENTITY AND COLLABORATION IN CONSTRUCTION

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Based on an 18 month ethnographic case study of a construction partnering project, the paper adopts practice based theory for understanding the identity formation and practices of collaboration in construction. Drawing upon practice based theory in general and actor network theory and communities of practice in particular, the construction project is interpreted as configuration of networked practices characterized by strong professional practices (e.g. architects and contractors) and locally negotiated collaboration practices. During the construction project, actors gain experiences in relation to the actual building and their profession, but concurrently they learn how to engage in collaboration with other professions in the project. These practice-based learning processes are very influential and effective. Newcomers to a profession quickly learn the name of the game – for better or for worse. Overtime they learn to behave competently at the boundaries between professions forming their identity and a sense of belonging in relation to an institutionalized role and the realization of the physical building. In this process the actors develop "pride" in terms of authorship of the physical building and membership their profession. However another consequence of these learning processes is the development of prejudices. Prejudices are often viewed as a negative aspect of building processes as it hinders collaboration among the professions. Consequently prejudices is often seen as something which should be eliminated e.g. in the partnering concept. Stemming from practice based theory the paper on the contrary argues that prejudice represents accumulated experiences from previous projects shaped by the negotiation of meaning within professions. In this perspective prejudice is integrated in the daily building practices – enabling and inhibiting collaboration. Pride and prejudice are thus central constitutive elements of present construction practices in the formation of identity and development of collaboration processes.

Keywords: identity, collaboration, practice based theory, partnering, prejudice.

INTRODUCTION

Pride and prejudices seems always to have been tied to the products and processes of construction. The pride is closely linked to the products as they have lasting impacts on local societies and might survive for millenniums. Due to their sizes they are often very visible and thus are the products of construction often subject to great debate and possible admiration and critique.

While the product last for ever, the process of construction is much more temporary and ephemeral. The construction industry realizes its products through inter-firm

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Thuesen C (2013) Pride and prejudice – identity and collaboration in construction *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 457-467.

project organizations, often portrayed as temporary and unique. A specific division of labour and roles exists organizing contractors, engineering companies, and architects in the shared endeavour. Although there are examples of transcending these roles, they are generally maintained in the majority of building projects. Construction project are thus constellations of professional practices, which maintain well-defined and well-exercised roles.

Loosemore and Tan (2000) analyse these roles as occupational stereotypes and identify and their mutual perceptions and expectations. While not directly studying prejudices they argue prejudices arise from these stereotypes. Based on this insight this paper seeks to understand how these roles are exercised and developed, how collaboration occurs in practice.

AMBITION

This leads to the two-fold aim of the paper. First, the paper will introduce a practice-based perspective for understanding the organisation of practices in projects. This perspective will act as a platform for discussing the identity formation and practices of collaboration in construction.

THE METHOD

The paper develops an analytical strategy from two “mature” theories dealing with practice – Actor Network Theory (ANT) and Communities of Practices (CoP). Both these theories is a part of the wider “practice turn” in management and organizational studies (Nicolini 2012 & Schatzki et al. 2001) which places emphasis on understanding management and organizing through the unpredictable, embodied, and materially mediated, lifeworlds, of practitioners themselves, rather than through “best practice” ideals, abstractions and rationalist models of human behavior.

Although the theoretical framework of CoP originally have been studied in stable and well-defined contexts like photocopier repairmen (Orr, 1996), and claims processors (Wenger, 1998) recent studies shows the theory's application in project settings like the construction industry (Gherardi and Nicolini 2002 and Ruikar et al 2009)

In relation to project organizing ANT has been applied for understanding diverse projects as; building (Sage et al. 2011, Tryggestad et al., 2010; Harty, 2008; Suchman, 2000), transport (Latour, 1996), information system (Tatnall and Gilding 1999) and aerospace (Law, 2002). It is the general impression that ANT is a promising strategy for studying project work thus is Sage et al. (2011) concluding that ANT might “contribute to the further understanding of the dynamic, interdependent and emergent stabilizations and negotiations that constitute complex projects.” (pp. 288).

The intention is not to develop a full-scale Actor-Network analysis, but draw upon some fundamental ideas and strategies in the understanding of project practices. In this process, inspiration is drawn from a wide range of sources including the key-contributions within the field of Communities of Practices Theory (CoPT) and Actor Network Theory (ANT). This includes studies like John Law's analysis of the Life and Death of a military aircraft development project (Law 2002) and Jean Lave & Etienne Wenger’s development of situated learning theory (Lave & Wenger 1991; Wenger 1998).

Throughout the paper, the analytical strategy is applied on empirical material from an ethnographic study of a construction project.

Ethnographic research is one of the most celebrated methods for doing practice based studies (Nicolini 2012), for several reasons: It provides extensive and in-depth findings about practice due to the first-hand observation that is involved and as it usually is conducted over an extended period of time. In addition, because ethnographic research relies on observation rather than examinations or predetermined tests, the research can evolve and explore new lines of inquiry. In the novel "Pride and Prejudice" by Jane Austin the main character Elizabeth Bennet brings out the centrality of ethnographies research “But people themselves alter so much, that there is something new to be observed in them for ever.” (Austin 1813)

However ethnographic research has its disadvantages. Since it relies on observation it often takes a longer period of time to produce thorough and reliable results. Also, because the research is reliant upon the observations of just one or a few people, the conclusions are influenced by the observers' bias or ignorance.

Balancing these trade-offs the empirical material for this study was collected in an ethnographic study of a construction project – with a primary focus on design activities. During an 18 month period the author was present on a daily basis in the project participating in the ”main” design activities, covering all design meetings, workshops, and some internal and external meetings. Apart from participant observation, interviews of project members were conducted. An extensive part of the material (i.e. meetings and interviews) has been taped resulting in more than 90 hours of recordings. Furthermore, the formal documents created by the actors have been made available such as contracts, resumes, drawings etc.

The rich field material was originally gathered and analysed using Practice-Based Theory including ANT and CoP (Thuesen 2005 & Koch & Thuesen 2013). This analysis involved selecting special themes and studying knowledge processes around these. Building on the same platform of PBT this paper will discuss the practices of collaboration and identity formation.

Presenting this vast material in the format of a conference paper is an almost impossible exercise. Thus expects of the material is presented as small vignettes working as figurative elements in the development of the approach for understanding the organization of the practices in the project. This understanding is subsequently used for discussing the development of identity and collaboration based on a partnering workshop with a specific focus on prejudices.

CASE: CONSTRUCTING A WOLD-CLASS SCHOOL SYSTEM

The objective of the studied project was to develop a world-class school system for a Danish municipality. This included construction of a new school and refurbishment of four existing schools. The main companies in the project were, besides a main-contractor, an architect, a technical consultant, and a client advisor taking care of the contact with the municipality. The contractor comprised a team with members from two different departments for the refurbishment of the existing schools and building of the new school. The technical consultant had four specialists from different departments and a project leader assigned to the project. The architect had around six people working on the project with two different teams and one project leader.

THE PROJECT A CONFIGURATION OF NETWORKED PRACTICES

At first sight, the act of designing and building the schools appears complex or even chaotic. How might we understand this unfolding process?

Actor Network Theory enables us, with the fundamental notions of "actor and network", to understand how important components (actors) of the project's practices are tied together (networked) such as offices, schedules, goals, budgets, resumes, engineers, project leaders, clients, titles, and resources. In this process ANT operates with a fundamental principle of symmetry, where human and non-human actors are treated equally (Latour, 1996; Law, 2002).

This implies that practice is a socio-material configuration of persons and artifacts. For instance, the practice of designing the construction principle to be used in the school consists of calculations, a structural engineer to make the calculations and an assistant for producing the CAD drawings, information about material, supplies etc.

Professional practices - formed by Communities of Practices

A central point in ANT is that actors are defined by their relation to other actors – strong or weak. Within the actor-network of the project, there are differences in the strength of the ties. In this way, certain areas in the project's network have a higher concentration of actors (actors with strong relational ties). The practices of these areas might be concentrated in a way that it is being black-boxed by outsiders (actors with weak relational ties). In the project, this is typically professional practices - experts such as structural engineers. Lowe (2001) supports this, positing that black-boxes are an important feature of postmodern society in that their role has become centrally constitutive of professional practice.

Looking closer at the individuals of the professional practices we find them using similar tools and language, have similar identities and worldviews. It is useful to consider that these groups form around Communities of Practices.

By introducing Communities of Practices Theory, we have a theoretical framework for understanding how the professional practices in the project are developed and reproduced. Drawing on symbolic interactionism Wenger (1998) explains this as a "meaning making" process with two equal components - reification and participation.

A central process of this is how newcomers learn the practice of the community through legitimized peripheral participation (Lave & Wenger, 1991). In Jensen's (2001) words, this term indicates, "that the newcomer initially is given relatively easy tasks, where errors have relatively minor consequences (peripherality). But these tasks are nevertheless useful contributions to the community (participation), and therefore the person is granted acceptance as a participant (legitimacy). In the process of doing relatively simple tasks, the newcomer is placed in a position where she can observe, hear about and get a feel for more mature practices. So legitimate peripheral participation entails access to learning resources that are relevant to the person's future participation. Her position should not merely be viewed in terms of the simple tasks, which she carries out at the moment. The present position is a part of a learning trajectory that leads to more and more involvement in the community. Consequently, the position is also constitutive of her identity as a member of the community of practice." (Jensen 2001, p. 22) Vignette I on the following side illustrates this learning process of two newcomers in the project.

Focusing on the learning trajectories of the project's participants, it's interesting to notice the local effect of the institutionalized educational system. When members such as engineers and architects have ended their education, they are usually employed at companies heavily populated by either engineers or architects. In this way the educational system maintains a strong division of labour of the organisation of the practices in the project. Because of this institutionalized effect the professional practices can be assumed to cross organizational boundaries (Bloor & Dawson 1994).

Vignette 1: Mastering the practice

Shortly before the start of the design of the school, the architectural company hired a young architect Rasmus – who just graduated from the "Royal Academy of Fine Danish Art" in Copenhagen. In his new job, he was placed among the experienced architects at the drawing office and was spending most of his time in front of his computer drawing details – a very fundamental element of an architectural practice.

Susanne was employed by the contractor two years before the start of the school project. Most of her time was spent on managing small subcontractors – running around on the site monitoring them. After half-a-year, she complained about her workload to the project leader. She told him it was impossible for her to do her work in the quality that she wanted. The reply she received was "You must learn to muddle along professionally".

The members of the project constantly "reveal" the boundaries between these professional practices. The distinction is found in their applied language, often prejudiced, but also in the material artefacts, they produce, such as drawings. Even the design meetings follow a structured agenda with a separation of the professional practices.

Having introduced CoPT in order to illuminate the reproduction and development of the professional practices in the project, it is important to notice that we implicitly inherit the notion of boundaries. This might seem problematic as ANT rejects the notion of boundaries by using another topology – the network. This position is highlighted by Tsoukas (1992), stating that "the most controversial element in a social system is its boundaries" (p. 441). We therefore now return to the network topology.

Collaborative practices - coordination practices

The focus of our attention is now on the weak ties between professional practices of the project. These are important for understanding how the project's practices are coordinated and aligned - in other words how collaboration occurs. Here actors who/which span the different practices such as drawings, the physical school, and the design leaders play central roles. From a CoP perspective these actors can be interpreted as boundary objects and brokers, which are founded in the "meaning making" processes of reification and participation (Wenger 1998).

Boundary objects

CoP can interact by reification: the exchange of boundary objects, which are tangible or intangible artefacts than cross boundaries between CoPs and are objects of reification in these. Wenger's (1998) explanation of boundary objects draws heavily upon Star & Griesemer (1989) who see boundary objects as anchors or bridges between practices. According to Star & Griesemer (1989) "boundary objects are objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" (p. 414). This implies that boundary objects are assigned different meanings in different CoPs but their structure is common enough to more than one

community to make them recognizable. In ANT this process is explained in the concept of interpretive flexibility, where objects mean different things to different actors due to the variable geometry in the network of relations (Law and Callon 1992).

Various types of boundary objects knit the design process together. Some of the most visible are drawings spanning from sketches to detailed CAD-drawings, resumes, descriptions of customer wishes, spreadsheets, economical calculations etc. These objects are constantly developed throughout the process gradually getting closer to the final representation. Some of the boundary objects are an outcome of a professional practice – Carlile (2002) terms these "Ends". An example is the drawings, which are produced in the engineering and architectural practices while the contractor produces the economical calculations. This does not inhibit professions from "commenting" on boundary objects produced by other professions, as objects from one professional practice might apply constraints to the work in the other practices. This element of dependency makes the design process a matter of negotiating the right solutions suiting the different professional practices.

Brokers

The other type of interaction is by participation; that is, by sharing individuals – brokers in Wenger's terminology – who actively participate in several CoPs. Through this connection persons can introduce elements from one CoP into another.

Star & Griesemer (1989) also touches on this element in terms of multiple memberships of 'social worlds' which they term 'marginal man'. They are referring to work from the beginning of the last century discussing problems of identity and loyalty with multiple memberships of social classes. This discussion of marginality is also found in Wenger (1998) as brokers not are at the very center of the CoP, but usually work in the boundaries through legitimized peripheral participation. What however characterizes an "effective" broker is the ability to introduce new possibilities for meaning which requires some kind of status in the community.

The existence of brokers in the project is rare compared to the crowded population of boundary objects. The closest match we find is the "bridge" between the "design team" and the professional practices. In the design meetings the professional practices are represented by one or two persons functioning as brokers between the design team and the home base. From the participating practices, the brokers might be marginal but in a larger perspective, these persons are critical in the coordination of the professional practices – being responsible for the negotiation of the right solutions and delivering the right design to the customer in the end. The mastery of this coordination is central to the learning process of the members of the professional practices, illustrated by Vignette II.

Vignette II: Mastering the coordination

Even if the architect Rasmus initially used most of his time drawing details, at the end of the project he was given the "responsibility" of designing a small extension to an existing building. In this process, he more frequently participated in the design meetings, representing the architectural company together with an experienced colleague. This experienced architect later explained the learning process that Rasmus was going through during a workshop: "Young architects is often the most idealistic, but as you start to work together with the other partners of the building project you continuously get better at finding compromises"

Also Susanne started to learn the skills of coordination, as she explained after having attended her first design meeting: "It was the first design meeting I attended – and I was disappointed, really disappointed about the communication between people. The way that people talked to each other and past each other. I had at least expected that people were talking nicely to each other and had the same visions about designing the best school"

On the contrary to the theories of CoP it is interesting to notice that the coordinating activities in the case are taken care of by "masters" of the professional practices. Thus both Susanne and Rasmus are first introduced to the core elements of their professional practices, before they are introduced to the practices of collaboration.

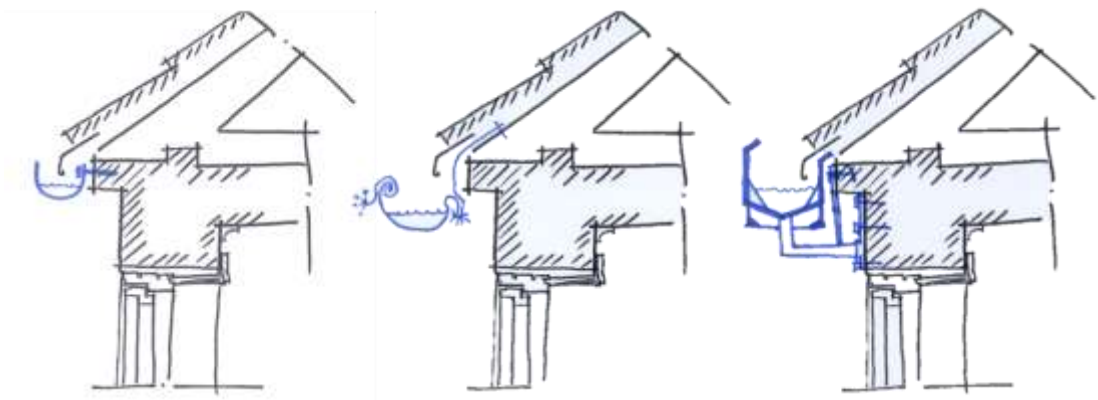
In fact it is questionable if the collaboration practices at all can be categorized as brokering activities or they just represent fierce negotiations between the professional practices without any mutual understanding…. As Susanne observers these coordination encounters are filled with tensions and conflicts.

COLLABORATION AND PREJUDICIES

One of reasons for the fierce negotiations might be found in the prejudices of the different actors. Prejudices are often thought of as a source of conflict but as we shall see in the following example they also represents a source for establishing smooth collaboration practices.

The example is from an initial workshop in the project where the central professional practices were participating. As a part of the workshop the participants were presented with an exercise on their mutual prejudices. The exercise started with a general introduction to prejudices in construction followed by an example on how different professions would design a solution for mounting gutter at the school (see figure 1).

Figure 1: Prejudices exemplified. Gutter solutions developed by different actors.



Subsequently the different participants were asked to identify and articulate their prejudices of the other professions in the project including the client/users. The result is shown in table 1 on the next page based on a distinction between Subject and Object of the prejudices. The outcome of the exercise was subsequently transformed into another exercise developing Key Performance Indicators for the project. After the

workshop these KPIs were successfully used as a boundary object regularly measuring the quality of collaboration in the project. Building upon the developed understanding of the project practices we will in the following discus the role and character of prejudices.

While prejudices often are seen as something to be minimized or eliminated a practice- based perspective introduces them as collective experiences which structure and enable/inhibiting the processes of collaboration.

By reading the table horizontally the table shows how the different profession (objects) are viewed illustrating shared believes among the other professions (subject). Thus the client are perceived as inexperienced and having difficulties in making decisions. The architects are viewed as ones who favour aesthetics designs and expensive solutions. The engineers are risk averse and the contractors are money fixated and favour cheap solutions.

Reading the table vertically another characteristic of prejudices emerge. The prejudices not only reveal the view on the different actors (horizontally) but also reveal core beliefs of the subject (vertically). Thus the architects are feeling constrained by all the other actors revealing "artistic" freedom is a fundamental driver of their profession. On the contrary the contractor statements reveal that managing budget and time is central to their profession. In this way prejudices is both looking outward and inward and thereby they enabling the identification of possible areas of conflicting dependencies in a project.

Table 1: Prejudices between the different professions in the project.

Subjects → Objects↓	Architect	Engineer	Contractor
Client/user	Constraining	Arduous	Keeps the money
	Demanding	Can't make decisions	Lack of preparation
	Amateur	optimistic about how much they can get for their money	Lack of trust
		Is not a homogeneous group	Inability to grasp decisions and economy
		Can't keep track of the kids	No timely decisions
Architect		Design is more important than structure	Difficult to comprehend
		wears black clothes	Expensive solutions
		Structures must not be visible	Lack of trust
		Installations should also ideally be hidden	No sense of time
		pompous, conceited	
Engineer	wears both belt and suspenders		Over estimates
	Limiting and constraining		”His word are law”
	Categorically		
Contractor	Undisciplined	Never does as drawn and described	
	Money-fixated	Creative with extra work	
	Pushes	Bad work (quality)	
	Constraining	Can't keep the schedule	
		Always shortcomings on delivery	

It is noticeable how the characteristics of the prejudices are diverse. Thus it can be argued that the prejudices represent the fundamental division of labour in the industry…placing them at the core of the organisation of the industry.

DISCUSSION AND IMPLICATIONS

Some of the learning points from the case suggest different strategies for development of more smooth collaboration practices.

The first relates to the absence of real brokers in the project. While collaboration practices is sustained by masters from the professional practices none of the humans actors really bridges the different professional practices, thus are collaboration inherently build on accumulated experiences from other projects - prejudices. However within the contracting company there where examples of actors who worked as design managers for the contractor but with an educational background as an architect. These design managers where often considered as the most successful due to their ability to mediated between the different professional practices.

The second strategy is about challenging the one of-a-kind collaboration practices of construction - developing long term relations. This was also present in the case - although in the periphery. In the project there was a special relationship between the architectural company and the HVAC engineer from technical consultant. The reason was that the later didn't work in the headquarter of the company but was employed at a local office in the same city as the architectural company. Due to their local presence the local office of the technical consultant and the architectural company had worked together on several projects throughout the years and consequently they had developed a deep, detailed and tacit understanding of each other's practices. This was illustrated at a design meeting where one of the architects stated "We don't need to coordinate with him (the HVAC engineer) because we know how he draws". Even though this way of repeating collaboration is challenging to set up, it is recently found to be a core practice among successful project managers (Jørgensen 2013).

While the two examples might be difficult to achieve in every project a more deliberately strategy for handling prejudices might be beneficial. Because, although prejudices can act as a hindering they also represent a source for understanding the actions of others and thus might workshops like the one in the case facilitate more conscious collaboration practices.

CONCLUSION

This paper has explored the formations of identity and collaboration in construction. Identity is closely linked to the membership of the professional practices like being an architect and in the physical manifestations of their practices (the building). However while the product of the projects lasts the experiences from the process vanishes and becomes embedded in the future practices in the form of prejudices. Since these prejudices represents collective experiences which structure and enables the collaboration processes they should not be disregarded but taken into account in managing and organizing the project team.

ACKNOWLEDGEMENT

The author is deeply grateful to the constructive reviewers. Their guidance has been really valuable in the development of the paper. Specifically I would like to thank you for the reference to the wonderful quote of Elizabeth Bennet in Pride and Prejudice.

REFERENCES

Austen, J. (1883) Pride and Prejudice, Egerton, London UK

Arthur Tatnall, A. and Gilding, A. (1999) “Actor-Network Theory and Information Systems Research”, Proc. 10th Australasian Conference on Information Systems, pp. 955-966

Bloor, G. & Dawson, P. (1994), "Understanding Professional Culture in Organisational Context", Organisation Studies, vol. 15, no. 2, pp. 275-295.

Carlile, P. R. (2002), "A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development", Organization Science, vol. 13, no. 4, pp. 442-455.

Gherardi, S. and Nicolini, D. (2002) "Learning in a constellation of interconnected practices: Canon or dissonance?" Journal of Management Studies, vol. 39, no. 4, pp 419-436.

Harty, C. (2008), “Implementing innovation in construction: contexts, relative boundedness and actor-network theory”, Construction Management and Economics, Vol. 26 No. 10, pp. 1029-41.

Jensen, T. E. (2001), "Performing Social Work - Competence, orderings, spaces and objects", Department of Psychology, University of Copenhagen.

Jørgensen, K. Schultz, C.S. & Bonke, S. (2013) "Processer og metoder i det fejlfrie byggeri - Erfaringer og anbefalinger fra projektledere i entreprenørbranchen", Report published at Technical University of Denmark ISBN 978-87-92706-97-3

Koch, C. & Thuesen, C. (2013) Knowledge sharing in construction partnering projects - redundancy, boundary objects and brokers, Int. J. of Project Organisation and Management, 2013 Vol.5, No.1/2, pp.156 - 175

Latour, B. (1996), Aramis: Or for the Love of Technology, Harvard University Press, Cambridge, MA

Lave, J. and Wenger, E. (1991) Situated Learning. Legitimate Peripheral Participation. Cambridge University Press, Cambridge

Law, J. (2002), Aircraft Stories: Decentering the Object in Technoscience, Duke University Press, Durham, NC.

Loosemore, M. and Tan C. C. (2000) Occupational stereotypes in the construction industry. Construction Management and Economics, Vol.18, No. 5, pp 559- 566.

Lowe, A. (2001), "Accounting information systems as knowledge-objects: some effects of objectualization", Management Accounting Research no. 12, pp. 75-100.

Nicolini, Davide (2012), Practice Theory, Work, and Organization, Oxford University Press

Orr, J. (1996) Talking about Machines: An ethnography of a Modern Job. Cornell University Press, Ithaca, NY.

Ruikar K., Koskela L. and Sexton, M. (2009) Communities of practice in construction case study organisations: Questions and insights. Construction Innovation: Information, Process, Management, Vol. 9 No. 4, pp 434-448

Sage, D., Dainty, A., and Brookes, N. (2011),"How actor-network theories can help in understanding project complexities", International Journal of Managing Projects in Business, Vol. 4 Iss: 2 pp. 274 - 293

Schatzki, T.R., Knorr-Cetina, K. and von Savigny, E. (2001), The Practice Turn in Contemporary Theory, Routledge, London.

Star, S. L. & Griesemer, J. R. (1989), "Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39", Social Studies of Science, vol. 19, pp. 387-420.

Suchman, L. (2000), “Organizing alignment: a case of bridge-building”, Organization, Vol. 7 No. 2, pp. 311-27.

Thuesen, C. (2005), "Knowledge Utilization in Projects – a Practice-based Perspective", OLKC 2005 Conference, Boston, USA

Tryggestad, K., Georg, S. and Hernes, T. (2010), “Constructing buildings and design ambitions”, Construction Management and Economics, Vol. 28 No. 6, pp. 695-706.

Tsoukas, H. (1992), "Ways of Seeing: Topographic and Network Representations in Organization theory", Systems Practice, vol. 5, no. 4, pp. 441-456.

Wenger, E. (1998) Communities of Practice Learning, Meaning, and identity.Cambridge University press. Cambridge.

INTER-ORGANISATIONAL RELATIONSHIPS AND SUPPLY CHAIN MANAGEMENT

TO CONTINUE INVESTMENT IN A COLLABORATIVE INNOVATION PROJECT: A GOOD DECISION?

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Collaborative innovation projects are projects in which firms come together to jointly develop and commercialize a new building product, system or service. They are an example of the type of inter-firm relationships that are said to enhance construction innovation. Organisational behaviour research, however, suggests that firms participating in collaborative innovation projects run the risk of escalating commitment and may continue to invest for irrational reasons. The current study examined whether firms in the Dutch construction industry participating in such projects are susceptible to this escalation. Two escalation effects were investigated: the effect of expected loss of sunk costs, and the effect of perceived project stage. The study surveyed 154 firms participating in 25 collaborative innovation projects. The hierarchical nature of the data (i.e. the firms are all nested within innovation projects) meant a hierarchical linear model was used to examine the effects. A statistically significant association was found between expected loss of sunk costs and the likelihood of a firm continuing investment. However, contrary to what escalation theory would predict, the association was found to be negative, rather than positive. No statistically significant association was found between perceived project stage and the likelihood of a firm continuing investment. These results suggest that, when deciding whether or not to continue to invest in a collaborative innovation project, firms in the construction industry are unlikely to fall victim to either of the two escalation effects. Rather, the negative association identified raises the question as to whether firms are abandoning collaborative innovation projects too early.

Keywords: decision theory, innovation, inter-organisational relation.

INTRODUCTION

When it comes to innovation, it has been suggested that the construction industry is characterized by a low rate of innovation; also described as "zephyrs of creative destruction" (Winch 1998). A review of the literature on construction innovation highlighted six main factors which either drive or hinder construction innovation (Blayse and Manley 2004). One factor is the type of relationship between firms in the industry. For example, a study by Dubois and Gadde (2002: 629) indicated that tighter relationships between firms beyond individual construction projects could enhance the

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Rutten MEJ, Dorée AG and Halman JIM (2013) To continue investment in a collaborative innovation project: a good decision? *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 471-481.

opportunities for innovation. Miozzo and Dewick (2004: 71) observations on the relationship between inter-firm collaboration and construction innovation commented: "In a complex systems industry, such as construction, firms must rely on the capabilities of other firms to produce innovations and this is facilitated by some degree of continuing cooperation between those concerned with the development of products, processes and designs." When considering how relationships between firms may foster construction innovation Dubois and Gadde suggested that what is needed are tighter relationships between firms beyond the level of individual construction projects or, as Miozzo and Dewick saw it, developing relationships between firms with some degree of continuing cooperation. The current study focuses on collaborative innovation projects which are a good example of this type of relationship between firms.

A collaborative innovation project is a project in which firms join forces to cooperate in the development and commercialization of a new building product, system, or service for a range of potential customers or clients (Blindenbach-Driessen *et al.* 2010: 577). Examples from the literature include the joint development and commercialization of a new modular housing system (Hofman *et al.* 2009) and the joint development and commercialization of a new environmentally friendly window (Rutten *et al.* 2009). For a collaborative innovation project to exist and to achieve success, firms must be willing to commit resources to the project. Therefore, given the industry's generally low rate of innovation, is the decision to allocate resources to a collaborative innovation project a good decision, or not?

The so-called Radar-Blank Plane (RBP) experiments conducted by organisational behaviour researchers provide relevant results. These experiments suggest that, once a firm starts to participate in a collaborative innovation project it may escalate commitment (for examples, see Arkes and Blumer 1985; Conlon and Garland 1993). A firm is said to escalate commitment when it, for reasons that are not economic, decides to allocate additional resources to continue the project (Staw 1976; Schmidt and Calantone 2002). Although escalation of commitment is a widespread phenomenon present in various contexts (Brockner 1992), research indicates that the tendency to escalate commitment may vary between populations (Tan and Yates 1995; Van Putten *et al.* 2010). This raises the question of whether firms in construction industry that do participate in collaborative innovation projects are likely to escalate commitment.

The current study aim, building on the findings of the RBP experiments, was to examine whether firms in the construction industry that participate in collaborative innovation projects are susceptible to two escalation effects: a). the effect of expected loss of sunk costs, and b). the effect of perceived project stage. It would be unfortunate if firms were susceptible to these escalation effects as the resources available to firms to invest in the development and commercialization of new building products, systems and services are limited. In these scenarios, escalation of commitment would be an undesirable phenomenon.

THEORETICAL BACKGROUND AND HYPOTHESES

The first RBP experiments were conducted in the 1980s (Arkes and Blumer 1985) as part of research into the influence of sunk costs (i.e. resources already spent) on the escalation of commitment behaviour. The participants first had to read a scenario of an innovation project in which a radar-blank plane was being developed. They then had to decide whether to abandon the innovation project, or to allocate additional

resources to continue the innovation project. The results showed that, once an innovation project had incurred costs, the participants were more willing to continue investing in the project compared with a project that had not yet incurred any costs. These findings were remarkable since microeconomic theory posits that only the variation in future revenues and costs between alternative courses of action are relevant when making choices, i.e. that, effectively, sunk costs are deemed to be irrelevant (Horngren *et al.* 2007).

Since then, researchers have continued to use the RBP scenarios to study various effects (Rutten *et al.* 2013). The sunk cost effect has become the most studied. 18 RBP experiments have shown the following results. Ten experiments found a significant positive relationship suggesting that sunk costs make it more likely that firms continue to invest in an innovation project (Arkes and Blumer 1985; Garland 1990; Garland and Newport 1991; Arkes and Hutzel 2000; Moon 2001b, a; Van Dijk and Zeelenberg 2003). Three experiments were ambiguous and, depending on the type of participant or the measure of the dependent variable, either a positive significant relationship or no significant relationship was found (Conlon and Garland 1993; Tan and Yates 1995; Van Putten *et al.* 2010). Four experiments found no significant relationship suggesting that sunk costs are not influential on whether firms continue to invest in an innovation project (Conlon and Garland 1993; Tan and Yates 1995; Garland and Conlon 1998; Moon *et al.* 2003). And one experiment found a significant negative relationship suggesting that sunk costs make it less likely that firms continue to invest in an innovation project (Garland and Conlon 1998). Overall, the most common finding was that sunk costs were positively associated with the likelihood of continuing investment.

Various scholars have explained these positive associations by drawing on loss aversion theory (Arkes and Blumer 1985; Garland and Newport 1991). This theory states that people have a strong desire to avoid losses and are particularly averse to losses that are certain. It has been argued that this tendency underlies the sunk cost effect as decision-makers may think that to abandon an ongoing innovation project will result in "a certain loss of the amount already invested (Arkes and Blumer 1985: 132)" and, as a result, it is more attractive to choose to continue investing in the innovation project. This line of reasoning is also referred to as a "sunk cost fallacy" in the literature (Arkes and Ayton 1999). This research may be relevant for firms in the construction industry that participate in collaborative innovation projects as they also could fall victim to this same fallacy. Consequently, we hypothesize that:

> Hypothesis 1. The loss of sunk costs that a firm participating in a collaborative innovation project expects if it would abandon the collaborative innovation project is positively associated with the firm's likelihood of continuing their investment.

The second effect most studied in the RBP experiments is the project completion effect first reported by Conlon and Garland (1993). The term project completion refers to how close an innovation project is to completion. In general, innovation projects are really only completed when the newly developed product or service has become profitable in the market place. Conlon and Garland had noticed that, in previous RBP experiments, the level of sunk costs was confounded with the degree to which a project was completed. Therefore, they sought to separate out the variables by conducting two experiments. Both experiments showed a significant positive relationship between the degree to which a project was completed and the likelihood

of continuing investment. This confirmed their expectation that a firm's desire to complete an innovation project actually does increase as project completion gets nearer (Conlon and Garland 1993: 410). Since then, the project completion effect has been examined in eight other RBP experiments (Garland and Conlon 1998; Moon 2001b, a; Moon *et al.* 2003; He and Mittal 2007; Harvey and Victoravich 2009). The results of these experiments were similar to the results of the two experiments by Conlon and Garland. This means all 10 experiments have observed a significant positive relationship which strongly suggests that the closer an innovation project is to completion the greater the likelihood is that a firm will continue to invest in it. Once again, findings from the field of organisational behaviour are relevant to firms in the construction industry that participate in collaborative innovation projects. As such, we would expect, for example, that firms working with innovation projects already in the market introduction stage would be more likely to continue to invest in them as when compared with firms with projects that are still in the earlier development stage. Consequently, we hypothesize that:

> Hypothesis 2. The stage of a collaborative innovation project, as perceived by a firm that participates, is positively associated with the firm's likelihood of continuing to invest.

METHOD

In order to test these two hypotheses we conducted a survey among Dutch firms participating in a collaborative innovation projects developing and commercializing new building products, systems, or services. By studying firms in real-world settings, rather than university students in laboratory settings (which is the case with most RBP experiments), we have added a field study to a research stream otherwise dominated by laboratory studies. From a methodological perspective, this represents a form of triangulation (Colquitt 2008).

Sample and data collection

A two-stage sampling procedure was used to select firms. First, we contacted organisations in the Netherlands familiar with collaborative innovation projects and the firms involved. This included two construction industry associations and three semi-governmental organisations promoting innovation. This led to the identification of 32 collaborative innovation projects eligible for the study. For 25 of these collaborative innovation projects, involving in total 154 firms, we received the names and email addresses of the individuals who on behalf of the firms participated in the collaborative innovation projects. The number of firms in a collaborative innovation project ranged from 3 to 10.

The survey was constructed using online survey software (Unipark EFS Survey). An invitation email with a link to the survey was sent to each firm between April 2009 and March 2010. Non-responders were sent a reminder after two weeks and a second reminder after four weeks. Of the 154 firms, 122 responded to the survey which represents a response rate of 79%. 15 firms were excluded as they did not complete the survey. Four other firms were excluded as, in fact, they had not invested in a collaborative innovation project. Thus, the final sample included 103 firms.

Variables

Likelihood of continuing investment (dependent variable)
The likelihood that a firm continues to invest was measured by asking the question: "How likely it is that your firm continues to invest in the collaborative innovation project?" The response scale ranged from 1, very unlikely, to 7, very likely.

Expected loss of sunk costs (independent variable)
The loss of sunk costs that a firm expects if it would abandon the collaborative innovation project was measured by asking: "If your firm would decide to quit now, would that lead to a great or small loss of investments for your firm?" The response scale ranged from 1, very small, to 7, very great.

Perceived project stage (independent variable)
The stage of the collaborative innovation project as perceived by a firm was measured by asking: "In what stage is the collaborative innovation project?" Responses were coded 0, for exploratory or development stage, and 1, for market introduction or market growth stage.

Control variables
Two more variables were included since, based on previous research (Conlon and Garland 1993; Moon 2001b), we thought that they may have a causal effect on the dependent variable and could be correlated with at least one of the independent variables. This makes them important variables to be controlled for (Allison 1999). These were: the "perceived enthusiasm among potential customers or clients"; and, the "length of participation".

The former control variable was measured by asking respondents to indicate their level of agreement with the following statement, "Potential customers or clients are enthusiastic about the new product, system, or service." The response scale ranged from 1, strongly disagree, to 6, strongly agree.

The latter control variable was measured by asking, "Since when is your firm involved in the collaborative innovation project? Please select quarter and year," and subtracting the respondent's answer from the quarter and year in which the respondent completed the survey.

Method of analysis

The analysis is based on the notion that the data have a nested structure, i.e. the firms involved are all nested within collaborative innovation projects. We adopted hierarchical linear modeling (HLM; Raudenbush and Bryk 2002) to investigate our hypotheses as have other studies involving nested data (Hitt *et al.* 2007). HLM has an important benefit in examining nested data when compared with analysis using ordinary least squares regression (OLS). In nested data observations are not independent. However, OLS assumes that observations are independent. Violation of this assumption leads to underestimation of the standard errors of regression coefficients and this increases the risk of type I errors. A type I error occurs when "we believe that there is a genuine effect in the population when, in fact, there isn't (Field 2005: 31)." HLM, on the other hand, takes into account the nested structure of data. It reduces the risk of type I errors by partitioning the residual variance into a 'between-group' component and a 'within-group' component (in this study the groups correspond to the collaborative innovation projects). An online video presentation from the Centre for Multilevel Modeling (Rasbash 2006) provides further information on how this works.

RESULTS

Table 1 presents the descriptive statistics and correlations for the variables used in this study. The survey found that 88% of the firms in the sample employ less than 250 employees and that the sample consists of a variety of firms: architectural and engineering firms (15%); construction firms (33%); suppliers (21%); and, other types (31%). The survey also found that 79% of the respondents rated his or her influence on their firm's decision to continue investment as either large, or very large.

Table 1: Means, Standard Deviations, and Correlations

Variable	Mean	s.d.	1	2	3	4
1 Likelihood of continuing investment	5.17	1.45				
2 Expected loss of sunk costs	3.95	1.78	–.19†			
3 Perceived project stage	0.42	0.50	.20*	–.11		
4 Perceived enthusiasm among potential customers or clients	4.59	0.86	.19†	.22*	.01	
5 Length of participation	2.25	2.51	.14	.03	.38**	–.18†

Firms' n = 103, collaborative innovation projects' n = 25.

† $p < .10$

* $p < .05$

** $p < .01$

Two-tailed tests.

In running the HLM model and in order to calculate the intraclass correlation coefficient (ICC), we first ran a "null" model in which no independent or control variables were entered. The null model resulted in an ICC of 0.14, indicating that 14% of the variance in a firms' likelihood of continuing investment is due to differences between collaborative innovation projects. In contrast 86% of the variance in the likelihood of a firm continuing investment is due to differences between firms. Second, we added the independent and control variables to the HLM model. Adding the independent and control variables shows that these variables explain 11% of the variance in the likelihood of a firm continuing to invest ($R^2 = .11$). Table 2 presents the results of the HLM model.

The tests of the two hypotheses gave the following results. Hypothesis 1 predicted that the expected loss of sunk costs when abandoning the collaborative innovation project will be positively associated with a firms' likelihood of continuing investment. The results in Table 2 do not support this hypothesis. On the contrary, the results show a statistically significant negative relationship which the coefficient of -0.196 being significant at the .05 level. This is a complete contradiction of Hypothesis 1.

Hypothesis 2 predicted that the perceived stage of the collaborative innovation project will be positively associated with firms' likelihood of continuing investment. The results do not support this hypothesis either. The coefficient for perceived project stage is positive (0.338) but this is not statistically significant since the p-value is greater than .05.

Table 2: Results of Hierarchical Linear Modeling for Likelihood of Continuing Investment

Variable	Predicted effect	Coefficient	s.e.	p	R^2
Null model					
Intercept		5.175***	0.175	<.001	
Random-intercept model					
Intercept		5.024***	0.185	<.001	.11
Expected loss of sunk costs	H1 (+)	–0.196*	0.079	.016	
Perceived project stage	H2 (+)	0.338	0.302	.266	
Perceived enthusiasm among potential customers or clients		0.452**	0.167	.008	
Length of participation		0.087	0.060	.155	

Firms' n = 103, collaborative innovation projects' n = 25.

Expected loss of sunk costs, perceived enthusiasm among potential customers, and length of participation have been centered around the grand mean.

* p < .05

** p < .01

*** p < .001

Two-tailed tests.

DISCUSSION

The present study set out to investigate the behaviour of firms in the construction industry participating in collaborative innovation projects. The aim was to test whether these firms are likely to escalate their commitment in such projects given two possible influencing factors. First, the thought that abandoning the project will lead to a large loss of sunk costs. Second, the notion that the project is at an advanced stage. The results of this study suggest not. We now discuss potential explanations for the (somewhat surprising) results and their implications and limitations.

The results indicate that firms that expect a large loss of sunk costs, if they would abandon a collaborative innovation project, are less likely to continue to invest than firms expecting a small loss of sunk costs. This is a remarkable finding since, based on loss aversion theory and the results of the RBP experiments, one would expect the opposite. The question is how to explain the negative relationship found? Contrary to most RBP experiments one showed a negative sunk cost effect. The researchers involved argued that the negative effect might be explained by the participants' relatively high "sensitivity to expenditures" (Garland and Conlon 1998: 2035). The idea here is that a heightened sensitivity to expenditures can lead people to behave more cautiously when deciding whether or not to invest future resources. This might be a characteristic of the negative relationship we found. In our sample, 88% of the firms had less than 250 employees and, thus, the sample is dominated by small and medium-sized firms (SMEs). This is not surprising since the construction industry is well-known for its high percentage of SMEs (Dainty *et al.* 2005). It has been argued also that, in order to understand the innovation dynamics in construction industry, one needs to take account of the dynamics of how SMEs innovate (Sexton and Barrett 2003a, b) when the resources available to them "to innovate in parallel with normal business" are very scarce (Barrett and Sexton 2006: 331). Therefore, the negative

relationship found in this study might not be so surprising. SMEs in the construction industry that expect a large loss of sunk costs, if they would abandon a collaborative innovation project, are likely to have been spending a relatively large share of the scarce resources they have available to innovate. This may heighten their sensitivity to spending future resources and make them more cautious to continue investment when compared with firms that have spent fewer resources.

This line of reasoning prompts a further question. In which of the two situations might firms' investment decisions be flawed - when they have spent a small amount or a large amount of resources? Since we controlled for the perceived enthusiasm of potential customers and clients, firm's likelihood of continuing to invest seems, from an economic point of view, to be either irrationally high in the first situation, or irrationally low in the second situation. These are considerations that firms might want to be aware of.

Furthermore, the results suggest that firms that consider a collaborative innovation project to be at an advanced stage are not more likely to continue to invest when compared with firms that consider such projects to be at a less advanced stage. The project-based nature of the construction industry may explain why we did not find the same positive relationship as that found in the RBP experiments. Whereas the RBP experiments involved student participants, our survey engaged with "professional experts at doing projects" who, as a collaborative innovation project progresses, might be less inclined to substitute the project's goal with the goal of completing what was started. This explanation is supported by a study on the endowment effect (List 2003). This is an escalation effect found in other contexts which states that owning a good increases its value to the owner. List’s study showed that professional experience eliminated the endowment effect. Overall, the results suggest that it would not be necessary to warn firms involved in collaborative innovation projects against a project stage effect.

CONCLUSION

When firms come together and collaborate in developing and commercializing a new building product, system or service, then organisational behaviour research suggests they may escalate commitment. This would be an undesirable phenomenon, particularly when the resources which firms in the construction industry have available for innovation are often limited. In this respect the current study brings good news. The effects we studied do not seem to suggest that firms are more willing to continue investing in a collaborative innovation project, either when a firm expects a large loss of sunk costs if it would abandon the collaborative innovation project, or when a firm realises that the collaborative innovation project has reached an advanced stage. In fact, we conclude that firms that expect a large loss of sunk costs if they would abandon a collaborative innovation project, are less likely to continue to invest than firms that expect a small loss of sunk costs. This represents a de-escalation effect (instead of an escalation effect).

The main limitation of this study, as is the case with most studies on firms (Short *et al.* 2002), is that our data comes from a non-random and not a random sample. Non-random sampling procedures may bias results. Therefore, our study results do need to be interpreted with caution.

We can conclude with some practical implications of our study and, in particular, the implications of the de-escalation effect found. The de-escalation effect suggests that a

firms' willingness to continue to invest is either irrationally high when little has been spent, or irrationally low when a lot has been spent. In other words, the results seem to offer the following advice to firms in the construction industry: "Participating in a collaborative innovation project? Take care not to continue just because you have spent a little, or to quit just because you have spent a lot."

REFERENCES

Allison, P D (1999) "Multiple regression: A primer". Thousand Oaks: Sage Publications.

Arkes, H R and Blumer, C (1985) The psychology of sunk cost. "Organizational Behavior and Human Decision Processes", 35(1), 124-40.

Arkes, H R and Ayton, P (1999) The sunk cost and concorde effects: Are humans less rational than lower animals? "Psychological Bulletin", 125(5), 591-600.

Arkes, H R and Hutzel, L (2000) The role of probability of success estimates in the sunk cost effect. "Journal of Behavioral Decision Making", 13(3), 295-306.

Barrett, P S and Sexton, M G (2006) Innovation in small, project-based construction firms. "British Journal of Management", 17, 311-46.

Blayse, A M and Manley, K (2004) Key influences on construction innovation. "Construction Innovation", 4(3), 143-54.

Blindenbach-Driessen, F, van Dalen, J and van den Ende, J (2010) Subjective performance assessment of innovation projects. "Journal Of Product Innovation Management", 27(4), 572-92.

Brockner, J (1992) The escalation of commitment to a failing course of action - toward theoretical progress. "Academy Of Management Review", 17(1), 39-61.

Colquitt, J A (2008) Publishing laboratory research in amj: A question of when, not if. "Academy Of Management Journal", 51(4), 616-20.

Conlon, D E and Garland, H (1993) The role of project completion information in resource-allocation decisions. "Academy Of Management Journal", 36(2), 402-13.

Dainty, A R J, Ison, S G and Briscoe, G H (2005) The construction labour market skills crisis: The perspective of small–medium-sized firms. "Construction Management and Economics", 23, 387-98.

Dubois, A and Gadde, L E (2002) The construction industry as a loosely coupled system: Implications for productivity and innovation. "Construction Management and Economics", 20(7), 621-31.

Field, A P (2005) "Discovering statistics using spss". Thousand Oakes: SAGE Publications.

Garland, H (1990) Throwing good money after bad - the effect of sunk costs on the decision to escalate commitment to an ongoing project. "Journal of Applied Psychology", 75(6), 728-31.

Garland, H and Newport, S (1991) Effects of absolute and relative sunk costs on the decision to persist with a course of action. "Organizational Behavior and Human Decision Processes", 48(1), 55-69.

Garland, H and Conlon, D E (1998) Too close to quit: The role of project completion in maintaining commitment. "Journal of Applied Social Psychology", 28(22), 2025-48.

Harvey, P and Victoravich, L M (2009) The influence of forward-looking antecedents, uncertainty, and anticipatory emotions on project escalation. "Decision Sciences", 40(4), 759-82.

He, X and Mittal, V (2007) The effect of decision risk and project stage on escalation of commitment. "Organizational Behavior and Human Decision Processes", 103(2), 225-37.

Hitt, M A, Beamish, P W, Jackson, S E and Mathieu, J E (2007) Building theoretical and empirical bridges across levels: Multilevel research in management. "Academy Of Management Journal", 50(6), 1385-99.

Hofman, E, Voordijk, H and Halman, J (2009) Matching supply networks to a modular product architecture in the house-building industry. "Building Research And Information", 37(1), 31-42.

Horngren, C T, Sundem, G L, Stratton, W O, Schatzberg, J and Burgstahler, D (2007) "Introduction to management accounting". 14th ed. Upper Saddle River, N.J: Pearson Prentice Hall.

List, J A (2003) Does market experience eliminate market anomalies? "Quarterly Journal of Economics", 118(1), 41-71.

Miozzo, M and Dewick, P (2004) Networks and innovation in european construction: Benefits from inter-organisational cooperation in a fragmented industry. "International Journal Of Technology Management", 27(1), 68-92.

Moon, H (2001a) The two faces of conscientiousness: Duty and achievement striving in escalation of commitment dilemmas. "Journal of Applied Psychology", 86(3), 533-40.

Moon, H (2001b) Looking forward and looking back: Integrating completion and sunk-cost effects within an escalation-of-commitment progress decision. "Journal of Applied Psychology", 86(1), 104-13.

Moon, H, Conlon, D E, Humphrey, S E, Quigley, N, Devers, C E and Nowakowski, J M (2003) Group decision process and incrementalism in organizational decision making. "Organizational Behavior and Human Decision Processes", 92(1-2), 67-79.

Rasbash, J (cited 2013) "What is it and why you should do it (multilevel modelling)". [Available online from http://www.bristol.ac.uk/cmm/learning/videos/.]

Raudenbush, S W and Bryk, A S (2002) "Hierarchical linear models: Applications and data analysis methods". Thousand Oaks: Sage Publications.

Rutten, M E J, Dorée, A G and Halman, J I M (2009) Innovation and interorganizational cooperation: A synthesis of literature. "Construction Innovation", 9(3), 285-97.

Rutten, M E J, Dorée, A G and Halman, J I M (2013) Exploring the value of a novel decision-making theory in understanding r&d progress decisions. "Management Decision", 51(1), 184 - 99.

Schmidt, J B and Calantone, R J (2002) Escalation of commitment during new product development. "Journal of the Academy of Marketing Science", 30(2), 103-18.

Sexton, M G and Barrett, P S (2003a) A literature synthesis of innovation in small construction firms: Insights, ambiguities and questions. "Construction Management and Economics", 21, 613-22.

Sexton, M G and Barrett, P S (2003b) Appropriate innovation in small construction firms. "Construction Management and Economics", 21, 623-33.

Short, J C, Ketchen, D J and Palmer, T B (2002) The role of sampling in strategic management research on performance: A two-study analysis. "Journal Of Management", 28(3), 363-85.

Staw, B M (1976) Knee-deep in the big muddy: A study of escalating commitment to a chosen course of action. "Organizational Behavior and Human Performance", 16(1), 27-44.

Tan, H T and Yates, J F (1995) Sunk cost effects - the influences of instruction and future return estimates. "Organizational Behavior and Human Decision Processes", 63(3), 311-9.

Van Dijk, E and Zeelenberg, M (2003) The discounting of ambiguous information in economic decision making. "Journal of Behavioral Decision Making", 16(5), 341-52.

Van Putten, M, Zeelenberg, M and van Dijk, E (2010) Who throws good money after bad? Action vs. State orientation moderates the sunk cost fallacy. "Judgment and Decision Making", 5(1), 33-6.

Winch, G (1998) Zephyrs of creative destruction: Understanding the management of innovation in construction. "Building Research And Information", 26(5), 268-79.

CAPACITY BUILDING IN EMERGING ECONOMIES THROUGH INTERNATIONAL CONSTRUCTION VENTURES- CASE STUDY OF THE NMPP PROJECT

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Although International Construction Joint Venture (ICJV) projects are believed to be beneficial with regard to aiding capacity building in the local construction industry, it is still debatable, whether such skills and technology transfer effectively occurs in the hosting companies in emerging economies. Substantial research on technology and skills transfer from developed country construction companies to emerging counterparts reveals worrying trends. South African construction companies are therefore not immune to these undesirable trends. Three main issues are dealt with in this paper: whether foreign partnering company have knowledge and technology that the local partner is lacking; how international construction joint venture projects are structured at delivery stage; and what are the key strategic elements of expertise transfer in an international construction joint venture project relating to organisational structure. The study used case studies to identify, analyze and establish the relationship between interaction in the work place and collaboration in job tasks. Finally, the paper proposes a conceptual project delivery structure that can accelerate the transfer of expertise in the South African Construction Industry (SACI).

Keywords: capacity building, knowledge transfer, international construction, joint venture, organizational learning, knowledge based views, South Africa

INTRODUCTION

A scrutiny of technology development across the world reveals interesting dynamics. According to Ray (2012), there are strong indications to suggest that the transfer of technology (TT) from developed economies to the emerging economies plays an important role in meeting the technological needs of the latter. He argues that a strict patent regime adopted by an emerging country encourages the transfer of the latest technology from the developed countries. When this scenario is taken at industry level, the specifics and dynamics of the industry influence the strict patent regime

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Rwelamila PD, Henjewele C and Mkandawire S (2013) Capacity building in emerging economies through international construction ventures- case study of the NMPP project *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 483-492.

adopted at country level. The results reported in this paper focused on the South African construction industry (SACI).

According to the Construction Industry Development Board (CIDB) (2004), the performance and capability of the industry is pivotal to transport and communication, import and export, industry development, and to all the logistics of a growing economy that increasingly supports an integrated and economically active population. The SACI is considered to be one of the few African advanced construction industries and thus its role extends beyond the borders of South Africa to other countries across the continent, and the current African infrastructure backlog suggests that the SACI's role is more prominent across the continent today than ever before.

The findings of the Infrastructure Consortium for Africa (ICA) (2010) strongly suggest that inefficient and insufficient infrastructure holds back Africa's economic growth per capita by 2% each year, and reduces firms' productivity by as much as 40%. Thus, Africa will need to invest approximately 40 Billion US Dollars of annual investment in infrastructure over the coming decade and a further 40 Billion US Dollar worth of upkeep on existing networks [Organization for Economic Co-operation and Development (OECD) (2008)].

In order to meet the South African and African infrastructure demands, the SACI needs to possess sufficient competent skills, technology and resources capacity. According to Rwelamila (2006) and Merrifield (2006), the SACI is lacking experience, skills and technology to meet the demand for successful delivery of these projects both within South Africa and across the continent. Unless serious efforts are made to address capacity constraints, cost escalations and poor quality are likely to stifle growth going forward. Hence, the need to overcome the shortage of domestic skills and technology through joint ventures with overseas partners (Sewapaul 2007).

This paper aims to shed some light on the relationship between interaction in the work place and collaboration in job tasks. Although knowledge could potentially come from within the project or country, this paper focuses on international transfer of knowledge through joint ventures. It looks at how the relationship within the JV companies affects the sharing of knowledge and technology. To achieve this, the paper reviews theory and practice of TT and discusses the role played by the international construction joint ventures (ICJV) in the acquisition of knowledge and technology. Finally, the paper presents a case study to demonstrate how the gap identified through the synthesis and analysis of theory and practice of TT literature can be filled.

THEORY AND PRACTICE OF TT – EMPHASIS ON INTER-FIRM TT

According to Bessant and Francis (2005), studies on TT have primarily adopted "the economic trade approach" in developing a linear technology transfer model. Reflecting on the early 1980s research on TT, Hope (1983) observed that most research on TT emphasized the effectiveness of specific technologies that were being transferred within a broader context of economic development. Wahab, Rose and Osman (2012) further observed that the same emphasis dominated the 1980s research on TT from the strategic management perspective.

Post 1980s research took TT research to the next level with an emphasis on the significance of learning at the organizational level (Figuereido, 2001). Figuereido (2001) argued that learning at the organizational level should be considered as a key element in facilitating technology transfer. Thus TT models started to absorb the

principles of the organization development movement advanced by French and Bell (1995).

According to Wahab, Rose and Osman (2012), strategic management researchers have further contributed to the development of TT frameworks centred on the knowledge-based view (KBV) of the firm and organizational learning (OL) perspective. These perspectives have quite similar dimensions, in terms of the outcomes, processes, barriers and facilitators and have significantly contributed to the expansion of TT models. This is supported by the literatures from both KBV and OL perspectives that appear to subsume most of the contributions of the TT literatures (Daghfous, 2004).

It is important to note from a review of literature that the relevant theories and practices, which are found to be related to intra and inter-firm technology transfer, are the international trade theory, foreign direct investment (FDI) theory, resource-based theory, knowledge-based view of the firm perspective and organizational learning perspective. Some scholars apply the terms 'technology' and 'knowledge' interchangeably to establish a close association between technology transfer and knowledge transfer (Kogut and Zander, 1993; Sazali and Raduan, 2011). Due to a lack of space and brevity, only theory and practice literature within the research theme – inter-firm technology transfer is reviewed under this section from a selected few researchers. These were selected for their connection with organizational learning and knowledge based views, which are the focus of this paper.

Inter-firm technology transfer

Liao and Hu (2007) found that inter-firm technology and knowledge transfer are viewed as a process of inter-organizational learning. This view is consistent with Huber's (1991) work on organizational learning perspective, which emphasized knowledge acquisition by the organizations. There are strong indications to suggest that for some time, knowledge acquisition of new capabilities through organization learning has been recognized as conferring a sustainable competitive advantage on the firms (Bontis, Crossan, and Hulland, 2002).

A number of studies (for example Eisenhardt and Schoohaven, 1996 and Harrigan, 1988) have confirmed that the important tool for organization learning is through strategic alliance formed between different organizations. The formation of strategic alliances is motivated by a variety of technical and economic objectives. These may include the need to spread the costs and risk of innovation, economies of scale, access to new markets, the search for legitimacy and the acquisition of new technical skills or technological capabilities from alliance partners (Contractor and Lorange, 1998; Harigan, 1988).

Furthermore, researchers (for example Kogut, 1988) have argued strategic alliance provides an ideal platform for organizational learning, giving access to knowledge, skills and competencies of their partners. This is particularly true when two or more organizations are brought together because of their different skills, knowledge and strategic complementarities and in this way the inter-organizational learning process can occur through vicarious learning and grafting.

According to Huber (1991), vicarious learning occurs when organizations acquire knowledge through learning from the experience of other organizations. On the other hand, the grafting process enables the organizations to increase their store of knowledge by acquiring knowledge not previously available within the organization through mergers, acquisition and alliance (Huber, 1991).

From the knowledge-based perspective, Inkpen (2000) argued that organizations gain competitive advantage when they are able to acquire and transfer new knowledge from outside their boundaries. In their study on knowledge management processes and International Joint Ventures (IJV), Inkpen and Dinur (1998) suggested that strategic alliance offer organizations learning opportunity to the partners through several organizational arrangements such as JVs, licensing agreements, distribution and supply agreements, research and development partnerships and technical exchanges. They categorized organizational arrangements into two broad categories:

- Equity alliances - the transfer or creation of equity ownership either through direct investment or the creation of equity JV
- Non-equity alliances - where no equity transfer or creation of new organization is involved

Based on organizational theory, Kogut (1988) argued that strategic alliance through inherent long term partnering provides the partners opportunities to transfer embedded knowledge between them. Hence, strategic alliances create a cooperative, shared and mutual learning environment and effective transfer of knowledge.

In his work on learning through JVs, Inkpen (2000) suggested that strategic alliance act as a mechanism for competitive advantage where partners mutually aspire to achieving the individual and collective objective of the relationship. Pak and Park's (2004) empirical study on cross border knowledge transfer in international joint ventures with Korean partners found a positive relationship between equally shared JV and knowledge transfer. This was also confirmed by Lin's (2007) work in China, which found that the U.S management control on JV had a positive impact on the acquisition of managerial knowledge by Chinese partners.

A reflection on theory and practice of inter-firm TT

The reviewed literature above provides a sound cross-section of a plethora of dynamics in inter-firm TT, but clearly confirms the objectives of this paper: to address the gap and contribute to knowledge on inter-firm TT through ICJCV. There is no formally reported research conducted in South Africa, across the African continent or other developing countries on knowledge and technology acquisition and specifically on international construction joint venture projects. The research reported in this paper, which focuses on international construction joint venture (ICJV) projects, is thus considered the first in South Africa, Africa and within developing countries.

CAPACITY BUILDING IN ICJVS – THE CASE STUDY OF NEW MULTIPRODUCT PIPELINE PROJECT (NMPP)

The New Multiproduct Pipeline Project (NMPP) comprised the construction of approximately 700km of welded steel pipeline with new pump stations and storage terminals throughout the KwaZulu Natal, Free State, Mpumalanga and Gauteng provinces in the Republic of South Africa.

The Client (Employer) of the NMPP project was Transnet Pipelines, a division of Transnet Ltd which currently operates over 3,000km of pipelines in the Republic of South Africa. Transnet Pipelines' primary business involves the provision of infrastructure (pipelines, pump stations, storage tanks etc) for the transporting of petroleum products from various manufacturing facilities to the South African market places for its clients which include BP, Caltex, Engen, Sasol Gas, Shell and Total. At the time of this study, the NMPP project was valued at approximately 5billion rands (625 million US dollars).

The construction of the NMPP project was undertaken by an integrated international construction joint venture partnership, involving Group Five (Pty) Ltd, a local South African engineering & construction company and Spiecapag, a French construction company. The joint venture was known as the Spiecapag/G5 JV. The joint venture was established so that the partnering companies could assist one another in their field of expertise in order to deliver the NMPP project, which is technically challenging. Spiecapag provided its technical expertise in pipeline installation, while Group Five (Pty) Ltd provided its local knowledge of South Africa, and the administration and financial support necessary in facilitating a project of that scale. The construction of the NMPP project commenced in August 2008 and at the inception of the study, progress was at 60% with final completion expected in May 2011.

While Spiecapag boasts a strong presence in the West African countries like Cameroon, Nigeria etc, it does not have previous operational experience in South Africa and the Southern African region as a whole. The NMPP project marks Spiecapag's first presence in the Southern African region and therefore a joint venture partnership with a well established South African company, Group Five (Pty) Ltd, acted as a facilitator for entry into new geographical market. Although Group Five (Pty) Ltd has previously been involved in pipeline construction projects via local joint ventures, it is still developing its standalone capabilities in pipeline construction, especially petrochemical pipelines. Therefore teaming up with a renowned international pipeline contractor like Spiecapag provided G5 with learning opportunities to build such capacity.

Case study analysis

The main hypothesis

Hmain: The ICJV structure that promotes joint participation of local personnel with expatriates in shared activities of the international construction joint venture project is positively correlated with the local company's level of skills and technology acquisition from the foreign partner.

Sub-hypotheses

Two sub-hypotheses were formulated from the main hypothesis and tested. The first sub-hypothesis is on the relationship between interaction in the work place and collaboration in job tasks:

H0: There is no significant relationship between collaboration in job tasks and the foreign employees' willingness to share their knowledge and technology with local employees

H1: There is a significant relationship between collaboration in job tasks and the foreign employees' willingness to share their knowledge and technology with local employees.

The second sub-hypothesis is on the relationship between collaboration in job tasks and sharing of knowledge and technology:

H0: There is no significant relationship between interaction in the work place and collaboration in job tasks.

H2: There is a significant relationship between interaction in the work place and collaboration in job tasks.

Research method design, research instruments and profile of respondents

Design of research method

The case study incorporated both qualitative and quantitative methods via a two-phase design. The research began with a quantitative study to assess the extent to which knowledge and technology acquisition occurs in the ICJV project. It was followed by a qualitative study to describe and analyse in detail the common drivers of knowledge and technology acquisition or lack thereof in the ICJV project in relation to its structure.

Design of research instruments and profile of respondents

A 44 question structured questionnaire was administered to the project participants - the philosophy and details of the instrument (including its administration) were reported in Rwelamila and Mkandawire (2010). Follow-up interviews were conducted to three focus groups each with not more than 20 people, in which open-ended questions were asked.

Profile of respondents

125 randomly selected employees in the Spiecapag/G5 JV within NMPP project were involved in the case study. As expected from a typical construction project in South Africa, the majority of respondents were male (82%). Respondent were categorised by management roles in three levels: non-management, middle management and senior management levels. Among respondents, 58 per cent were non-management, 33 per cent were middle and 9 per cent were senior management. The sample represents a fair distribution of management responsibilities in a typical organisation or project.

Summary of results

Table 1 presents key findings fundamental to understanding the relationship between interaction at work place and collaboration in job tasks. The Spearman's correlation statistics conform that both hypotheses were valid and that collaboration in job tasks is strongly linked to the willingness of the foreign employees' to share their knowledge and technology with local employees. Based on the sample of 125 respondents from this project, we can conclude the following:

1. As interaction among foreign and local employees increases in the work place, collaboration in job tasks also increases. Therefore, interaction of employees in the work place is vital to enhance collaboration in job tasks [Coefficient of Determination (r2) = 69%; $\rho < 0.01$].
2. As the collaboration between local and foreign employees in job tasks increases the foreign employees are more willing to share their knowledge and technology with the local employees [r2 = 53%; $\rho < 0.01$].

Table 1: Pearson's correlation statistics (N=125)

Tested hypothesis		Spearman's correlation (r)	Sig (2-tailed)
H1	Correlation between interaction and collaboration	0.833	$\rho < 0.01$
H2	Correlation between collaboration and knowledge sharing	0.731	$\rho < 0.01$

The follow-up qualitative study further found that organization structure was a critical success factor for knowledge transfer to materialize, and that the local partner acquires enough knowledge and technology from the foreign partner if:

- The structure enhances project success. Project success, which is determined by factors such as cost, time, quality, utility, stakeholder management and health and safety, should not be hampered at the expense of knowledge and technology acquisition. JV partners were concerned with this
- The structure helps minimize the cultural shock period. The study established that regardless of whether the employees are foreign or local, they all go through a cultural shock period when mobilized together in a project.
- The structure emphasizes the sharing of the same project objectives. It was found that knowledge and technology sharing might become feasible when employees share the same project objectives. On doing so, employees bear the responsibility of achieving those objectives, and as a result, they find it compelling to collaborate in tasks and share information, knowledge and technology.

CONCLUSIONS

1. The importance of the JV structure: even though the primary rationale for adoption of the section-based structure is to facilitate knowledge and technology acquisition in an international construction joint venture project, the structure is also perceived to be pivotal to enhancing project success.
2. The need for integration: with the integration of local and foreign employees in one project section, the foreign and local employees will feel compelled to collaborate in job tasks and share knowledge and technology.
3. The importance of risk mitigation: in any international JV, the foreign partner is more likely to be risk averse than the local partner and hence will incline more towards adopting a structure that is more capable of mitigating project risks.
4. The importance of local partner commitment to knowledge and technology acquisition: the local partnering company should also show commitment to knowledge and technology acquisition to its employees.

RECOMMENDATIONS

Building on the key findings discussed above, a Section-based joint venture project structure was proposed to facilitate speedy acquisition of knowledge and technology in ICJV projects in South Africa. As indicated in Figure 1, a Section-based structure is recommended for international construction joint venture projects where knowledge and technology acquisition from the foreign partnering company become one of the objectives for a local company.

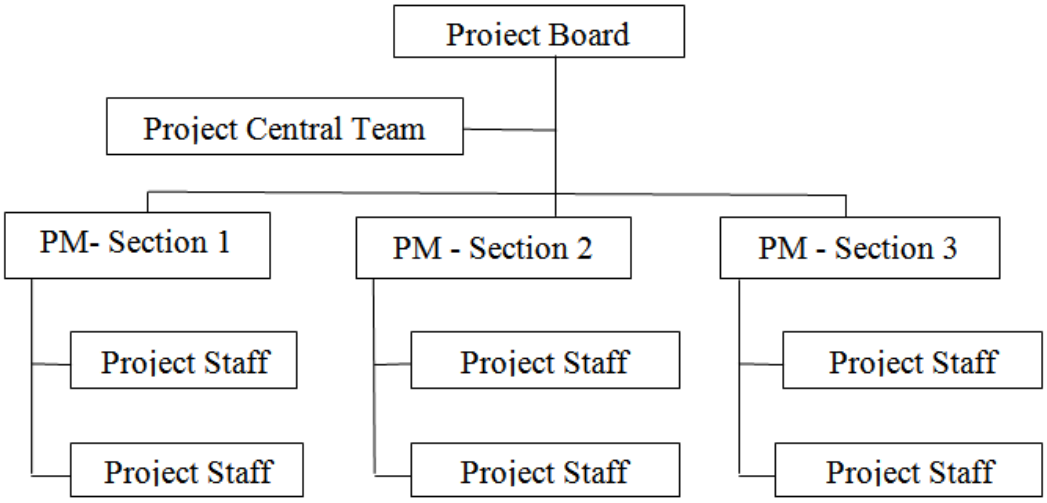

Figure 1: Section-based joint venture project structure

A Section-based structure should follow the establishment of the project's three chief layers:

- The project board will comprise senior management personnel from the head offices of the respective members. Its responsibility is to ensure that the objectives and interests of the partnering companies are well articulated in the ICJV and that the project receives the required support from the parent companies.
- The project central team comprises individuals from various departments (e.g. human resources, commercial, finance, safety, quality, engineering, IT, procurement, etc) who possess relevant qualifications and experience in their disciplines and have sound project management knowledge. Its primary function is to coordinate the various project sections and to execute activities that can be duplicated. The team will also execute other project activities, which could be outsourced from other organizations.
- The whole project is delivered by dividing it into sections. Each of the project sections is managed by a designated project manager, and depending on the size of the project, nature of the project and availability of resources the project sections may comprise full project scope or only specific tasks.

It is recommended that the project structure should be determined at the JV negotiation stage. Since the project is divided into small sections, the project managers have relatively smaller teams to manage and are closer to the teams. The Section-based structure integrates foreign and local employees from various disciplines into one project family. The greater integration in the teams will foster sharing of knowledge and technology - not as a need to teach the local employees but rather as a need to co-adapt. Therefore, this structure enfolds and fulfils the principles discussed above, i.e. it facilitates knowledge and technology acquisition without jeopardizing project success, helps minimize cultural shock period, and puts emphasis on the sharing of the same project objectives.

REFERENCES

Bessant, J., & Francis, D. (2005) Transferring Soft Technologies: Exploring Adaptive Theory. "International Journal of Technology Management and Sustainable Development", 4 (2), 93-112.

Bontis, N., Crossan, M., & Hulland, J. (2002). Managing an Organizational Learning System by Aligning Stocks and Flows. Journal of Management Studies, 39 (4), 437-70. http://dx.doi.0rg/lO.l 11 l/1467-6486.t01-l-00299, (Accessed March 19, 2012)

Bozeman, B. (2000). Technology Transfer and Public Policy: A Review of Research and Theory. Research Policy, (29), 627-655.

Construction Industry Development Board (CIDB) (2004). South African Construction Industry Status Report 2004, CIDB, Pretoria, South Africa.

Contractor, F. J., & Lorange, P. (1988). Why Should Firms Cooperate? The Strategy and Economics Basis for Cooperative Ventures. In: Contractor, F. J., Lorange, P. (Eds.), Cooperative Strategies in International Business. Lexington Books, Lexington, MA, 3-30.

Eisenhardt, K. M., & Schoonhaven, C. B. (1996). Resource-Based View of Strategic Alliance Formation: Strategic and Social Effects in Entrepreneurial Firms. Organization Science, 7(2), 136-150. Figuereido, P. (2001). Technological Learning and Competitive Performance. Cheitenham: Edward Elgar.

French, W. L. & Bell, Jr. C. H. (1995). Organization Development: Behavioural Science Interventions for Organizational Improvement. Eaglewood Cliffs, NJ: Prentice-Hall.

Harrigan, K. R. (1988). Joint Ventures and Competitive Strategy. Strategic Management Journal, 9, p. 141-158.

Hope, K. R. (1983). Basic Needs and Technology Transfer Issues in the "New International Economic Order". Journal of Economics and Sociology, 42 (3), 393-404. http://dx.doi.0rg/lO.l 11 l/j.l536-7150.1983.tb01726.x, (Accessed April 19, 2013).

Huber, G. P. (1991). Organizational Learning: The Contributing Processes and the Literature. Organization Science, 2 (1), 88-115..

Infrastructure Consortium for Africa (ICA). Challenges, Available at: www.icasfrica.org/en/infrastructure-issues/aims, (Accessed April 20, 2013).

Inkpen, A. C, & Dinur, A. (1998). Knowledge Management Processes and International Joint Ventures. Organization Science, 9 (4), 454-468.

Inkpen, A. C. (2000). Learning through Joint Ventures: A Framework of Knowledge Acquisition. Journal of Management Studies, 37 (7), 1019-1043. Kogut, B. (1988). Joint Ventures: Theoretical and Empirical Perspectives. Strategic Management Journal, 9 (4), 319-32.

Kogut, B., & Zander, U. (1993). Knowledge of the Firm and the Evolutionary Theory of the Multinational Corporation. Journal of International Business Studies, 24 (4), 625-646.

Liao, S. H., & Hu, T. C. (2007). Knowledge Transfer and Competitive Advantage on Environmental Uncertainty: An Empirical Study of the Taiwan's industry. Technovation, 27, 402-411.

Lin, W. B. (2007). Factors Affecting the Correlation between Interactive Mechanisms of Strategic Alliance and Technological Knowledge Transfer Performance. The Journal of High Technology Management Research, 17, 139-155.

Merrifield, A. (2006). Demand for Skills: An Analysis of the Proposed Infrastructure Spending Programme. CIDB, Pretoria, South Africa.

Organisation for Economic Co-operation and Development (OECD) (2010). Emerging public and sovereign fund investors in Africa's infrastructure: Challenges and Perspectives, Available at: www.oecd.org/dev, (Accessed April 15, 2013).

Pak, Y., & Park, Y. (2004). A Framework of Knowledge Transfer in Cross-Border Joint Ventures: An Empirical Test of the Korean Context. Management International Review, 44 (4), 435-455.

Ray, S. (2012). Technology Transfer and Technology Policy in a Developing Country, The "Journal of Developing Areas", 46(2), 371-396.

Rwelamila, P D and Mkandawire, S (2010). Capacity Building in International Construction Joint Venture Projects in South Africa: a Case Study of the NMPP Project, Unpublished Report, UNISA Graduate School of Business Leadership, Midrand, South Africa.

Rwelamila, P M D (2007) 'Project management competence in public sector infrastructure organisations', Construction Management and Economics, 25(1), 55 – 66.

Sazali, A.W & Raduan, C.R. (2011). The Inter Firm Technology Transfer in Malaysia – A Holistic Model. VDM Verlag Publishing, Saarbmcken, Germany.

Sewpaul, J. (2007). Overview of the Construction Industry-South Africa. Available at: www.export.gov/build/groups/public/@eg.../eg_main_020664.pdf, (Accessed April 19, 2013).

Wahab, S. A., Rose, R. C. and Osman, S. I. W. (2012). The Theoretical Perspectives Underlying Technology Transfer: A Literature Review, International Journal of Business Review, 7(2), 277-288.

A CASE STUDY OF JOINT PROCUREMENT AND PROVISION OF LEGAL SERVICES TO A GROUP OF A UNIVERSITIES IN THE MIDLANDS

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A Group of 5 UK Universities in the Midlands undertook a joint procurement process for the provision of Legal Services. The objective was to put in place common Framework Agreements. The Legal Services procured were divided into six lots and one of these was 'Property and Construction'. The lots were assembled into three packages and the contract for each package was awarded to one or more Service Providers. Albeit a service provider is to work for all the collaborating Universities. A competitive 'restricted' two-stage tender process was administered in accordance with the Public Contracts Regulations 2006, SI 2006/5. The Framework Agreements were awarded in 2012 to the most economically advantageous Solicitors' Practices. The participating Universities are being interviewed about the reasons for the joint procurement exercise, any challenges faced in its implementation and lessons learnt so far. Two interviews have been conducted so far and evaluated via content analysis to reveal that advantages to be gained from 'economy of scale' were the main impetus for the collaborative procurement. The negotiations between the Universities which led to the establishment of the collaboration and its subsequent sustenance have been friendly. The challenge identified so far concerns how to distribute work more fairly to legal services providers.

Keywords: bidding, collaboration, competitiveness, contractor selection, corporate strategy, framework agreement, negotiation, procurement; professional service.

INTRODUCTION

The joint procurement of Legal Services by a group of 5 UK Universities in the Midlands is the subject matter of this discussion which is informed by an on-going research that aims to evaluate the process used and challenges encountered thus far. A Group of Universities in the West Midlands meets periodically to discuss/plan collaborative procurement opportunities, share knowledge and best practice amongst other initiatives. This mirrors the recommendation of the 1994 Latham Report that clients should come together in forums (Crowe and Fortune, 2012). A sub-group of these Midland Universities conducted a procurement process for the Provision of Legal Services with the objective being to put in place a Framework Agreement that is fit for purpose and easily accessible by Universities in the Midlands region.

In context, procurement is the act of acquiring or obtaining a product or service (Lester, 2007); often for some consideration. Procurement can apply to any human endeavour e.g. buying a car, obtaining probate services, engaging a contractor to renovate or build a house, etc. In construction, the concept of procurement is popular

Charlson J and Chinyio E (2013) A case study of joint procurement and provision of legal services to a group of a universities in the Midlands *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 493-502.

and can entail many things e.g. obtaining land for a new project, sourcing the funding, selecting the contractor(s), managing the construction or built facilities, etc. (Murdoch and Hughes, 2008). A procurement system can be: separated, integrated, management-orientated or discretionary (Masterman, 2001). The separated or traditional approach to procurement was formalised in the 19th century and has for long provided a basis for obtaining construction services and products. In the 1960's integrated options like 'Design and Build' emerged and in the following decades, the management options were adopted e.g. management contracting and construction management. Towards the end of the 20th century, forms of procurement that emphasise collaboration emerged e.g. prime contracting, partnering, alliancing and to some extent the Private Finance Initiative. Partnering emerged in the USA in the 1980s from where its use has spread to other countries (Kumaraswamy and Dulaimi, 2001).

Some of the modern forms of construction procurement emphasise managing the supply chain where trust, collaboration and long-term relationships are preferred (Morledge et al. 2006; Manu et al. 2011). As the construction industry had long sought for ways of shrugging off its adversarial antecedents, forms of procurement that emphasise collaboration have been highly welcome. The NAO (2001) for instance, spoke highly of partnering and its ability to achieve greater benefits if its elements of trust and collaboration are allowed to thrive. Surveys (e.g. RICS, 2010) have shown a declining use of traditional contracting and an increasing uptake of other forms of procurement especially the collaborative types. Manu et al (2011) also identified the shift towards the use of more collaborative contracting relationships in the construction industry.

As a move away from traditional procurement where one client will obtain services or products from a supply chain, the UK Government proposed the option where several clients could jointly procure services or products through 'collaborative procurement'.

Collaborative procurement

The 'Government Procurement Service' (GPS) is an executive agency of the UK Cabinet Office, providing procurement guidance and savings. GPS particularly helps the public sector to be better at collaborative procurement, which includes the situation where more than one client is obtaining a service or product simultaneously. Other terms used to describe the concept are cooperative purchasing, group purchasing and consortium purchasing (Keskinocak and Savasaneril, 2008).

Collaborative procurement can be either horizontal, say between competitors or vertical say within a supply chain (Keskinocak and Savasaneril, 2008). An example of vertical collaboration in construction is supply chain management where the prime contracting form of procurement emphasises this principle.

Hitherto, the popular form of (vertical) collaborative procurement in construction has involved one client obtaining products or services from several suppliers. The flip side of (horizontal) collaborative procurement, which is emphasised in this paper, involves several clients obtaining services or products jointly from one or more suppliers. Indeed Boyd (2011) suggests that local authorities should collaborate and aggregate their purchasing so as to achieve reduced costs. Group purchasing has been used in the non-profit sector but it is being adopted, especially in more recent times, in competitive settings. One appeal of collaborative procurement is the cost savings it brings to the process i.e. reduced lead-times and transaction costs (Murray et al., 2011), greater bargaining power with suppliers (NAO, 2010) and greater clients' understanding of the expectations of service suppliers and vice-versa (Avila, 1997).

According to Dicken (2008) the Office of Government Commerce reported cost savings to Government departments of £650m in 2007; through the use of collaborative procurement. Further, an agreement for a shared service centre was signed in February 2013 and it is estimated to deliver savings of up to £600m a year for the taxpayer (HMG, 2013). Collaborative procurement has also been used in e.g. manufacturing and logistics (Keskinocak and Savasaneril, 2008). According to the NAO (2010), collaborative procurement does bring greater value for money and benefits and it is possible to improve on these gains. Meanwhile, the guides provided by the UK Cabinet Office and its establishments, e.g. Efficiency and Reform Group, can be adopted by many sectors and used to improve the benefits derivable from procurement.

RECENT TRENDS IN THE JOINT PROCUREMENT OF LEGAL SERVICES

There is an increasing trend of the joint procurement of legal services by public sector bodies. In this regard the UK Government finalised seven panels that service the entire public sector in 2003: IT, telecoms and e-commerce; property and estates; HR; construction; company and corporate; finance and banking; and general commercial. In its delivery, every successful firm offered a discount of up to 25 per cent on their commercial hourly rates (Rovnick, 2003).

In 2008, the largest public sector panel in Welsh history with a legal spend of over £8million was appointed for 4 years. The panel included the Welsh Assembly Government and 7 other public bodies and the legal services procured were grouped into property and commercial; corporate finance; environmental; employment and litigation (Parker, 2008).

In 2011, four local authorities in the West of England appointed 12 law firms and 20 barristers' chambers to a series of shared legal panels. North Somerset deputy head of legal services Fiona Robertson explained that the creation of shared panels was driven by cost-cutting targets, expected to save between £100,000 and £250,000. She also said "All four authorities deal with the same sorts of issues, so we hope to pool some of that work rather than continually reinventing the wheel." (Butcher, 2011a). Similar initiatives include: five West Yorkshire councils (Freedman, 2011); the South-West Wales Legal Consortium (Butcher, 2011b); the NHS Commercial Alliance legal panel worth up to £20million over 4 years(Butcher, 2011c) and the London Procurement Programme providing legal services to around 60 NHS Trusts in London, the West Midlands and the South of England (Butcher, 2011d).

The foregoing trends suggest an ever increasing uptake of the joint procurement of legal services. Aspects of construction which are covered by such collaborative procurements concern legal advice on purchase of land, disposal of physical assets on land prior to construction and selection of contractors and types of contracts to use therein. Where a client in a big project would have had to procure legal services for one project per time, the collaborative procurement option offers an alternative that is more cost-efficient plus other benefits. Although legal services have scope boundaries, they overlap with as well as stand as a gateway to procurement and contracting in construction projects.

Procurement of legal services by the Universities West Midlands Group

One recent quest of the Universities West Midlands Group was to identify and exploit collaborative procurement opportunities wherein the joint procurement of legal

services was accepted as being readily viable and hence rolled out for implementation. This joint approach was reported as a case study in the Lawyer by Butcher (2011e). This collaboration provided an opportunity to investigate the subject matters of this paper i.e. the rationale and efficacy of the process, difficulties encountered, benefits experienced and opportunities for construction.

Researchable questions

Some suggested questions for research in collaborative arrangements include (Jeroen et al., 2012): what are the barriers to and benefits of such arrangements? Under which conditions are collaborative relationships formed? What are the experiences of participants in collaborative relationships?

In addition, Gosling et al (2012) suggest that companies may fail to implement their supply chain improvement programmes effectively so a review of provision is advocated. Also; how can joint procurement by several clients apply to and benefit them regarding the development of new construction projects? Which procedures are most useful (Cheung et al., 2002); as these influence outcomes? The foregoing research questions were investigated and are addressed in subsequent sections of this paper.

RESEARCH METHOD

A qualitative approach was adopted in order to explore the research objectives in-depth (Fellows and Liu, 2008; Naoum, 2013) i.e.the reasons for the decisions that were and are being made as well as challenges encountered so far and lessons for the future. In addition, the Invitation to Tender is being reviewed as well as the applicability of joint procurement to construction. These details may not be readily packaged in numerical explanations, hence a qualitative exploration. The research is mainly a case study i.e. “a unit of human activity embedded in the real world; which can only be understood or studied when seen in full context” (Gillham, 2000). It is an ‘embedded case study’, i.e. a single case study that captures a typical case (Yin, 2009) of joint procurement by a group of clients.

Interviews were selected as the basis for data collection as they offer flexibility and opportunity for in-depth exploration of issues (Haigh, 2008). The on-going interviews in this research are 'semi-structured' (Farrell, 2011). To progress with the 'one-at-a-time' interviews (Fellows and Liu, 2008), a set of questions was prepared using the research aim and objectives as a basis (Andrews, 2003). The plan is to interview the procurement and/or legal officers of the participating Universities as they form the nexus of personnel who were involved in the negotiation and procurement process and are equally at the forefront of its implementing.

The research is complying with ethical protocols e.g. anonymity of interviewees being ensured plus handling data in strict confidence. Permission to commence the research interviews was sought with our University. The willing involvement of each interviewee was/is being sought. Also, the participants from the universities and tenderers were notified a priori that the University of Wolverhampton intended to evaluate this procurement exercise as a case study at a later date.

The interviews which are expected to take place between April and July 2013 are in progress. To date, two interviews have been conducted and these were with one legal officer (Interviewee 1) and a procurement professional (Interviewee 2). Interview Nos.1 and 2 lasted 40 and 37 minutes respectively and both were tape-recorded and transcribed.

The approach to data analysis which aligns with the research objectives is: to identify examples, phenomena, ideas, activities or explanations (Gibbs, 2007). To extract these, the researchers used the electronic 'cut and shuffle' method proposed for data analysis (by e.g. Gibbs, 2007; Farrell, 2011) in lieu of a software. Contents of the transcripts were cut and shuffled on the basis of 'subject matter' and used as a basis of describing the experiences of the interviewees. Findings from the two interviews and foregoing analysis are discussed below.

JOINT PROCUREMENT BY THE GROUP OF UNIVERSITIES

Each Institution in the West Midlands Group of Universities was allowed to opt in or out of the planned joint procurement while the possibility of joining-in at a later time was also adopted. Five of these Institutions initially opted to collaborate on the joint procurement of legal services and these are: University of Wolverhampton, Aston University, Coventry University, University of Worcester and Harper Adams University College. Going forward with this decision, as Interviewee 1 commented: "the joint procurement [was] … to get economies of scale in the procurement of external legal services."

The group [of 5] initially shared information amongst themselves in terms of where they were buying legal services from and what sort of rates they were paying. They did this so they could start obtaining a benchmark. They also sought advice from some London universities who had recently undertaken a collaborative procurement exercise for legal services in their area.

The joint framework is worth £4 million to £5 million; a first for the region and was driven by belt-tightening across the higher education sector. Interviewee No.2 explained thus: "The main driver behind this is to collaborate with other universities in order to achieve cost efficiencies and savings for all universities in the region. We also want to provide a flexible framework of service providers that can cover all specialisms of legal services that universities within the region can easily access."

The decision of the participating institutions was to have a Framework Agreement in place with providers who are able to cover all requirements under the category of Legal Services which were split into 6 Lots as in Table 1. A firm could bid for works in Group 1, 2 or 3 of Table 1, i.e. one firm could submit 3 bids.

Table 1: Legal Services Lots

Category	Nature of Service(s) involved
Group 1	Lot 1 - Commercial, contracts, intellectual property rights, data protection
	Lot 2 - Employment and pensions
	Lot 3 - Property and Construction
	Lot 4 - Regulatory, student issues, governance
Group 2	Lot 5 - Patents and trademarks
Group 3	Lot 6 - European Regional Development Funding

The contract period for the provision of services is three years with an option to extend by one year subject to satisfactory performance and mutual agreement of all

the parties. The estimated annual expenditure on legal services by the Group of Universities was identified as about £1 million.

Procurement Process

There was a competitive 'restricted' two-stage tender process which was administered from the University of Wolverhampton on behalf of the participants. The two-stage process was selected because the market was quite large and they needed to reduce the shortlist down before the tender stage. An electronic portal was used to tender and it was done in accordance with European legislation as applicable to a Schedule B service under the provisions of the Public Contracts Regulations 2006, SI 2006/5. The principles and best practice of an OJEU was applied to the process.

The invitation to tender detailed the information required from the bidders. This included a completed Pricing Schedule, detailing how they would provide the Services and their responses to certain 'Scenarios'. The evaluation process aimed to identify the tenders that offered 'best value' and not merely the lowest price. The criteria used to evaluate the tenders were weighted as 1) Price - 35%; 2) Quality - 65% which was further broken down as i) Tender Response evaluation - 35% and ii) Interview and Presentation evaluation - 30%.

About two dozens of firms expressed an interest. Tenders were submitted in September 2011. The selection interviews and presentations at stage 2 of the tender process took place over a full day and two half days. The panel of assessors on behalf of the group of five participating universities consisted of their legal officers and procurement professionals. These same set of personnel were involved in formulating the modus operandi of the collaboration including the pre-defined criteria for selecting the service providers. It is on this basis that these same set of persons were identified as best placed to speak as interviewees on behalf of the consortium.

Award of Contracts

Ten solicitors' practices were awarded Framework Agreements with a commencement date of 1 February 2012. Six legal firms were chosen for Lots 1 to 4; four legal firms for Lot 5 and two firms for Lot 6. Meanwhile a procurement report for sign off and award was drafted as well as a Buyer's Guide.

Accessing construction legal services under the framework agreements

Nomination or competition is used to assign work to legal practices in the framework but each University has the leeway to assign work to firms in either of these two ways. Interviewee 2 explained that for example, if legal advice was required for a new construction project, the recommendation would be to use a mini competition to obtain legal services offers from each of the providers for comparison and choice.

Interviewee 1 explained that "construction is a good example actually where you've got a pre-defined project, you know the scope of the legal input that you need and therefore you work on a fee quotation or a fee estimate for undertaking that work."

THE FIRST YEAR OF PROVISION OF LEGAL SERVICES

The Agreements have been in place for slightly over one year now and their performance is reviewed regularly. A well-supported training day where some of the legal services providers delivered seminars on e.g. commissioning legal services effectively was held in June 2012. Then in March 2013, after just over a year of

activity, the Universities met with all the legal services providers to review the progress of the Framework Agreement. There are plans for two training/networking events to be held each year.

Benefits gained so far

It was pointed out by the interviewees that tangible improvements have been realised over the year and these include cost reduction, compliant spend, greatly improved management information, training and collaboration. Interviewee 1 commented thus: "By joining together, strength in numbers …. I think it has encouraged the firms to sharpen their pencils in terms of fee rates and it's also given them an incentive to demonstrate to us that the work we need is done in a cost effective way". Interviewee 2 explained that "the rates are 20% less than the average of all the other universities' a year or so ago." This cost reduction theme mirrors Taggart et al's (2012) finding of an increased focus on 'cost' related supply chain factors.

The Universities now have management information that was either inaccessible or unknown prior to the Framework Agreement. The organisations produce and present progress reports on a quarterly basis so quarterly expenditure by Lot, university and legal services provider can be compiled for benchmarking.

There has been a strengthening of relationships between the universities. Interviewee 2 explained that they "can talk to each other and buy this piece of work together and share templates and documents whilst also obviously keeping confidentiality within each university at the same time. So there is a cross networking between the universities' legal experts."

Challenges faced

A challenge encountered so far is the coordination of the distribution of work to all the providers in the Framework Agreement. Some service providers may be getting more work than others under the framework agreement. The Universities are looking at ways to balance the distribution of work to the service providers.

Following the agreement, one of the providers went into administration and was bought by one of the other Framework providers. As these two organisations were initially in the framework agreement, their merger posed no significant challenge.

Potential for Construction and Property Legal Advice

The framework agreements have great potential for construction and property legal advice. Chinyio et al (2011) identified that higher education institutions have significant property portfolios and procure construction projects continuously. Interviewee 1 explained that universities need legal advice for their capital construction programmes for example, on the forms of contract and also for property acquisitions and disposal. His institution alone had spent in the order of £160 to £170 Million in capital works since the year 2000. Legal advice is needed regarding this high volume of work and obtaining it via the framework is more cost and time effective.

Lessons for the future

The frameworks in place have worked effectively. As an illustration of its success, three institutions have joined the collaboration on equal terms as allowed in the agreement. These include Keele University and Newman University College. The group of participating Universities has now grown from 5 to 8.

It is now thought the geographical area of just the West Midlands was too restricted and for example, East Midlands Universities should have been included. There is also a Scottish consortium that is currently endeavouring to procure legal services UK-wide for all universities and colleges.

CONCLUSIONS

This procurement exercise can be argued to have been a success in that genuine cost savings, knowledge-sharing and other benefits have been achieved. As a testament to this, a further three universities have joined the Framework Agreement. For the future, therefore, the universities aim to jointly procure other categories of spend.

By contrast with for example, analyses of traditional contracting or design and build projects, the procurement of legal advice for property and construction is rarely reported. Certainly, there is scope for further research in this area as the current economic squeeze will continue to drive institutions towards using options that are more cost-effective. A greater uptake of collaborative procurement henceforth will most likely be a common thing.

Currently there are thought to be no existing client-side collaborative framework agreements for new build projects in the HE sector. However, there is a huge potential for this collaborative procurement model to be used for some aspects of construction provision. For a start, it could be used in particular, for maintenance services where the needs of the Universities appear to be similar.

REFERENCES

Andrews, R. (2003) Research questions. London: Continuum.

Avila, E.A. (1997) Demystifying the Local Agency procurement and selection process for professional engineering consultant services. Journal of Management in Engineering, 13(2), 92-95.

Boyd, D. (2011) An evaluation of a system change in the purchasing of construction materials by local authorities. In: Egbu, C and Lou, E C W (Eds.), Proceedings 27th Annual ARCOM Conference, 5-7 September 2011, Bristol, UK. Association of Researchers in Construction Management, 695–704.

Butcher, C. (2011a) Four councils set up shared legal panels. "The Lawyer", 30 May 2011.

Butcher, C. (2011b) Raft of firms and chambers appointed to South-West Wales Legal Consortium. "The Lawyer", 9 July 2011.

Butcher, C. (2011c) Bevan Brittan picks up healthy slice of NHS work. "The Lawyer", 11 July 2011.

Butcher, C. (2011d) Birmingham Council lands NHS panel spot. "The Lawyer", 12 September 2011.

Butcher, C. (2011e) Midlands universities prepare to launch first joint legal panel. "The Lawyer", 11 July 2011.

Cheung, F.K.T.; Kuen, J.L.F. and Skitmore, M. (2002) Multi-criteria evaluation model for the selection of architectural consultants. Construction Management and Economics, 20(7), 569-580.

Chinyio, E. Gameson, R. and Suresh, S. (2011) The management of construction stakeholders by Higher Education Institutions (HEIs) in the United Kingdom (UK): A pilot study. In: Egbu, C and Lou, E C W (Eds.), Proceedings 27th Annual ARCOM Conference, 5-7 September 2011, Bristol, UK. Association of Researchers in Construction Management, 485–94.

Crowe, P. and Fortune, C.J. (2012) A preliminary method of classifying collaborative contractual behaviour in higher education construction projects. In: Smith, S.D (Ed.), Proceedings 28th Annual ARCOM Conference, 3-5 September 2012, Edinburgh, UK. Association of Researchers in Construction Management, 901–11.

Dicken, P. (2008) Joint buying has saved public sector £650m. Public Finance, Oct 31-Nov 6; p.9 [OGC report].

Farrell, P. (2011) Writing a built environment dissertation: Practical guidance and examples. Oxford: Wiley-Blackwell.

Fellows, R. and Liu, A. (2008) research methods for construction (3rd ed.), Oxford: Wiley-Blackwell.

Freedman, J. (2011) Kirklees Council leads appointment of West Yorks barristers panel. "The Lawyer", 19 May 2011.

Gibbs, G.R. (2007) Analyzing qualitative data. London: Sage.

Gillham, B. (2000) Case Study research Methods. London: Continuum.

Gosling, J. Towill, D. and Naim, M. (2012) Learning how to eat an elephant: implementing supply chain management principles. In: Smith, S.D (Ed.), Proceedings 28th Annual ARCOM Conference, 3-5 September 2012, Edinburgh, UK. Association of Researchers in Construction Management, 633–43.

Haigh, R. (2008) Interviews: A negotiated partnership. In Knight, A. and Ruddock, L. (eds) Advanced research methods in the built environment. Oxford: Wiley-Blackwell.

HMG (2013) First Independent Shared Service Centre to deliver government back office savings. [Accessed 11 March 2013]. Available at <https://www.gov.uk/government/news/first-independent-shared-service-centre-to-deliver-government-back-office-savings>

Jeroen, B.; Hans, V. and Bart, V. (2012) Supplier-contractor collaboration in the construction industry. Engineering, Construction and Architectural Management, 19(4): 342-368.

Keskinocak, P. and Savasaneril, S. (2008) Collaborative procurement among competing buyers. Naval Research Logistics, 55(6), 516-540.

Kumaraswamy, M. and Dulaimi, M. (2001) Empowering innovative improvements through creative construction procurement. Engineering, Construction and Architectural Management, 8(5/6), 325-334.

Lester, A. (2007) Project Management - Planning and Control (5th ed). Elsevier.

Manu, E.; Ankrah, N.A., Chinyio, E. and Proverbs, D.G. (2011) Control influence on trust and relational governance in the client-contractor dyad. In: Egbu, C. and Lou, E.C.W. (Eds.), Proceedings 27th Annual ARCOM Conference, 5-7 September 2011, Bristol, UK. Association of Researchers in Construction Management, 455–63.

Masterman, J.W.E. (2001) An introduction to procurement (2nd ed). : London, Spon.

Moreldege, R.; Smith, A. and Kashiwagi, D.T. (2006) Building Procurement. Oxford: Blackwell Science.

Murdoch, J. and Hughes, W. (2008) Construction Contracts: Law and Management (4th ed.) London: Taylor & Francis.

Murray, J.G.; Rentell, P,G.; Holland, T. and Locker, S. (2011) Why Collaborate on Local Government Procurement? The Experience of UK Councils. Journal of service science and management, 4(3), 325-333.

Naoum, S.G. (2013) Dissertation research & writing for construction students (3rd ed.). London: Routledge.

National Audit Office (2001) Modernising Construction. London: The Stationery Office.

National Audit Office (2010) A review of collaborative procurement across the public sector. London: NAO.

Parker, J. (2008) Welsh public sector bodies launch £8m super panel. "The Lawyer", 11 February 2008.

RICS (2010) Contracts in use: A survey of building contracts in use in 2010. London: Davis Langdon.

Rovnick, N. (2003) Change in fortune for Govt law firms. "The Lawyer", 31 March 2003.

Taggart, M. Koskela, L. and Rooke, J. (2012) Collaborative supply chain practices during severe economic downturn in the republic of Ireland. In: Smith, S.D (Ed.), Proceedings 28th Annual ARCOM Conference, 3-5 September 2012, Edinburgh, UK. Association of Researchers in Construction Management, 687–95.

Yin, R.K. (2009) Case Study Research: Design and methods (4th edition). London: Sage.

THE ROLE OF THE SUPPLY CHAIN IN ELIMINATION AND REDUCTION OF CONSTRUCTION REWORK AND DEFECTS: AN ACTION RESEARCH APPROACH

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During the past six years Ireland suffered a catastrophic economic reverse that impacted disproportionately on the construction industry, leading to a circa 80% reduction in output. The results of this have been bankruptcy, unemployment and bad debt. The changed environment has spurred the contractors to attach ever greater emphasis to production efficiency and cost reduction as a means of survival. An Action Research (AR) approach was used in this research to focus on improving the strategies adopted by a SME contractor for the control of defects in its supply chain. It is conservatively estimated in the literature that rework typically accounts for circa 5% of total project costs. Such activity is clearly wasteful and presents an obvious target to address. The AR intervention is at the diagnosing stage and involved examination of work on a pilot site, analysis of contract documents, including drawings, snag lists and specifications and semi-structured interviews with supply chain members. The results indicate the potential for the supply chain participants to both identify the root cause of defects and propose solutions, in terms of best practice to avoid future reoccurrence. Another key finding was the lack of any collaborative forums to contribute to production improvement and cost reduction. Additionally the processes, used to collect, manage and disseminate data on defects were found to be unstructured and uncoordinated, indicating scope for development of more useful methods. The research indicates good understanding of the potential benefits for supply chain collaboration but suggests the tools and knowledge to collaborate are currently lacking in the Irish SME sector.

Keywords: action research, defect, rework, supply chain management

INTRODUCTION

This report provides an interim assessment of results from the diagnosing phase of an on-going Action Research (AR) project involving an SME building contractor in Ireland. Ireland, suffered a severe and on-going economic reverse in the period 2007 - 2012. Construction has borne a disproportionate part of the burden in terms of bankruptcy, debt and unemployment. Output declined by circa 80% in that period (Taggart *et al.* 2012). In the decade prior to 2007, the industry was at the forefront of a property led boom, its predominance, at 24% of GDP was seen as unsustainable by many commentators (DKM cost consultants 2009). The industry is undertaking a very

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Taggart M, Koskela L and Rooke R (2013) The role of the supply chain in elimination and reduction of construction rework and defects: an action research approach *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 503-512.

painful adjustment, shedding over half of its workforce and also adjusting to a reality, whereby tender prices reduced by circa 28% from peak (SCSI 2012). The end of 2012 saw some signs that the industry had reached the bottom of the economic cycle and some stability had been reached, albeit that any significant uplift in output was some way off (SCSI 2012).

Contractors have adopted a pronounced focus on lowering cost to gain workload and ensure survival. During the early part of the downturn, weaker companies resorted to below-cost bidding as a survival strategy (SCSI 2012). 2012 shows signs that this approach is moderating and there is some stability in tender costs (Davis Langdon 2011). The eradication of rework and defects in the construction process is an obvious target for cost reduction and efficiency gains by contractors, as it is the unnecessary effort of re-doing a process that was incorrectly implemented the first time (Love & Edwards 2004). In most instances contractors will not be paid for the rework. The defects involved can be discovered at various stages of the process, both during the construction period and after handover, during the maintenance period and beyond (Love & Edwards 2004).

The focus of this paper concerns defects that are associated with the period at or around the project completion stage. Rotimi *et al,* (2011) define these defects as 'snagging' a term common in the industry, but little used in the literature. Likewise Sommerville *et al,* (2004) without explicitly stating it, associate snagging as an activity whereby defects are captured at project end by terminal 'snag lists'. Prominent in the literature is the lack of agreed definitions. In later work, Sommerville (2007) speculated that many items that are not defects, often found their way onto sang lists. A common example is the adding of items that are missing or partially complete, essentially as a reminder. This paper aims to highlight the potential improvements in harnessing a collaborative supply chain, to eliminate defects and rework at the completion stage of projects.

CAUSATION AND COSTS OF REWORK

The defects literature is wide ranging as to suggestions of the root causes of rework. There is however general agreement that underlying cause often lays deeper than superficial blaming of the operative or their immediate supervisor (Atkinson 1999). In some cases they are of course the root cause. A small cross-section of suggested root causes of defects includes: Design issues, construction issues and product failures (Sommerville 2007). Poor understanding of drawings and specification, using superseded information, poor communications, poor co-ordination of sub-contractors, ambiguous working instructions, poorly trained operatives and inadequate supervision (Chung 1999). Love *et al,* (1999) differentiates between *common causes* that are linked to the process being followed, such as inadequate information flow in the supply chain and *special causes* that arise outside of the process of work, these can emanate from unilateral client changes or adverse weather conditions for example. Rotimi *et al,* (2011) note that aesthetics play a part in determination of acceptable standards. What is of an acceptable level in one project may be rejected upon inspection in another project having higher perceptions of quality. Atkinson (1999) providing a comprehensive review, covers the more mundane causation drivers found elsewhere in the literature, but extends the discussion further to include global issues such as organisational culture, time, economic, political and societal pressures. Josephson & Hammarlund (1999) again find commonality with the literature, but additionally emphasise client impact, in terms of the stability of client personnel in

ensuring information flow and the impact of late changes instructed by clients and end-users / occupiers. Several attempts have been made to gather this long and broad list of suggested causation into a coherent conceptual framework, with Josephson et al, (2002) worthy of mention. The authors usefully apportion approximate cost percentages to their model, taken from extensive field studies. They suggested the principal headings of causation and their contribution to rework costs were: design related 26%, production management related, 25%, workmanship related 20%, materials related, 17%, client related, 6% and machine or plant issues, 3%.

Whilst there is some literature commonality in terms of causation, the area of defects costs is confused with many suggested cost estimates and a variety of disparate models for calculating costs, together with a range of variables as to what is or is not included in each model. Most estimates are generally expressed at a percentage of the total project cost (TPC) given over to rework. Love (2002) discusses the difference between direct costs, which are related to additional labour, materials and plant needed for rework and indirect costs, stemming from return visits, extra plant hire, waiting time etc. Love cautions that in some cases the indirect costs may be many multiples of the direct costs. Both Love (2002) and Sommerville (2007) find that snagging and defects are entrenched in the industry and are discussed as a normal and acceptable part of the process. Indeed in an Irish context a book on the subject was published during the recent boom entitled *'The Irish Home Buyer's Guide to Snagging'*. As this phenomenon is treated as a routine occurrence, we may speculate that the supply chain reflect these costs in their pricing models. Thus there is the potential for this inefficiency to be passed along the supply chain to the ultimate client. Common standard forms of contract confirm the 'acceptable' nature of defects in construction, by laying out methodologies whereby monies are retained, subject to completion of the inevitable list of defects. The Irish public works contracts are an example of this phenomenon.

Josephson et al, (2002) note that the act of managing reworks is in itself inherently inefficient as it requires a degree of supervision and co-ordination, involved in appraisal costs. This includes the collection of data via snagging inspections and collation and distribution of the resultant documents. Thereafter several cycles of checking and sign off are typically required. Return visits are likewise an inefficient practice and require additional indirect costs (Love & Edwards 2004). The literature does not agree on how much such activity costs but many suggestions have been made: Love *et al*, (1999) noted claims in the literature that a holistic cost of rework could range as high as 12.4% of TPC. Love & Li (2000) cited two projects where rework costs were 3.15% on one project and 2.4% on the other. Love *et al*, (2004) noted a range of reported rework costs ranging from 3% to 23%. Josephson & Hammerland (1999) reported on a large longitudinal study that suggested rework costs were 2% - 6% during the project and additionally 3% - 5% during the maintenance period. Hwang *et al*, (2009) suggest that rework costs are typically 5% of TPC in the United States. Applied to Ireland the 5% figure equates to circa €375 million in 2012. However at the height of the recent boom, (2007) this extends to €1.89 billion annually. Should the industry recover to sustainable levels suggested by DKN cost consultancy (2011) then rework would cost €850 million per annum. These figures alone justify further research into this area in search of methods to eliminate and reduce rework and defects.

SUPPLY CHAIN IMPROVEMENT POTENTIAL

For various reasons, including geographical, historical and language, construction processes in Ireland are similar to the UK (Thomas & Hore 2002). The production model is generally of shell main contractors, arranging the work of numerous and fragmented sub-contractors selected on the basis of lowest cost. Taggart *et al,* (2012) noted that on the one hand the economic climate in Irish construction was highly adversarial, whilst on the other the industry showed a sophisticated understanding of collaborative approaches and felt that collaboration and cooperation were essential elements of success.

A significant study by Karim *et al,* (2006) noted that sub-contractors viewed the main-contractor as their 'customer' and showed little concern for and often had little direct communication with other sub-contractors with whom they were interacting. This means that problems were pushed onto the next part of the supply chain, until they were detected on terminal or interim snag lists. Koskela *et al,* (2006) supports the assertion that problem detection is often found in a later stage of the supply chain than problem creation. A Supply Chain Management approach to the problem of defects at handover would entail an agenda of stopping to fix the problems as they occur (Liker 2004), this of course means earlier detection in the process and by extension a new means of trapping errors, suggesting greater sub-contractor involvement and collaboration. Improved efficiency over time can be gained by attention to continuous improvement, but to achieve this better metrics to measure defects and rework are needed, allowing reduction targets to be set. (Lee & Amaral 2002).

In recent years the emergence of affordable information technology (IT) at the site level offers potential for significant improvement in supply chain collaboration in the area of defects elimination and management of the defects and rework process. Significant literature contributions have been made by; Bowden et al. (2006) Kim et al. (2007) and Craig & Sommerville (2007) who all describe attempts to collaborate the site processes involved in collection and management of defects data using mobile IT devices, that link back to database systems. The accounts however focus on larger projects and contractors. The quality appraisal costs (Rosenfeld 2009) involved in purchasing equipment, on-going technical support and staff training described are relatively modest for such contractors, but are more challenging for the plethora of SME contractors found in Ireland, particularly the many small sub-contractors. Essentially a balance needs to be struck between costs of ensuring quality and costs of non-quality (Rosenfeld 2009). The literature would benefit from more study pertaining to the use of affordable mobile IT by SME companies and it is planned that future reports from this study will address that area.

PILOT CASE STUDY OVERVIEW

As part of a wider PhD study, a pilot field study using an AR approach was undertaken to gather knowledge about Irish construction practices and attitudes concerning the management and understanding of defects, particularly in and around the project completion phase. AR adopts an inductive research approach based on a cycle involving diagnosing of a problem, action planning, action taking, evaluation of results, and specification of learning in a manner that is readily usable by participants (Susman & Evered 1978). A key factor is the notion of collaborative problem solving between researcher and organisation. In this study the 'problem' to be resolved is the on-going costs and disruption of rework on the main contractor's projects. AR thus directly promotes organisational change as well as the more normal research outputs

of description, understanding and explanation (Robson 2000). This study utilised several data collection methods including analysis of project drawings, specifications and written reports including snag lists, semi-structured interviews with key participants including design team, main contractor and sub-contractors (10 No) and visual observation of defects on the project. At the completion of the project a number of reflective discussions with participants also took place.

The project involved construction of a health department project in Ireland, valued at circa €1.5 million. The project was let by two-stage tender to a local SME contractor, appointed using a 'traditional' version of the Irish public works contract with separated design and construction elements. Interviews with participants found consensus that they felt the project was generally successful and completed in a co-operative manner.

ANATOMY OF A SNAG

A considerable concern in the literature is the lack of root cause analysis of supply chain problems (Fellows 2012). An illustrated example of a typical snag is provided here. *(Photographs by author)* Photographs A, B & C show examples of snags taken from the site managers terminal snag list, No 21,42 & 62 all show co-located electrical plates / sockets which have associated defects, mainly of an aesthetic nature. An inspection found 15 locations where sockets / plates were co-located, many of them showed minor defects and were repetitively marked on the snag list. Discussions with the stakeholders including the site manager, electrical engineer, electrical contractor and decorator found that they all felt this was a 'normal' snag that they had encountered on many previous projects.

Photograph A (Top left) Surface mounted sockets on plaster wall. Photograph B, (Top Right) Recessed sockets with tile surround. Photograph C, (Left) Recessed sockets in painted and plastered wall.

Each required a return visit for rectification. Given the nature of rework required, several visits are needed to facilitate filling, redecoration and repair. It was noted via inspection, that the distance between the sockets influenced the likelihood of defects. Sockets that were closer together (0 - 50mm) exhibited many more defects than those further apart. Those with spacing above 50mm exhibited few if any snags.

A detailed discussion and consideration of the root cause of these snags yielded the following insights: Similar snags occurred with a variety of specifications, tile, and plaster, surface mounted and recessed. No two sets of co-located sockets (15 No found) had the same spacing. Spacing appeared totally random. A second project with co-located sockets was examined (11 No found) and supported the same conclusion. It was agreed during discussion that the individual electricians were randomly spacing the sockets. The electrical design drawings used CAD symbol notation to show the approximate position of sockets, no explicit dimensions were given leaving the individual electrician to decide the spacing. Further discussions found that follow on trades (plasterer, tiler, and painter) all found difficulty in working with the tiny elements of material found between sockets. Slithers of tile, small areas of plaster etc. leading to the defects. Larger pieces were easier to work with and yielded no defects.

The proposed solution is relatively simple and adopts a lean construction approach (Koskela 1994), by standardising the process. In the next iteration of the AR cycle the participants will use a standard spacing of 100mm for all conduits between co-located sockets. The propensity of defects will be checked to assess the success of the intervention. It is expected that the intervention will yield more consistent design and eliminate rework at no extra cost. If successful there is the possibility of conduit suppliers providing pre-sized and threaded conduit spacers thus speeding up the site element of the work whilst ensuring a standardised result.

The above example suggests that sub-contractors and suppliers can collaborate in the supply chain to eliminate common defects in advance, by joint contribution of their expert knowledge. However on this project none of the contractors or suppliers was asked to give any pre-construction input or critique of the design and report that to be normal practice. Part of the wider AR study will also provide a number of visual management tools to disseminate the knowledge to the supply chain so that learning can take place. It is also planned that workshops will be held in conjunction with the Construction Industry Federation (CIF) to further disseminate learning to the wider industry. It is also worth noting that the snags described above were listed for rework by sub-contractors who were not directly involved in the root cause of the problem, which is design related.

PILOT STUDY OVERVIEW OF MANAGEMENT SYSTEM

Using the AR approach the pilot study project was used to build up knowledge of the management systems for controlling rework and snags. This included site observation of work and semi-structured interviews with participants. Defects / Snag lists were scrutinised and synthesised daywork costs were added to gauge their impact. The following key points were noted.

The sub-contractors did not formally check their own work. The design team and site manager held periodic site walks and detected some issues. When interviewed all of the participants strongly supported the notion of 'collaboration' but agreed they had no formal forum or mechanisms to do so (on this project or elsewhere). Their efforts to avoid defects were thus informal and unstructured. Towards the end of the project the site manager, architect, electrical & mechanical engineers produced snag lists that were examined for this study. All were provided electronically either in Microsoft Word or in PDF format. The lists had idiosyncratic layouts. The two engineers worked for the same company but their lists had different layout. Interview data confirmed that participants generally worked separately on this task with no interdisciplinary or cross-organisational collaboration. No IT based information sharing systems was

evident and only the Architect had any previous experience of working with collaborative IT systems.

For comparison purposes the lists were benchmarked against Sommerville *et al*, (2004) who investigated the commonality of headings on defects / snag lists and provided twenty-two items of information that may be found on such lists. Key concerns here were: 1) the lists had no revision number system, such that different versions of the list may be in circulation and lead to confusion as to which was the most up to date list. 2) The lists had no obvious updated 'status' process, thus without undertaking another full inspection one could not identify how many snags had been rectified at any given time. 3) Only one list (mechanical) had allocated a number to each defect, this makes it difficult to identify individual snags in an easy way and makes higher-level statistical analysis of the lists all but impossible. 4) The lists make no connection between sub-contracts works packages, thus 'shared' defects that may require collaboration to rectify is not identified. Also because of this factor lists cannot be sorted by sub-contractor name, they thus receive the whole list, not just their own list of defects. 5) No list provided any 'due date' by which the defect must be rectified. 6) The client was not consulted concerning this terminal inspection process. Subsequently they provided a short list of defects / snags of their own. This necessitated additional return visits accruing additional direct and indirect costs. The participants confirmed they generally used informal mechanisms to gauge client satisfaction with the finished product. No formal metrics that measured key performance indicators (such as quality / number defects) were used and was not normal practice.

The nature of the defects in terms of description and their location within the site was generally adequate for the sub-contractors to identify the defect and location. However this was not entirely the case, some general items were evidenced, such as *'touch up all marks on painted walls'* without any corresponding location, requiring the decorator to make a subjective judgement as to the amount of rework required. Other items listed (on all four lists) could properly be defined as being incomplete or missing entirely rather than defective.

The nature of the data provided and the media (Word / PDF) meant the data was of limited use for any further analytical purposes, unless data re-entry was undertaken. The management process was incoherent and not supportive of a collaborative approach to the defects issue, a lack of standardisation in the process and the lack of any analytical potential are obvious, but relatively easy to rectify, should the participants design and implement a more collaborative and robust system for identification, elimination and rectification of the defects. Interview data confirmed that none of the participants had any previous training in how to design and implement such collaborative working practices. They recognised that change in this area requires senior management support and generally felt that would be forthcoming from their organisation.

The literature strongly suggests that one reason that contractors have not historically addressed the defects issue is because they do not fully comprehend how much it truly costs them. To illustrate this issue to the participants, the site managers snag list was assessed on site and each snag was assigned an estimated number of work hours for rectification and appropriate estimate of new materials and plant costs. The figures were then multiplied through using hourly daywork rates verified by an independent senior PQS. The costs associated with the site managers' list corresponded to 1.3% of

the construction cost of the project. Additionally there are costs associated with the other three defects lists, defects rectified during the project and defects that may arise during the maintenance period. We may thus speculate that added together a conservative figure of 5%, (supported by the literature) of construction cost would be spent on rectification of defects on this project, which is generally held by all participants as otherwise successful.

CONCLUSION

This study has considered the information gained from a scoping exercise using an Action Research approach to develop an action plan to address the defects and rework issued of an SME building contractor. Future work will provide reports on the implementation phases of this project. The information presented here allows several preliminary conclusions to be drawn that can be tested in future phases of the project. It has been demonstrated that there is potential for collaborative root cause analysis by supply chain members to identify and eliminate repetitive defects, contributing to a long-term continuous improvement process. Elimination is of course preferable to reduction in the longer-term. It has also been demonstrated that there is potential to refine the management process used to identify and rectify defects by adopting a collaborative and standardised process. This would be more data rich and thus user friendly at project level and provide analytical interrogation possibilities at the organisational level. The likely cost benefits and customer satisfaction possibilities of this approach have been outlined and can be expanded upon in future project phases. Finally the information suggests participants strongly support the need for formal collaborative or at least more informal co-operative approaches. They don't however currently adopt systems and processes at a collaborative level for mutual benefit.

REFERENCES

Atkinson, A.R. (1999) The role of human error in construction defects "Structural Survey" 17 (2), 231 - 236

Atkinson, A. (2002). The pathology of defects: a human error approach. "Engineering Construction and Architectural Management" 9 (1) 53 - 61

Bowden, S. Dorr, A. Thorpe, T. and Anumba, C. (2006) Mobile ICT support for construction process improvement. "Automation in Construction" 15, 664 - 676

Chong, W.K and Low, S.P. (2005) Assessment of Defects at Construction and Occupancy Stages "Journal of Performance of Constructed Facilities", 283 - 289

Craig, N. and Sommerville, J. (2007) Records Management and Information processing on construction sites using digital pen and paper "Records Management Journal" 17 (3) 201 -215

Davis Langdon (2011) "Davis Langdon Ireland Annual Review 2011", Dublin, Davis Langdon

DKM (2009) "Review of the construction industry 2008 and outlook 2009 – 2011". Dublin, DKM Economic Consultants Ltd.

Fellows, R. (2010) New research paradigms in the built environment "Construction Innovation" 10 (1), 5-13

Josephson, P.E. & Hammarlund, Y. (1999) The causes and costs of defects in construction "Automation in Construction" 8 (2) 681 – 687

Josephson, P.E, Larsson, B. and Li, H. (2002) Illustrative benchmarking rework and rework costs in Swedish Construction Industry "Journal of Management in Engineering". April 2002, 76 - 83

Karim, K., Marosszeky, M., & Davis, S. (2006) Managing subcontractor supply chain for quality in construction "Engineering, Construction and Architectural Management", *13*(1) 27-42.

Kim, Y.S, Oh, Se, W, Yong, K, Cho & Jong, W, Seo. (2008) A PDA and Wireless web-integrated system for quality inspection and defect management of apartment housing projects. "Automation in Construction" 17 (2008) 163 - 179

Koskela, L. Henrich, G. Owen, R and Vrijhoef, R. (2006) Theory based production and project management "Proceedings of the 3rd International Salford Centre for Research and Innovation symposium" *(SCRI)* Delft, Netherlands.

Hwang, B.G, Thomas, S.R, Haas, C.T, and Caldas, C.H, (2009) Measuring the impact of rework on construction cost performance "Journal of Construction Engineering and Management", March 2009 187 – 198

Lee, H.L. and Amaral, J. (2002) Continuous and sustainable improvement through supply chain performance management. "Stanford global supply chain management forum". SGSCMF-W1-2002. Stanford University

Liker, J.K. (2004) "The Toyota Way", New York, McGraw-Hill

Love, P.E.D, Li, H. and Mandal, P. (1999) Rework: a symptom of a dysfunctional supply-chain "Journal of Purchasing & Supply Management" 5 (1999) 1 -11

Love, P.E.D. (2002) Influence of project type and procurement method on rework costs in building construction projects "Journal of Construction Engineering & Management" Jan / Feb 2002 18 – 29

Love, P.E.D, (2002b) Auditing the indirect consequences of rework in construction: a case based approach "Managerial Auditing Journal" 17 (3) 138 - 146

Love, P.E.D. & Edwards, D.J. (2004) Forensic Project Management: The Underlying Causes of rework in construction projects "Civil Engineering and Environmental Systems" 21 (3) 207 - 228

Love, P.E.D, Irani, Z. and Edwards, D.J. (2004) A rework reduction model for construction "IEEE Transactions on Engineering Management" 51 (4), 426 – 440

Robson, C. (2002) "Real World Research" 2nd Ed. Oxford, Blackwell Publishing

Rosenfeld, Y. (2009) Cost of quality versus cost of non-quality in construction: the crucial balance. "Construction Management and Economics" (Feb 2009) 27, 107 - 117

Rotimi, F.E., Tookey, J. Craig, N. and Rotimi, J.O.B. (2011) Opportunities for defect reporting in new residential buildings: A case for New Zealand In: Egbu, C and Lou, E.C.W. (Eds) Procs "27th Annual ARCOM Conference", 5 - 7 Sept 2011, Bristol, UK, Association of Researchers in Construction Management 643 – 652

SCSI (2012) "The Irish construction industry 2012", Society of Chartered Surveyors Ireland. Dublin, SCSI

Sommerville, J. Craig, N & Bowden, S. (2004) The Standardisation of Construction Snagging "Structural Survey". 22 (5) 251 - 258

Sommerville, J. (2007) Defects and rework in new build: an analysis of the phenomenon and drivers "Structural Survey" 25 (5) 391 – 407

Susman, G. I & Evered, R.D. (1978) An Assessment of the scientific merits of action research "Administrative Science Quarterly" 23 (4) 582 – 603

Taggart M; Koskela L and Rooke J (2012) Collaborative supply chain practices during severe economic downturn in the Republic of Ireland In: Smith, S.D (Ed) "Procs 28th Annual ARCOM Conference", 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 687-695

HOW CAN SUPPLY CHAIN MANAGEMENT PROLIFERATE IN SOUTH AFRICAN CONSTRUCTION?

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Noted interdependencies affects how activity coordination is approached in construction as actors have to constantly adjust and direct activities and resources in and between numerous supply chains and construction sites. This is one of the reasons why process effectiveness and efficiency have been the focus of supply chain management (SCM), mainly in a project based context. Due to the documented need to enact efficiency in construction, an exploratory case study was conducted on a general contracting (GC) firm based in a South African region. Insights gained from the study show how the concepts inherent in SCM is understood within the firm; how the coordination of production processes affect the creation of value demanded by clients through the GC; and the transaction governance structures that are often used within supply chains by the GC. The insights from the case study suggest that there appears to be a major scope for the implementation of SCM in the practice of construction management in South Africa. In other words, the attempt to drive project performance improvement through a proactive management of the supply chain could prove to be valuable for project stakeholders in South Africa.

Keywords: construction, performance, supply chain management, South Africa.

INTRODUCTION

Key drivers of change in the industry are forcing firms in the construction setup to adapt and reinvent themselves for the sake of enhanced effectiveness and efficiency. Much of this adaptation is occurring in the supply chain as effective firms are essential to the success of construction projects (Sommerville and Craig, 2006). The supply chain is thus a focus for increased ways of creating value for clients as it is deemed to be a vehicle for performance improvement and innovation in the industry (Pryke, 2009; 2012). SCM in construction addresses the impact of the supply chain on site activities with a view to reducing cost and time spent on each activity (Morledge et al. 2009). SCM can also facilitate the transfer of activities from site to earlier stages in the process so that site production can be enhanced. Thus, managing supply chains involved in a project in an integrative manner provides an opportunity to capture value, and, then deliver expected client satisfactions (Edkins, 2009).

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Emuze F and Smallwood J (2013) How can supply chain management proliferate in South African construction? *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 513-522.

However, for expected SCM related value to manifest, project factors in the form of the management of the design process, cost, and the entire construction process should be done with best practices in mind (Male, 2003). As an illustration, Male (2003) suggests that planning for the construction stage should start during detail design and it should involve suppliers within cluster groups; and project teams should endeavour to remove waste and engage in processes that could make quality checks redundant. While examples of events related to construction SCM that have made a case for its proliferation can be seen in developed economies (see chapters authored by Rimmer (2009), and others in Pryke, 2009), this is limited in developing economies. Gosling and Naim (2009a) contend that strategies such as a shift between supply chain structures, supply chain integration, flexibility, time compression and the development of a new product process improvement could enact performance enhancement in the engineered-to-order (ETO) sector (construction inclusive). The need to understand risk and uncertainties in terms of construction SCM shows that 'flexibility' could alleviate sources of supply chain uncertainties that are related to control, process, demand, and supply (Gosling and Naim, 2009b). The advantages of construction SCM does not override the complexities associated with its implementation. For instance, as individuals and / or firms gain autonomy, the coordination burdens tend to grow and then require organisational structures that are able to manage a range of commitment loops concerning project completion (Azambuja and O'Brien, 2009; Isatto and Formoso, 2011).

The next section of the paper presents the rationale for the study, which is followed by a concise overview of GCs as drivers of SCM in construction. The methodology highlight how the primary data were collected and the findings were summarized in the case study section. A succinct discussion then precedes the concluding remarks.

Research Rationale:

Although many South African based GCs have embraced quality related philosophies such as total quality management (TQM) over time (Rhodes and Smallwood, 2002; CIDB, 2011; Emuze and Smallwood, 2011a; Smallwood and Emuze, 2012), there appears to be ambivalence toward the holistic adoption of SCM. Thus, how a major GC goes about managing its supply chains in South African construction became the focus of this study. This is important as major health and safety (H&S) failures, rework and cost overruns are often blamed on project parties that are under the control of GCs (CIDB 2004; 2009). More importantly, with the expected increased investment in the industry in South Africa (Pillay, 2013), the management of subcontractors and suppliers working for GCs is crucial for profitability and business survival in the sector. In other words, the monotonous management of supply chains could also limit performance progress in the sector.

CONTRACTORS AS DRIVERS OF SCM: AN OVERVIEW

The construction management literature indicates that the client or the contractor can champion the implementation of SCM in construction. Male and Mitrovic (2005) offer a useful way of thinking about supply chains by distinguishing between the types of supply chains. They say project supply chain (PSC) is a direct response to a client requirement, and organisational supply chain (OSC) describes the main contractor as a business entity or organisational supply chain. Building on the airport and airline analogy of Male (2002), which saw the main contractor as the supply chain 'hub', meeting various client needs by managing various project-specific supply chains, they drew a distinction between PSC and OSC.

The notion of an OSC is particularly interesting as it draws attention to the main contractor's ability to manage and influence a number of project-specific supply chains for different clients, irrespective of the clients' inclination and ability to utilise SCM. This distinction recognises that main contractors with sufficient organisational and economic size, as the hub of numerous supply networks, have the ability to develop their organisational supply chain and provide numerous highly differentiated clients with the resulting benefits. This is based on the premise that sustained high levels of demand are needed to maintain standing supply chains, whose members are willing to invest and innovate for the benefit of a single client. The main contractor's ability to form long-term relationships with subcontractors stems from its ability to provide a multitude of clients with benefits of an OSC, irrespective of the client's disposition towards SCM (King and Pitt, 2009). Main contractors, as 'hubs' in the constellation of demand and supply chain systems, derive their competitive advantage from balancing the competing needs of these different requirements within PSC through organising the procurement and management of their own multi-project supply network (Male and Mitrovic, 2005).

In this extended role, contractors are ideally placed to increase their market power and become supply chain leaders working directly for clients on a more regular basis. Their supply chain strategy becomes one of assembling the right teams, at the right time and in the right locations to build various built environment fixed assets for clients. The aforesaid shows that the construction supply chain is simply a network of firms that agreed to work together in order to realise objectives relative to construction projects. The days of vertical integration or rather the era whereby a single firm can singly realise a construction project can be deemed to be simply over for now. Prevailing circumstances in the industry necessitates a proactive approach to the management of actors / and firms involved in project conception and realisation. Venkataraman and Pinto (2008) elaborate on the topic when they contend that as a direct result of factors such as globalisation, best value for customer money, inventory management, and complexities, risks and uncertainties attached to projects, it is necessary to adopt SCM approaches in construction. According to them, project supply chain complexities underscore the importance and need for project-based organisations to manage their total supply chain in a more formal and organised manner. They contend that SCM approaches such as partnering, information, and risk sharing can greatly reduce uncertainties and complexities attached to projects. In addition, management approaches that goes with SCM such as purchasing, distribution, and logistics will not only enable organisations to realise major gains through the elimination of wastes in the process, but also they should provide opportunities for businesses to improve their operations.

METHODOLOGY

The initial stage of the study adopts the use of a single case study because at the centre of the case study as a research method lie context-dependent knowledge and experience, which are central to expert activities (Flyvberg, 2011). More so, a detailed scrutiny of a single example of a class of phenomena may be useful in the preliminary stages of an investigation since it provides hypotheses that can be tested with a larger number of cases in a future study (Flyvberg, 2011). The objective of exploratory studies is not to test or to confirm a specific hypothesis. Rather it is done to familiarise the researcher with the subject matter so as to make it more explicit. According to most qualitative study authors, the case study (which focuses on contemporary

phenomena rooted in a real-world context) must be used when the objective is to know more about a specific topic in which control of the events are limited.

Thus, the data were collected through on-site face-to-face interviews in the month of July in 2012. The data were tape recorded before transcription. The data were analysed in a thematic manner based on the interview questions. The interviews were designed to collect data on the extent that the firm understand the concepts of SCM in construction, the transaction governance structures that can be identified within the supply chains working with the GC, and the characteristics of SCM in South African construction as perceived by the GC.

The firm that was studied had 4 on-going projects inside, and around the Nelson Mandela Metropolitan University (NMMU) in Port Elizabeth at the time of the fieldwork. A unique element of the case study is that the GC has over the years served as employers of construction management graduates of NMMU and targeted research have been conducted on behalf of the firm at the NMMU Unit for the Study of Construction Processes (USCP). In addition, such targeted research endeavours examined how quality and health and safety (H&S) can be improved in the firm. At a regional level, the GC has received a number of H&S awards from the Western Cape Province where it has its main operations. The selection of the GC was purposive in that the firm is noted for extensive use of subcontractors and suppliers for project delivery. The next sections provide an overview of the background of the GC and the interviewee as well as the practice based responses that were recorded in the fieldwork.

FINDINGS - THE CASE STUDY

In terms of the background, the firm is a general contractor that is focus on non-civil engineering projects – buildings and other non-residential projects. Rather that executing all that is involved in a project, the GC can be considered as a construction management firm that make use of subcontracting extensively. The firm operates in more than one province in South Africa, although it is still very far from being considered a national entity. Established in 1985 in Cape Town as a building firm, the firm over time specialised in design and construct and later venture into general contracting by the late 90s. The board of directors of the firm is headed by a CEO that has extensive experience in the industry. The size of the firm in terms of turnover is about R750m (£48.5m) annually and in terms of employees, the firm employs a total number of 120 permanent staffs.

With the permission of the top management of the firm, an hour long semi-structured interviews were conducted with the Commercial Manager of the firm twice. The interviews took place on-site inside NMMU. The Commercial Manager position in the firm entails the procurement of projects and contract management. The interviewee has been with the GC for over eight (8) years at the time of the interview. The interviewee is a holder of a BSc and MSc construction management qualifications from a South African university. Apart from demographic information, the interviewee responded to two (3) main open-ended questions and 1 close-ended question. The open-ended questions had forty-three (43) sub questions, while the close-ended questions had nineteen (19) sub questions.

PERCEPTIONS OF SCM IN THE FIRM

The first main question asked the interviewee the extent that organisations understand the concept of supply chain management in construction. In responding to this, the

interview opined that SCM is not formalised as it is erratic in construction when his experience is taken into consideration. However, the interviewee suggests that SCM can be viewed as organised bodies that endeavour to be efficient in their collective undertakings. He went further to say that the firm perceive a supply chain to be an organised group of suppliers that are committed to providing products and services to the GC.

When asked how relationships between project parties affect the entire supply chain, the interviewee was of the opinion that relationships between the client and the entire supply often improve project delivery; relationships between suppliers and the entire supply chain may foster collusions that is on the rise in the industry; and the effect of the relationship between the GC and project consultants on one hand and the entire supply chain on the other hand could improve project delivery. It is however notable that the interviewee was unable to mention the interdependencies that are evident in supply chains, although he suggests that reliable database constitute a tool that is synonymous with SCM in the firm. Based on the perceptions of the interviewee, having a reliable database of professional suppliers is a significant benefit of SCM. The interviewee however noted that the benefit can be marginalised by price fixing.

Using on-going projects and pasts projects of the firm as the point of reference, the interviewee was asked "how does the coordination of production processes affect the creation of value required by your clients?" The interviewee responded by saying that productivity measures and cost reports were often used to monitor efficiency in their site operations. Late material delivery on some of their sites does affect operational performance through delays that affect the entire project. It is notable that despite a number of initiatives that is put in place, half of the time, late delivery of materials to sites is experienced by the GC according to the interviewee. For instance, the interviewee said that the GC usually buy materials as they are needed; make purchase arrangements with suppliers on time; specify the quantities and dates that materials are needed on site for suppliers; and in some cases, the firm would have to buy and stockpile materials off-site for a later use on site in order to avoid delay.

The later usually lead to increased inventory cost allocated to such projects. In addition, the interviewee affirms that they are able to keep track of material delivery and related activities because each site has a dedicated store man who is mandated to check materials upon delivery. He cited several cases where materials were returned to suppliers because they fail to comply with specifications. The GC often encounters either late delivery of material or the delivery of sub-standard materials. To this end, the GC makes it a point to check the work of subcontractors and suppliers thoroughly and quality sheets are always used to evaluate the performance of such subcontractors and suppliers. This must be done as poor quality and late delivery or completion constitute major issues that are related to the work done by subcontractors on some of their project sites. The interviewee illustrated how the firm ensures that subcontractors and suppliers deliver project related commitments, so that client satisfaction can be assured. In essence, long-term relationships are developed with suppliers and subcontractors that are able to perform to the satisfaction of the GC. Improved products and services as well as preferential rates are some of the benefits of such relationships mentioned by the interviewee.

TRANSACTION GOVERNANCE RELATED ISSUES

Issues pertaining to transaction governance structures that can be identified within supply chains constituted the main theme of the third open-ended question. The

interviewee noted that the firm often make use of the best combination of price and quality as the criteria for the selection of subcontractors and suppliers for their project needs. However, preference is always given to firms (subcontractors and suppliers) that are based at the location of projects. When asked for reasons behind this policy, the interviewee responded that local suppliers are more flexible and they have the added advantage of having the knowledge and understanding of the local industry. Nevertheless, the GC usually source for subcontractors through the Master Builders Associations (MBA) that are based in project locations and industry related referrals. Once sourced, the subcontractors and suppliers are used repeatedly for projects in their locations as long as their performance is not compromised.

The interviewee even noted that the GC seldom makes use of a subcontractor on a 'once off' basis. Selected subcontractors and suppliers are expected to sign an in-house contract agreement (bespoke) with the GC after a purchase order is given to them. Prior to the contract signing, required documents in the form of specifications and designs are made available to the subcontractors and suppliers. A combination of competitive tendering and negotiation is used to secure the services of subcontractors and suppliers in the firm. Although a non-performance penalty clause is included in the bespoke contract agreement with subcontractors and suppliers, performance incentives are obvious omissions in such contracts. The GC has however encountered disputes between itself and subcontractors and suppliers in its books according to the interviewee. The disputes often relate to lack of delivery on the side of the subcontractors and suppliers. It is notable that such dispute normally ends at the arbitration stage.

PERCEIVED FEATURES OF SCM

As aforesaid, a close-ended question was also asked. With a 'yes', 'no' and 'unsure' response, the interviewee was requested to answer certain questions that are intended to record the features of SCM in the South African construction context. The perceptions expressed by the interviewee were either positive (Table 1) or negative (Table 2). Table 1 shows that the interviewee perceive that there is a prospect of future collaboration between project parties in South Africa and every member of a project team can contribute to project decisions. Further, the interviewee was of the opinion that project parties tend to trade blames when problems occur by pinpointing each organisation that is responsible for failures. However, the top management related to a particular project have the ability to resolve problems and that performance related feedbacks are always relayed to project parties.

Table 1: Features of SCM in South Africa construction context (Positive)

Question	Response
Is there a prospect of future collaboration between project parties?	Y
Does everyone have input into project decisions?	Y
Do project parties trade blames when problems occur?	Y
Do project parties pinpoint individual organisation for failures?	Y
Is learning and experiences shared mutually between project parties?	Y
Are problems resolved by top management involved in the project?	Y
Is feedback related to performance given to project parties?	Y

In contrast, the interviewee observes that top management of firms involved in a project rarely commit themselves to mutual objectives. Thus, mutual objectives are not always achieved at project completion and profit sharing tends to be unfair. While long-term relationships have been promoted with its advantages, the interviewee opined that supply chains are not always focus on such relationships. Information sharing within the chain is not also open or free. The table indicates that problems are not constantly resolved at their level of occurrence and open book costing is not used by project parties. The interviewee noted that 'reinventing' the wheel of past mistakes is not avoided as lessons learnt suffer implementation problems. Performance measures on projects are not consistent, while performance reviews are not conducted, either formally or informally. In terms of risk management, the table shows that a balance cannot be found between risks and reward among project parties; and risks are often not allocated to the best party that can bear it.

Table 2: Features of SCM in South African construction context (Negative)

Question	Response
Does top management of organisations commit to mutual objectives?	N
Are mutual objectives achieved at project completion?	N
Is profit fairly shared between project parties?	N
Do supply chains focus on long-term relationships	N
Do project parties exchange information freely?	N
Is open book costing used throughout the supply chain?	N
Are problems solved at the same level where they occurred?	N
Are lessons learnt in order to avert future occurrence of similar issues?	N
Are there common performance measures in projects?	N
Is performance reviewed regularly either formally or informally?	N
Can balance be found between risks and reward among project parties?	N
Is a risk generally allocated to the best party that can bear it?	N

DISCUSSION

The main insight that emerges from this study is that formal SCM in South African construction has proved rather elusive and difficult to realise in practice, especially from the experience of the GC that was examined. The reasons why this is the case is unclear from the study. Despite this impediment to proper collaborative working between the GCs and its supply chain, there appears to be some evidence of informal, but yet co-operative working with subcontractors that have long-term relationships with the firm. The work of Briscoe and Dainty (2005) may provide an explanation for this occurrence. Briscoe and Dainty (2005) suggest that collaborative relationships have the tendency to evolve more effectively when it is not constrained by the formal aspects detailed in a contract data. The informal management of the supply chain by the GC may well manifest in improvement since whenever longer-term relationships have evolved, the actors in the construction project have often developed effective systems of communication and information exchange to the extent of aligning their management systems for the benefit of the project (Briscoe and Dainty, 2005).

The number of subcontracting firms in South Africa that have risen in recent years due to the evolving nature of the industry (Shakantu et al., 2007; Emuze and Smallwood,

2011b), demands a shift in how contractors and their supply chain partners operates in terms of the management of the business of construction. For reasons not limited to competitiveness and survivability in a volatile market, firms in the industry should become alert to their approach to relationships when involved in horizontal integrative way of project delivery. Evidence from Sweden supports this argument. An analysis of economic data from the development of the national Swedish timber industry between 2008 and 2010 by Bjornfot and Torjussen (2012) indicates that the number of bankruptcies of SME in the northern Swedish timber industry were fewer than the national average. With two case studies, Bjornfot and Torjussen (2012) were able to show that the main reason for this pertained to the horizontal supply chain collaboration that existed among the firms. The collaboration entails 'flexibility' that enabled shared resources and capabilities among the collaborating firms.

The evidence of the benefits of a proactive approach toward SCM therefore suggests that the GC (and similar firms in the same situation) would gain if they consistently encourage long-term relationships where information sharing is open and free; lessons learnt on projects are shared to prevent future occurrences; and cost and profit issues are open to all project parties.

CONCLUDING REMARKS

The perceived ambivalence towards the use and / or adoption of SCM by South Africa GCs despite the widespread use of horizontal integration for project execution forms the main rationale for the study. With expected extensive use of subcontractors and suppliers in South Africa not slowing down in the near future, the management of these project actors is deemed to be vital to performance progress and profitability in the sector. The research strategy adopted the case study approach as when little is known about a phenomenon in a particular context, a single case can open up research questions and hypotheses that would form the core of a future study. The investigated GC provides a vivid example of construction management in practice in South Africa in that the firm makes use of suppliers and subcontractors to fulfil most of its obligated functions on site.

It was observed that management strategies that are synonymous with SCM are yet to be fully assimilated in the firm because only the possibility of a long-term relationship and the availability of a database constitute the main SCM approaches that are presently used by the firm. The perception of SCM in the sector is also not sophisticated enough for it to become a means of driving performance improvement in the firm. Nevertheless, the description and level of understanding of SCM that were visible when interviewing the informant support the notion that there is a major need to adopt a proactive instead of a reactive approach to how subcontractors and suppliers are managed by GCs in South Africa. The insights gleaned from this single case study provide the basis for the compilation of three hypotheses, which include:

- Imbalance view of the relationships among subcontractors and suppliers involved in a project has engendered non-formalised and often erratic management of the construction supply chain in South Africa;
- The use of bespoke form of contract agreement that may excessively serve the interest of principal contractors when engaging the services of subcontractors and suppliers influences the outcome of project relationships, and
- The achievement of mutual objectives by project parties has become elusive due to the absence of commitments to same by top management of the firms involved in a project undertaking.

However, it can be argued that the compilation of a future conceptual framework should be able to refine the proposed hypotheses and then encourage their falsification / corroboration through a rigorous empirical research.

ACKNOWLEDGEMENT

The author is grateful to the NMMU-cidb Centre of Excellence, hosted by the Built Environment Research Centre (BERC), for supporting this research project in 2012.

REFERENCES

Azambuja, M and O'Brien, WJ (2009) Construction supply chain modelling: Issues & perspective. In: W.J. O'Brien, C.T. Formoso, R. Vrijhoef, and K.A. London, (eds). "Construction supply chain management handbook". Boca Raton: CRC Press.

Bjornfot, A and Torjussen, L (2012) Extent and effect of horizontal supply chain collaboration among construction SME. "Journal of Engineering, Project, and Production Management", 2(1), 47-55.

Briscoe, G and Dainty, A (2005) Construction supply chain integration: an elusive goal. "Supply Chain Management: An International Journal". 10(4), 319-326.

Construction Industry Development Board (2011) "Construction Quality in South Africa; a client perspective: a discussion document". Pretoria: CIDB.

Construction Industry Development Board (2009) "Construction Health & Safety in South Africa: Status & Recommendations". Pretoria: CIDB.

Construction Industry Development Board (2004) "SA Construction industry status report-2004: Synthesis review on the South African construction industry and its development". Pretoria: CIDB.

Edkins, A (2009) Risk management and the supply chain. In S. Pryke (ed.) "Construction supply chain management: concepts and case studies". Oxford: Wiley-Blackwell.

Emuze, FA and Smallwood, JJ (2011a) Rework due to Human Error in South African Construction. In: "Proceedings of the 2011 CIB-W107-Construction in Developing Countries International Conference", 1-3 November, Hanoi Vietnam, 103-108.

Emuze, FA and Smallwood, JJ (2011b) Construction industry development: a South African perspective. In: "Proceedings of the 2011 CIB-W107-Construction in Developing Countries International Conference", 1-3 November, Hanoi Vietnam, 109-113.

Flyvberg, B (2011) Case study. In: N.K. Denzin and Y.S. Lincoln (eds.) "The Sage handbook of qualitative research". Thousand Oaks, California: Sage.

Gosling, J and Naim, MM (2009a) Engineer-to-order supply chain management: A literature review and research agenda. "International Journal of Production Economics", 122(2), 741-754.

Gosling, J and Naim, MM (2009b) Coping with project uncertainty in construction supply chains. In: "Proceedings of the 25th Annual Association of Researchers in Construction Management (ARCOM) Conference", 7-9 September, Nottingham, UK, Vol. 1, 813-822.

Isatto, EL and Formoso, CT (2011) Three theoretical perspectives for understanding inter-firm coordination of construction project supply chains. "Australasian Journal of Construction Economics and Building", 11(3), 1-17.

King, AP and Pitt, MC (2009) Supply chain management: a main contractor's perspective. In S. Pryke (ed.) "Construction supply chain management: concepts and case studies". Oxford: Wiley-Blackwell.

Male, S (2003) Future trends in construction procurement: procuring and managing demand and supply chains in construction. In: D. Bower (ed.) "Management of procurement". London: Thomas Telford.

Male, SP (2002) Supply chain management. In: N.J. Smith (ed.) "Engineering project management". 2nd ed. Oxford: Blackwell Science.

Male, SP and Mitrovic, D (2005) The project value chain: models for procuring supply chains in construction. In: "Proceeding of The Queensland University of Technology Research Week International Conference". Brisbane, 2005. QUT.

Morledge, R, Knight, A and Grada, M (2009). The concepts and development of supply chain management in the UK construction industry. In: S. Pryke (ed.) "Construction supply chain management: concepts and case studies". Oxford: Wiley-Blackwell.

Pillay, M (2013) From the CEO's Desk: the tortoise and the hare-ngineer. "SAICE-Civil Engineering", 21(2), pp. 1.

Pryke, S (2012) "Social network analysis in construction". Chichester: Wiley-Blackwell.

Pryke, S (ed.) (2009) "Construction supply chain management: concepts and case studies". Oxford: Wiley-Blackwell.

Rhodes, B and Smallwood, JJ (2002) Defects and rework in South African construction projects. In: "Proceedings of RICS COBRA Conference", Nottingham Trent University, Nottingham, 5-6 September,182–196.

Rimmer, B., 2009. Slough Estates in the 1990s-Clint driven SCM. In S. Pryke, ed. Construction supply chain management: concepts and case studies. Oxford: Wiley-Blackwell. pp.137-59.

Shakantu, WMW, Tookey, J, Muya, M and Bowen, P (2007) Beyond Egan's supply chain management: Advancing the role of logistics in the South African construction industry. "Acta Structilia", 14(1), 93-115.

Smallwood, JJ and Emuze, FA (2012) Status of Quality in South African Construction: The Case of a General Contractor. In: "Proceedings of the 6th International Conference and Workshop on the Built Environment in Developing Countries (ICBEDC-2012)", 4-5 December, Adelaide, Australia, 113-124.

Sommerville, J and Craig, N (2006) "Implementing IT in construction". Oxford: Taylor & Francis.

Venkataraman, RR and Pinto, JK (2008) "Cost and value management in projects". New Jersey: John Wiley & Sons.

A SOCIO-ECONOMIC FRAMEWORK FOR ADOPTING GOVERNANCE MECHANISMS IN LARGE CONSTRUCTION PROJECTS

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Construction projects typically involve a series of inter-related transactions among project parties across project phases with the objective of delivering a complex endeavor. Therefore, the transaction governance literature provides a solid foundation for developing the governance theory of construction projects. However, analyze considering the project-based literature, the conceptualization and theoretical underpinning for determining the contingency factors that have significant role in selection of governance mechanisms varies widely. Although TCE perspective has been criticized for its weakness in predicting the effectiveness of different governance mechanisms, most of studies have limited to TCE-based factors and neglected the social motivators for adoption of governance systems. This is departing point for this paper to make a two-fold contribution to the construction projects' governance literature. Firstly, it analyses different frameworks in the transaction governance literature and identifies the antecedents for the adoption of the proper governance mechanisms. It also studies the application of these factors in the context of construction projects. Secondly, drawing upon transaction cost economics (TCE) and social capital theory (SCT), this study develops a socio-economic framework for including both project-based and relationship-based characteristics of construction projects in the choice of proper governance system. The framework serves as a platform for future knowledge development on the governance of construction projects.

Keywords: construction project, governance mechanism, social capital theory, transaction cost economic

INTRODUCTION

Large construction projects typically involve multiple stakeholders in a series of inter-related transactions across various project phases with the objective of delivering a complex endeavor. The expanding complexity of these projects, diversity of specialism along with geographical and cultural dispersion of project participants caused differentiation and led to complex project structures crossing organizational boundaries. Adopting effective governance mechanisms for such undertakings is critical to the effective and efficient delivery of these projects. Some scholars recognized the unique characteristics of the construction industry and attempted to develop specific frameworks for choice of governance mechanisms for construction

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Banihashemi SY and Liu L (2013) A socio-economic framework for adopting governance mechanisms in large construction projects *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 523-532.

projects (Eccles, 1981; Winch, 2001). Transaction cost economics (TCE) has been the dominant theory foundation for such studies.

One of the TCE's focuses is on determining the boundaries of the firm to see if transactions should be conducted inside the firm or externally in the market in order to minimize costs. Accordingly, Williamson defines governance structure as an "institutional framework within which the integrity of a transaction is decided and transactions are negotiated and executed" (Williamson, 1979, pp. 235,239). Based on this view, Eccles (1981) argues that in large construction projects the general contractor is central to the project relationships and the fairly stable collection of firms in each project contains both market and hierarchical governance characteristics. Then, he proposes a new structural form, called "quasi-firm" and posits that this construction project-specific governance structure contains aspects of both classical and neoclassical contracting and is intermediate between bilateral and unified governance structures. Another focus of TCE is on introducing the critical environmental factors that affect the choice of governance structure. TCE formulates a new institutional economics in terms of transactions (Williamson, 1979) and takes an economic view toward transaction performance and connects the best alignment between governance structure and contextual factors to the least governance cost (Williamson, 1979). Winch, drawing upon this economic view of TCE, recognizes specific characteristics of construction projects to justify the choice of governance structure in construction projects' context (Winch, 1989, 2001).

While transaction cost economics has been instrumental in identifying the antecedents of specific governance mechanisms in various transactions, studies start to show that the locus of firm boundaries and the choice of governance mechanisms are not only dependent on economics, but are also socially motivated (Granovetter, 1985). Incorporating social elements into firm boundary decisions help scholars better understand the difference in organizational boundaries under similar economic conditions. For example, Granovetter (1985) criticizes TCE for ignoring the role of social relations among transaction partners in formation of their economic behavior. Granovetter argues that economic and social motivations are interdependent and therefore transaction cost economics and social relationships are underpinning theories to study organizational boundaries. Particularly, considering and analyzing the interaction between economic factors and social relationships may help scholars to explain the variations in organizational forms in different contexts and the way these variations affect organizational performance. Sociologic perspectives such as social capital theory, social network theory, theory of trust, and institutional theory have been used in relevant studies to explain the role of social factors in determining the proper governance structure. However, none of these perspectives have "appropriability" (Coleman, 1988) to totally embrace the concept of "social relations" and reflect the related social factors, except social capital perspective (Adler & Kwon, 2002). Adler and Kwon (2002) mentioned that social capital, as an umbrella concept, can bring under the one notion various phenomena such as informal organization, trust, culture, social support, social exchange, social resources, embeddedness, relational contracts, social networks, and inter-firm networks.

Studies that focus on the choice of governance mechanisms in the construction industry suffer from the same shortcoming—ignoring the social context that influence the choice of governance mechanisms, especially in cross organizational transactions. Although there were some attempts to incorporate the effect of social factors in forming project's governance structure (Badenfelt, 2010), these studies didn't have a

comprehensive view to consider both social and economic factors simultaneously and inclusively. This is a departing point for this study to contribute to both the literature on project governance and the construction management literature by developing a socio-economic framework for the choice of governance mechanisms in large construction projects. Drawing upon transaction cost economics and social capital theory, the framework takes into consideration of both project and relationship characteristics. This framework may enable clients or general contractors as responsible parties for making decision about project governance, to have better understanding of environmental factors that are important for the choice of different governance mechanisms in specific construction projects.

In following sections, firstly, literature on choice of governance mechanisms is reviewed. Then, the unique characteristics of construction projects and how these affects exchange conditions are discussed. Subsequently, we present a conceptual framework for the choice of governance mechanisms which combines both project characteristics and social factors. Finally, conclusions are drawn and future research directions discussed.

PERSPECTIVES ON INTER-ORGANISATIONAL RELATIONSHIPS GOVERNANCE

"Governance" is one of the most versatile terms in the literature which is used in a variety of ways and in diverse meanings. In the management and organization literature, one of the most popular applications of governance is related to mechanisms for controlling inter-organizational relationships (IORs) among two or more parties (Ruuska, Ahola, Artto, Locatelli, & Mancini, 2011). The literature on IORs governance is apparently divided into two major streams that each part is focusing on one crucial question. Firstly, "What are the typical governance mechanisms and what is the nature of the relationship between these mechanisms in explaining transaction performance?" Secondly, "What are the antecedents that lead to the adoption of these governance mechanisms?"

Addressing the first question, the existing literature has generally categorized governance mechanisms into two types, formal and informal governance mechanisms. Formal governance mechanisms mostly focus on formal and prescribed form of control and utilizes more tangible instruments (e.g. contracts, financial and non-financial reports, rewards, etc.) to regulate the inter-organizational transactions. The second type of governance mechanisms are informal mechanisms that mainly focus on deploying informal means (e.g. frequent interactions, informal socialization, joint problem-solving, joint decision-making) to govern transactions among exchange partners. The main focus of this study, however, is on the second question to identify and categorize the existing predictive factors and the underlying theories for explaining them and then customize the applicable factors for the construction industry.

Reviewing transaction governance literature shows that transaction cost economics (TCE) has been underlying paradigm for explaining the predictive conditions in adoption of proper governance mechanisms (Williamson, 1979). TCE assumes that the main motivator for transaction partners to adopt various governance mechanisms in their inter-organizational relationships is to minimize transaction costs (Poppo & Zenger, 2002). This economic view considers transaction as the basic unit of analysis and introduces several transaction characteristics as antecedents of governance mechanisms, including asset specificity, uncertainty, and frequency (Williamson,

1979). Although TCE has generated significant insights, there have been some inconsistencies in some research findings in explaining the relationship between TCE-based factors and efficiency of selected governance mechanisms. For example, Poppo and Zenger (2002) pointed out that relationship between environmental dynamism and relational governance is positive, whereas Joshi and Campbell (2003) asserted that this relationship is not always positive and is affected by the partners' collaborative approach. Similarly, whilst TCE-based studies (e.g. Simon, 1991) believed that the partners stop cooperation when they know the "repeated game" is ending, Uzzi (1997) indicated if there were embedded relationships between partners, they continued their cooperation even after approaching the endgame. These new findings revealed the narrow rationality of TCE perspective on explaining transactional relationships and consequently led to emergence of social and institutional factors. Supporting this idea, Zhou et al. (2003) mentioned three motivators for the behavior of partners in transaction relationships including: (1) transaction costs, (2) social relations, and (3) institutional constraints. Moreover, some studies have examined the role of trust in adoption of formal and informal governance mechanisms (Das & Teng, 1998; Sengun & Wasti, 2009). For example, Sengun and Wasti (2009) argued that the level of trust between partners is positively associated with informal governance in exchange relationships, whereas formal governance is negatively related to trust.

According to aforementioned perspectives, sociological theories (e.g. social network theory, institutional theory, theory of trust) have been applied to predict the variations in economic transactions that are not captured by the logic of TCE. That is, they explain the effect of relational factors on the behavior of exchange partners and provide additional insights on the adoption of governance mechanisms in transactional relationships (Li, Xie, Teo, & Peng, 2010).

EXCHANGE CONDITIONS IN CONSTRUCTION PROJECTS

As a classic definition, a transaction occurs whenever 'a good or service is transferred across a technologically separable interface' (Williamson, 1981, p. 552). Having said that, a construction project can be assumed to be a combination of transactions that are taking place among project participants, to deliver the project outcome. Therefore, construction projects require effective governance system in order to regulate these transactions for delivering value for the client (Winch, 2001). There have been a number of attempts to develop a framework for adoption of appropriate governance mechanisms in construction projects (Walker & Wing, 1999; Winch, 2001). However, focus of these studies has been mostly on TCE perspective, ignoring the effect of social characteristics. In this sense, the TCE-based concept of transaction hazard has been customized to the construction project context and a number of project characteristics that play a key role in estimating the degree of complexity and uncertainty of these projects have been introduced. In this section, we review the relevant literature to elucidate the meaning of all environmental factors in the context of construction projects and their effects on the choice of governance mechanisms. Then, based on findings, we propose a new framework that combines the effect of economic and social factors in predicting the proper governance system for construction projects.

Project Characteristics

As mentioned before, in transaction governance literature, transaction is considered as the unit of analysis and some features of transaction have been introduced as antecedents for adoption of specific governance mechanisms. The most common

factors are uncertainty, complexity, and asset specificity. However, there isn't any consensus among scholars about explanation and interpretation of these concepts. In the following paragraphs, the original meaning of these concepts and the relevant interpretation of them in the field of construction projects will be explained.

Complexity

Transaction complexity has been defined as the existence of many interdependent and interrelated skills and organizational routines that spans the firm boundaries and consequently requires the transaction parties to take part in each other's activities in a regular basis (Gulati & Singh, 1998). Although the concept of project complexity and its operationalization has received little attention in construction project literature, there were some studies that tried to build a foundation for this concept (Baccarini, 1996; Fellows & Liu, 2012). For example, Baccarini (1996) devised a comprehensive definition for project complexity in the field of construction projects by reviewing the relevant literature. Baccarini defined the project complexity as 'consisting of many varied interrelated parts' and operationalized it in terms of 'differentiation' and 'interdependency'. He articulated differentiation as 'the number of varied elements', e.g. tasks, specialists, components, whereas the interdependency is related to the degree of interrelatedness between elements. Both differentiation and task interdependence increase the need for cooperation and mutual adaptation between project partners. They also promote ambiguity in terms of predicting the results of any failure in the project that causes complicated situation for partners in finding the responsibility of each party and sharing the loss. For reducing this ambiguity and safeguarding project partners against opportunism, most of scholars suggest the usage of formal control mechanisms such as equity or property rights as well as more detailed contracts (Lin et al., 2012). Also, it is predicted that the increase in the complexity of the project lead to the decrease in the level of informality in partner's relationships. That is, instead of having casual meetings or informal working communications and information exchange, the partners prefer to document everything in order to make the future claims possible.

Uncertainty

Some studies used uncertainty as a general concept (Dekker & Abbeele, 2010; Winch, 2001), whereas other scholars considered different aspects of uncertainty like behavioral uncertainty (Kirsch, Ko, & Haney, 2010; Lin et al., 2012; Rooks, Raub, & Tazelaar, 2006), environmental uncertainty (Cannon, Achrol, & Gundlach, 2000; Carson, Madhok, & Wu, 2006; Claro, Hagelaar, & Omta, 2003; Dekker, 2004; Lin et al., 2012), or task uncertainty (Cannon et al., 2000; Dekker, 2004; Turner & Simister, 2001). Williamson (1979) defined uncertainty as a problem that is originated from unpredictable consequences of human nature, such as bounded rationality and self-interest. He argued that environmental uncertainty appears when the business environment is unstable and the firm cannot predict following changes in the market and technologies and the consequences that are associated with these changes. Some studies used 'monitoring problems' or 'behavior observability' as an indicator for behavioral uncertainty that refers to the client's difficulties to assess the quality of the product or services provided by the contractor at the time of delivery, to compare tenders, to compare it with alternative products or services, and to compare the price-quality relation of alternative contractors (Kirsch et al., 2010; Rooks et al., 2006). Like complexity, uncertainty creates high level of ambiguity between partners. Accordingly, partners will try to reduce the probability of opportunistic behavior and guarantee the stability by utilizing more contractually arranged governance structure

in the project. This formalization, also, facilitates the planning and execution of the project activities (Dekker, 2004).

Asset specificity

Williamson (1979) defined asset specificity as 'the degree to which an asset can be redeployed to alternative uses and by alternative users without sacrifice of productive value'. Asset specificity can refer to different kinds of assets such as human asset and physical asset. The physical asset refers to investments such as equipment, machineries, materials etc. Whereas human asset refers to HRM investments, such as training of staff in terms of knowledge about the partner, methods to deal with the partner, and other business practices specifically to operate with the selected partner (Hoetker & Mellewigt, 2009). Prior research argues that asset specificity is an important transactional attribute that affects the choice of governance system (Lin et al., 2012). When a firm make transaction-specific investment in a project, its partner may exploit the situation by threatening it to terminate the contract, which results in losing the value of specialized assets. Facing such threats, the investor company must trade off between value losses and the cost of contract. The increase in the potential value loss due to transaction-specific investment will justify the more complex and detailed contracts to cover the consequences of breach and termination as well as the processes by which such threats will be handled (Reuer, Ariño, & Mellewigt, 2006). Also, it is assumed that high level of asset specificity, particularly when the assets are mainly knowledge-based, will make informal governance mechanisms even more preferable than formal governance mechanisms because it may help overcome the embedded and tacit nature of knowledge-based assets (Hoetker & Mellewigt, 2009).

Relationship Characteristics

As discussed before, inconsistencies in TCE interpretations about some exchange conditions led to emergence of different explanations that were based on sociological theories such as social network theory, institutional theory, and theory of trust. We posit that all the sociological factors that have been covered by these theories can be collected under the social capital theory as an umbrella concept for explaining all the sociological conditions in exchanges among project partners. The source of the social capital is the social relations among exchange parties. Adler and Kwon (2002) distinguishes social relations from market and hierarchical relations and assumes that any concrete relation is likely to involve a mix of all three types. It also argues that market and hierarchical relations nurture the social relations. Social capital, like other forms of capital, is a long-lived asset and can be escalated through investment in building network of relations among exchange partners (Adler & Kwon, 2002). As a set of resources rooted in relationships, social capital has three different attributes: structural capital, cognitive capital, and relational capital (Nahapiet & Ghoshal, 1998). In the following paragraphs, we define each of these dimensions of social capital and discuss their potential effect on the choice of governance mechanisms.

Structural social capital

According to social network theory, the structure and the quality of social relations between partners affect the form of economic actions (Uzzi, 1997). In the context of inter-organizational relationships, embedded relationships facilitates joint activities and reduces behavioral uncertainty (Li et al., 2010). This definition is very close to the meaning of the structural social capital that reflects connections among individuals or organizations and how they share information. Based on the definition, structural social capital is related to prior ties between project partners and the quality of past

collaboration. Hence, organizations that had more collaborative experiences in the past may have better understanding of each other and those repeated interactions may provide more information about the nature of the other partner (Zhang, Wan, Jia, & Gu, 2009). This familiarity may decrease the effect of uncertainty as well as the risk of exploitation and opportunism. Thus, we can claim that structural social capital among project partners can moderate the positive (negative) relationship between project characteristics and the efficiency of formal (informal) governance mechanisms.

Cognitive social capital

Institutionalization in the context of inter-organizational relationships is a formalization process that strengthens the inter-firm relationship beyond the interpersonal relationship between boundary spanners. That is, the well-developed relational norms, shared goals and shared values through institutionalization of exchange partners' relationships can positively influence the use of formal and informal governance mechanisms (Li et al., 2010). Reviewing the definition of cognitive social capital, the focus is on shared values and common vision among partners that is considered as a capital that may encourage the development of trusting relationship (Tsai & Ghoshal, 1998). According to the literature, due to the similar background and expectations, the project partners that have shared values may have more effective communication with each other. This communication is further facilitated by the fact that the partners have implicit understanding of each other because of shared values. Additionally, partners who share values are more likely to make commitments prior to formal cooperation, which strengthens the bonds among them and nurtures the trust (Zhang et al., 2009). So it is predicted that cognitive social capital among project partners moderates the positive (negative) relationship between project characteristics and the efficiency of formal (informal) governance mechanisms through reducing the uncertainty and spreading the feeling of confidence.

Relational social capital

Two dimensions of trust, goodwill trust and competence trust (Das & Teng, 1998, 2001), are closely related to the calculation of different types of perceived risk. This distinction parallels the idea that trust is the expectation of a partner fulfilling a collaborative role in a risky situation (Nooteboom, 1996), and relies on both the partner’s intention to perform and its ability to do so. Goodwill trust is linked to relational risk, and refers to the expectation that a partner intends to fulfill their role in the relationship. Competence trust refers to the expectation that partners have the ability to fulfill their roles. This is related to performance risk, and can be measured as the contractor’s resources and reputation. As explained by Nahapiet & Ghoshal (1998), trust is the most important indicator of relational social capital. Existence of trust among project partners has a great influence on shaping collaborative atmosphere in the project and facilitates the efficiency of informal mechanisms. As a result, we claim that relational social capital moderates the positive (negative) relationship between project characteristics and the efficiency of formal (informal) governance mechanisms.

Figure 1, demonstrates the project characteristics and relationship characteristics as two types of contextual factors and their effect on the adoption of different governance mechanisms in construction projects.

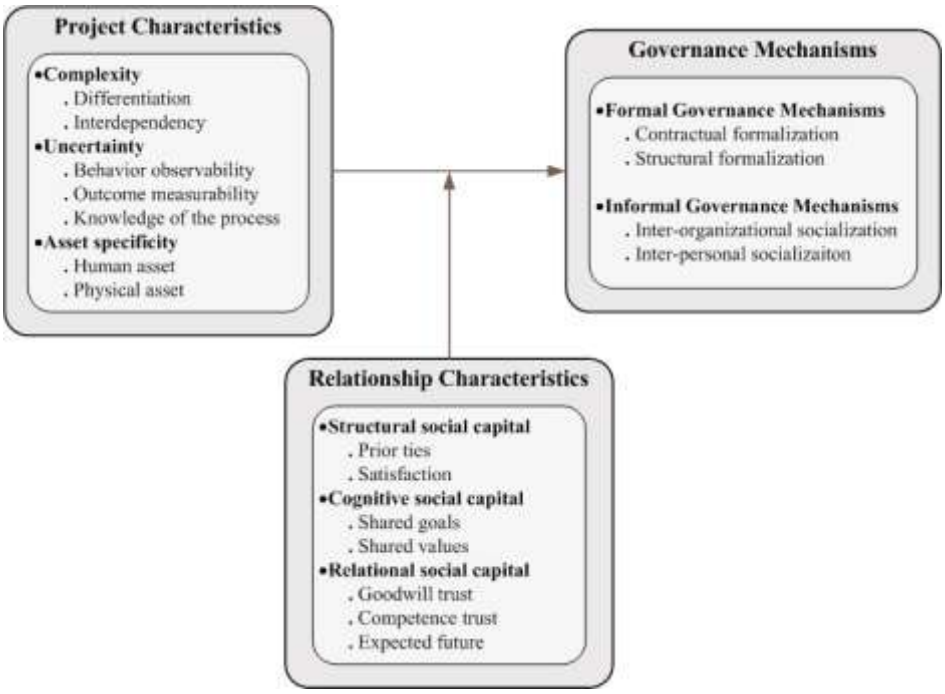

Figure1: Socio-economic framework for adoption of governance mechanisms

CONCLUSIONS

This paper started with a review of the current literature on construction project governance and identified the limitations of the existing governance frameworks. It showed that extant literature focused mainly on economic factors for determining the governance structure in construction projects, while neglecting the important role of relational factors that are embedded in the relationship among partners. A new framework has been proposed which has taken into account both economic and social aspects of construction projects. Furthermore, the framework divided the antecedents into two categories including project characteristics and relationship characteristics. The new framework provides a more comprehensive perspective on the antecedents of adopting specific governance mechanisms. This integrative perspective gives project planners a more comprehensive view over the project and helps them to hire more efficient governance mechanisms to regulate the relationships among project partners. However, more research should be done to investigate the relationship between these factors and formal and informal governance mechanisms in construction projects. Moreover, it is suggested that the association of these factors and their interaction be empirically investigated in future studies.

REFERENCES

Adler, P. S., & Kwon, S. (2002). Social Capital: Prospects for a New Concept. Academy of Management Review, **27**(1), 17–40.

Baccarini, D. (1996). The Concept of Project Complexity—A Review. International Journal of Project Management, **14**(4), 201–204. doi:10.1016/0263-7863(95)00093-3

Badenfelt, U. (2010). I Trust You, I Trust You Not: A Longitudinal Study of Control Mechanisms in Incentive Contracts. Construction Management and Economics, **28**(March), 301–310. doi:10.1080/01446191003587745

Cannon, J. P., Achrol, R. S., & Gundlach, G. T. (2000). Contracts, Norms, and Plural Form Governance. Journal of the Academy of Marketing Science, **28**(2), 180–194.

Carson, S. J., Madhok, A., & Wu, T. (2006). Uncertainty, Opportunism, and Governance: The Effects of Volatility and Ambiguity on Formal and Relational Contracting. Academy of Management Journal, **49**(5), 1058–1077.

Claro, D. P., Hagelaar, G., & Omta, O. (2003). The Determinants of Relational Governance and Performance: How to Manage Business Relationships? Industrial Marketing Management, 32, 703–716. doi:10.1016/j.indmarman.2003.06.010

Coleman, J. S. (1988). Social Capital in the Creation of Human Capital. American Journal of Sociology, 94(1988), 95–120.

Das, T. K., & Teng, B.-S. (1998). Between Trust and Control: Developing Confidence in Partner Cooperation in Alliances. Academy of Management Review, **23**(3), 491–512.

Das, T. K., & Teng, B.-S. (2001). Trust, Control, and Risk in Strategic Alliances: An Integrated Framework. Organization Studies, **22**(2), 251–283. doi:10.1177/0170840601222004

Dekker, H. C. (2004). Control of inter-organizational relationships: evidence on appropriation concerns and coordination requirements. Accounting, Organizations and Society, **29**(1), 27–49. doi:10.1016/S0361-3682(02)00056-9

Dekker, H. C., & Abbeele, A. V. (2010). Organizational Learning and Interfirm Control: The Effects of Partner Search and Prior Exchange Experiences. Organization Science, **21**(6), 1233–1250.

Eccles, R. G. (1981). The quasifirm in the construction industry. Journal of Economic Behavior & Organization, **2**(4), 335–357. doi:10.1016/0167-2681(81)90013-5

Fellows, R., & Liu, A. M. M. (2012). Managing Organizational Interfaces in Engineering Construction Projects: Addressing Fragmentation and Boundary Issues across Multiple Interfaces. Construction Management and Economics, 30(August), 653–671.

Granovetter, M. (1985). Economic Action and Social Structure : The Problem of Embeddedness. American Journal of Sociology, **91**(3), 481–510.

Gulati, R., & Singh, H. (1998). The Architecture of Cooperation : Managing Costs and Coordination Concerns Appropriation in Strategic Alliances. Administrative Science Quarterly, **43**(4), 781–814.

Hoetker, G., & Mellewigt, T. (2009). Choice and Performance of Governance Mechanisms: Matching Alliance Governance to Asset Type. Strategic Management Journal, 30, 1025–1044. doi:10.1002/smj

Joshi, A. W., & Campbell, A. J. (2003). Effect of Environmental Dynamism on Relational Governance in Manufacturer-Supplier Relationships: A Contingency Framework and an Empirical Test. Journal of the Academy of Marketing Science, **31**(2), 176–188. doi:10.1177/0092070302250901

Kirsch, L. J., Ko, D. G., & Haney, M. H. (2010). Investigating the Antecedents of Team-Based Clan Control: Adding Social Capital as a Predictor. Organization Science, **21**(2), 469–489. doi:10.1287/orsc.1090.0458

Li, Y., Xie, E., Teo, H.-H., & Peng, M. W. (2010). Formal control and social control in domestic and international buyer–supplier relationships. Journal of Operations Management, **28**(4), 333–344. doi:10.1016/j.jom.2009.11.008

Lin, H.-M., Huang, H.-C., Lin, C.-P., & Hsu, W.-C. (2012). How to Manage Strategic Alliances in OEM-based Industrial Clusters: Network Embeddedness and formal governance mechanisms. Industrial Marketing Management, **41**(3), 449–459. doi:10.1016/j.indmarman.2011.04.003

Nahapiet, J., & Ghoshal, S. (1998). Social Capital, Intellectual Capital, and the Organizational Advantage. Academy of Management Review, **23(**2), 242–266.

Nooteboom, B. (1996). Trust, Opportunism and Governance: A Process and Control Model. Organization Studies, **17**(6), 985–1010. doi:10.1177/017084069601700605

Poppo, L., & Zenger, T. (2002). Do Formal Contracts and Relational Governance Function as Substitutes or Complements? Strategic Management Journal, 23, 707–725. doi:10.1002/smj.249

Reuer, J. J., Ariño, A., & Mellewigt, T. (2006). Entrepreneurial alliances as contractual forms. Journal of Business Venturing, 21(3), 306–325. doi:10.1016/j.jbusvent.2004.09.003

Rooks, G., Raub, W., & Tazelaar, F. (2006). Ex Post Problems in Buyer–Supplier Transactions: Effects of Transaction Characteristics, Social Embeddedness, and Contractual Governance. Journal of Management & Governance, 10, 239–276. doi:10.1007/s10997-006-9000-7

Ruuska, I., Ahola, T., Artto, K., Locatelli, G., & Mancini, M. (2011). A new governance approach for multi-firm projects: Lessons from Olkiluoto 3 and Flamanville 3 nuclear power plant projects. International Journal of Project Management, **29**(6), 647–660. doi:10.1016/j.ijproman.2010.10.001

Sengun, A. E., & Wasti, S. N. (2009). Revisiting Trust and Control: Effects on Perceived Relationship Performance. International Small Business Journal, **27**(1), 39–69. doi:10.1177/0266242608098346

Simon, H. A. (1991). Organizations and Markets. The Journal of Economic Perspectives, **5**(2), 25–44.

Tsai, W., & Ghoshal, S. (1998). Social Capital and Value Creation: The Role of Intrafirm Networks. Academy of Management Journal, **41**(4), 464–476.

Turner, J. R., & Simister, S. J. (2001). Project contract management and a theory of organization. International Journal of Project Management, **19**(8), 457–464. doi:10.1016/S0263-7863(01)00051-5

Uzzi, B. (1997). Social Structure and Competition in Interfirm Networks : The Paradox of Embeddedness. Administrative Science Quarterly, **42**(1), 35–67.

Walker, A., & Kwong Wing, C. (1999). The relationship between construction project management theory and transaction cost economics. Engineering Construction and Architectural Management, **6**(2), 166–176. doi:10.1046/j.1365-232x.1999.00090.x

Williamson, O. E. (1979). Transaction-Cost Economics: The Governance of Contractual Relations. Journal Of Law and Economics, **22**(2), 233–261.

Williamson, O. E. (1981). The Economics of Organization : The Transaction Cost Approach. American Journal of Sociology, **87**(3), 548–577.

Winch, G. (1989). The construction firm and construction project: A transaction cost approach. Construction Management and Economics, 7(4), 331–345.

Winch, G. (2001). Governing the Project Process: A Conceptual Framework. Construction Management and Economics, **19**(8), 799–808. doi:10.1080/01446190110074264

Zhang, Z., Wan, D., Jia, M., & Gu, L. (2009). Prior Ties, Shared Values and Cooperation in Public-Private Partnerships. Management and Organization Review, **5**(3), 353–374. doi:10.1111/j.1740-8784.2009.00154.x

Zhou, X., Li, Q., Zhao, W., & Cai, H. (2003). Embeddedness and Contractual Relationships in China's Transitional Economy. American Sociological Review, **68**(1), 75–102.

THE IMPACT OF VARYING ASSET SPECIFICITIES OF SUBCONTRACTORS ON RELATIONSHIPS DEVELOPMENT IN CONSTRUCTION

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The adoption of more collaborative relationships in the supply network is recommended to provide sustained performance improvement, greater effectiveness and efficiency in operations. Transaction cost economics (TCE), however, argues that competitive advantage results from efficient governance of transactions, which involves tailoring of procurement procedures to transaction characteristics and thus viewing an optimum relationship as a function of asset specificity. Nonetheless, relationships between the main contractors and their subcontractors are complex. This paper explores impact of varying asset specificities of subcontractors on their relationships development. The data is part of an ongoing exploratory study which to date comprises, 7 semi-structured interviews individuals who are involved in the procurement of subcontract packages. The analysis is structured around the key attributes influencing asset specificity of subcontractors. Results suggest that subcontractors can be grouped on the basis of their asset specificity. Low asset specificity is associated with arm's length relationship, whilst high asset specificity is closely linked to collaborative relationship. The development of bilateral dependency between main contractor and subcontractor starts at tender stage and follows different trajectories, depending on subcontract trade.

Keywords: asset specificity, main contractor, relationship development, subcontractor

INTRODUCTION

The traditional way in which economic activities are carried out is fast changing due to increasing competitiveness and technical nature of products (Errasti et al., 2007). Since traditional procurement procedures are considered potential root causes for opportunism (Ireland, 2004; Cheung et al., 2003), interest in more collaborative relationships has increased in recent years as an alternative approach to traditional procurement and project governance (Eriksson et al., 2007). The adoption of more collaborative relationships in the supply network is recommended to provide sustained performance improvement, greater effectiveness and efficiency in their operation, and change the structure of business processes in the industry as well as an engineering basis with which to design, plan, and manage construction projects in a collaborative manner (Wolstenholme, 2009; Egan, 2002; 1998).

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Blay-Armah A and Ross A (2013) The impact of varying asset specificities of subcontractors on relationships development in construction *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 533-543.

Transaction cost economics (TCE) is one of the most frequently used theoretical framework when investigating procurement and inter-firm relationships in general (Eriksson and Laan, 2007; Eriksson, 2006) and in construction (Rahman and Kumaraswamy, 2002). According to TCE, competitive advantage results from efficient governance of transactions (Williamson, 1985), which involves tailoring of procurement procedures to transaction characteristics (Eriksson, 2006). TCE argues that market-governed transactions build upon the availability of many possible sources for a buyer who compares and chooses one of them on the basis of the best quality/price combination. The existence of a large pool of suppliers presumably allows lower transaction cost through the benefits of market competition. Similarly, the availability of predetermined resources within a hierarchy also reduces transaction cost, where the buyer does not incur expenses of searching and gathering information.

On the other hand, it is acknowledged that the system of subcontracting in construction offers several advantages over internalisation, such as production efficiency and organisational flexibility (Hartmann and Caerteling, 2010), but it adds coordination costs. The quest for costs minimisation has led firms to develop informal collaborative arrangements (Lee et al, 2009). However, subcontractors offer different resources, expertise and technologies and the main contractor has established preferred subcontractors it uses for quotations, which means that some subcontractors are more likely to eventually undertake the work package than others. This can be referred to as specificity (Ross, 2011). Hence, it would be interesting to explore current contractors' procurement procedures from a TCE perspective in order to analyse their fit to transaction characteristics, which explains contractors' strategies for subcontracting and the ensued relationships. The purpose of this research is to investigate the impact of varying asset specificities of subcontractors on relationship development in the supply networks.

The rest of the paper is organised as follows. First, a presentation of the theoretical framework, explaining how subcontracting decisions can be affected by transaction cost and asset specificity. This is followed by forms of relationship in construction. This is followed by a research strategy adopted for the study and data analysis. The paper concludes with a report of the results, a conclusion and outline of future research.

THEORETICAL FOUNDATION

One of the influential frameworks for analysing decisions to outsource work packages is the theory of TCE supplemented by management theory to determine the best type of relationship an organisation should develop in the marketplace (Williamson, 1985; 1975). TCE assumes that the attributes of a transaction determine what constitute the efficient market, hierarchy or relationship. The key properties that affect the transaction include: bounded rationality, opportunism, small numbers bargaining, and information impactedness. According to Williamson (1985), these are considered to be transaction difficulties and associated with cost increase when transactions are characterised by: asset specificity, uncertainty, and frequency.

The transaction relates to the degree of asset specificity which is referred to as the nontrivial investment in transaction-specific assets (Williamson, 1985). It is the main transaction cost element that affects the threat of opportunism and, thus, choice of subcontracting strategy and form of business exchange. If asset specificity, and uncertainty are low, and transactions are relatively frequent, transactions are governed by markets. On the other hand, high asset specificity results in transactional

difficulties with transactions being performed internally within the firm. Medium levels of asset specificity lead to bilateral relations in the form of collaborative arrangements between the firms. Hence, there is a degree of dependence that one or other of the parties to a transaction can take advantage of. One obvious way of reducing the risk of opportunistic and related behaviour is collaborative arrangements which attempt to deter any such behaviour by offering the opportunity to work together for common goals, in a long-term ongoing relationship (Mclvor, 2000). The buying organisation therefore faces two extremes of the subcontracting decision – "variable boundary or fixed boundary" of the firm (Cox et al., 2007). The primary concern is determining the boundaries between these two extremes (Mclvor, 2000). TCE assumes that the decision will always be considered taking into account the scope for cost reduction and the importance of asset specificity. The firm should subcontract activities if performing internally would require excessive investment to get the lowest unit cost. Hence, when asset specificity is high the cost governing transaction through market mechanisms may exceed the potential flexibility and production cost benefits of subcontracting.

Conversely, subcontracting decisions are driven by "core competences" in relation to transaction cost (Mclvor, 2000). Ebers (1997) refers to increased responsiveness and flexibility, capabilities, and competences as the motivation for collaboration. Parker and Hartley (2003) further suggest that subcontracting decisions should be seen not as the outcome of some deterministic relationship based on transaction costs issues alone, instead the results of strategic choices taking consideration of both costs and firms' internal capabilities and strategic goals. Prahalad and Hamel (1990) maintain that core competences are not physical assets. Thus, asset may be tangible or intangible.

Using both the transaction cost perspective with the resource-based perspective, careful calculation of the relative transaction costs and internal capabilities or benefits can be determined thereby providing optimal subcontracting decision based on cost–benefit as well as grounds for entering into some kind of relationship to procure the good or service. This is illustrated by Fig. 1 below.

		Asset specificity		
		Low	Medium	High
	Occasional	A Subcontract	B Subcontract/ internalise ?	C Internalise
Frequency	Recurrent	A1 Subcontract	B1 Subcontract/ internalise ?	C1 Internalise
		low Capability	Medium	High

Fig. 1 Asset specificity versus internal capability in subcontracting decision adapted from Eriksson (2006)

Where asset specificities and internal capabilities are low, the case for subcontracting through arm's-length contracts is high (subcontract). Conversely, where asset specificities are high – which may be due to strategic importance of the activity or because of the threat of lock-in as a result power asymmetries in the supply chain, and internal capabilities to carry out the activity efficiently exist, the case for subcontracting may be minimised (internalise). In such circumstances, however, the activity will be subcontracted through close external contracts based on various forms of long-term collaborative arrangements as opportunistic behaviour and lock-in are protected against by these arrangements (Parker and Hartley, 2003). In the case of medium asset specificities and internal capabilities, subcontracting will be conducted through close external contracts based on various forms of long-term collaborative arrangements similar to the high specificities and capabilities situations.

However, the frequency of transaction determines the strategy and relationship. Finally, it is assumed that where the subcontracting decision is less obvious, strategy selection and the form of relationship will depend on careful calculation of the relative importance of asset specificity and internal capability or benefits.

In this paper we investigate the impact of varying asset specificities of subcontractors on their relationships development in supply networks as different asset specificities are associated varying degree of cost of free market transactions. A decrease in cost of free market transactions may lead to increase use of free market mechanisms and, hence less collaborative business exchange in the supply networks.

RELATIONSHIPS IN CONSTRUCTION SUPPLY NETWORKS AND SUBCONTRACTORS

Subcontracting is one of the key links in the supply network and has a significant impact on the overall success of the project delivery. The procurement of construction subcontractors involves many activities: categorising the supplier-base, establishing bidding competition, creating mechanisms for managing the subcontracted activities, reducing supplier-related risk, assessing and comparing the potential supply partners, and establishing relationship contracts (Ng et al., 2009; Errasti et al., 2007; Miller et al., 2002). Strategically, organisations may enter into business relationships in order to innovate, access new markets, overcome local market restrictions, raise entry barriers and share risk for mutual benefit. Operationally, reasons such as the capability of the frim and the need to focus on core competences the strategic importance of a product/service and its criticality to the final product, and the cost of procurement relative to performing internally, may influence the decision to outsource (Beach et al., 2005; Mclvor, 2000).

Despite the opportunities available to some main contractors, King and Pitt (2009) maintain that there is difficulty involved in developing a managed supply network. Ireland (2004) declares that adversarial relationships and opportunism are the norm contractor-subcontractor relationships. Dainty et al. (2001) conclude that there exists a general mistrust among subcontracting firms that make up the construction supply chain. Briscoe et al. (2001) also identify attitudinal barriers to collaboration at the main contractor-subcontractor interface. This problem is echoed by Briscoe and Dainty (2005) who submitted that lack of trust is key inhibitor to integration of supply chain.

However, it is acknowledged that supply chains can exist in various forms and can vary significantly in their complexity and diversity (Cox et al., 2007). According to

Briscoe and Dainty (2005) and Dainty et al. (2001) construction supply chains on larger projects typically involve hundreds of different companies supplying materials, components and a wide range of construction services. Dubois and Gadde, (2000) observe the need for variety in supplier relationship. This is because customers can use the skills and capabilities of their suppliers, and cope differently with diverse interdependency situations. Consequently, the nature of the relationships that are developed can take many different forms, ranging from those based entirely on market forces to those structured around various forms of collaborative arrangements (Svahn and Westerlund, 2009; Beach et al, 2005). Two main types of exchange can be distinguished: transactional or market-based and the relational or collaborative (Eriksson et al., 2007; Beach et al., 2005). Brief descriptions of these relationships in the context of the construction industry follow.

Market-based relationships

Eriksson et al., (2007) suggest that market-based relationship typically involves non-repeated short-term dealings with a distinct beginning and end. Similarly, Miller et al. (2002) conclude that contractors normally maintain relationship with a variety of different specialists trade contractors and offer sporadic works, matching the skills of the specialist to those required for the successful completion of a construction project. This practice however places very little emphasis on the development of the subcontracting sector in the construction industry. One significant feature of price-based market relationships is its focus on price and contract formalisation (Eriksson and Laan, 2007). Emphasising only on the price implies the buyer does not take the opportunity to take into account characteristics of the supplier such as competence and capacity, resulting in a permissive approach (Heide and John, 1990). This strategy allows the use a large pool of potential suppliers who are often replaced, as buyers are able to facilitate competition and focus on price and immediate pay-offs (Svahn and Westerlund, 2009). Consequently, the use of collaborative tools, such as shared objectives and teambuilding techniques may be non-existence (Cheung et al., 2003), resulting in increased need for authority since there is no or low human asset specificity (Eriksson, 2006).

Collaborative relationships

The primary goal of collaborative networks is to improve relationships among parties involved, and to achieve long-term commitment between two or more organisations for the purpose of achieving specific business objectives by maximising the effectiveness of the relationship, either in single project partnerships or in long-term orientation (Beach et al., 2005). In collaborative relationships, subcontractors undertake more than one construction project or several construction activities at any point in time. In this form of working exchange, the contractor has a degree of certainty of the quality of work. Conversely, the subcontractor gains a degree of certainty concerning job security over a specific time-period. This is especially useful in the planning and optimising the production schedules (Sözen and Kayahan, 2001). It thus removes incentives to sacrifice long-term gains for short-term benefits.

Unlike market-based, consideration of the characteristics of the supplier, such as competence and capacity becomes vitally important (Anderson and Oliver, 1987). Considerations regarding the collaboration and nurturing of the relationship indicate social control (Eriksson, 2006).Through social control, however, the parties establish an implicit sense of satisfactory and unacceptable behaviour (Aulakh and Gencturk, 2000), making more formal and comprehensive the contracts unnecessary. This may

be represented by soft parameters such as collaborative ability, reputation and earlier experience of the subcontractor. The presence of these collaborative tools indirectly decreases the emphasis on authority, since these tools create high human asset specificity, leading to switching costs for the buyer (Eriksson and Laan, 2007). Consequently, the higher the emphasis on asset specificity, the more weight on soft parameters, and the higher the emphasis on collaborative exchange, and vice versa.

RESEARCH DESIGN

Whilst there are distinctions between philosophical assumptions associated with both quantitative and qualitative paradigms, it is possible to combine both methods for use within a single study. Commonly referred to as a “mixed method” research approach, this method uses the strengths of one method to enhance the other (Tashakkori and Teddlie, 1998), which is realised by encapsulating both qualitative and quantitative dataset results to offer a comprehensive understanding of the research questions, resulting in a balanced view of the topic in a study which is as accurate and thorough as possible. As revealed by (Bryman and Bell, 2011), combined quantitative and qualitative approach is the most effective technique used to reduce bias. Furthermore, this combined approach has been acknowledged for its legitimacy in creating a more comprehensive representation of both statistical trends and participant perspectives, permitting cross validation of the results, eliminating dogmatism (Plowright, 2011), whilst ensuring the discovery of robust findings in a way not possible when considering the datasets in isolation (Creswell, 2008).

As contracting organisations opinions and views are the driving force behind the study, a qualitative approach has been undertaken through semi-structured interviews, in order to explore the stated research questions. Purposive sampling has been intentionally selected to identify survey participants to provide data in a high-quality qualitative study. Consequently, a small sample size of 7 respondents were selected in order to provide information which is both rich and deep in nature which is commonly unobtainable from large sample sizes. This specific sample size was also selected to provide a representation of the wider population.

Participants were selected from both large and medium organisations situated in the Northwest of England with diverse working experience and positions. They were key personnel within these organisations at both strategic and operational levels. Interviews were both conducted on telephone and face-to-face. Each interview lasted between 40minutes and 1hour. Questions were adapted to reflect the companies’ strategic objectives to allow the identification of approaches to working relationships that were being employed, and attributes which could have an influence on such approaches.

Each interview was transcribed in full and coded using NVivo 10 computer software to assist the analysis process. The approach to data analysis was to have multiple cases and consequently, the method of generalisation was "analytic induction," where a predetermined topic areas related to the objectives of this study were used as a template with which to compare the interview results. The analysis was a process of using multiple perceptions to clarify meaning, verifying the repeatability of an observation or interpretation and referencing back to the literature review and results. The assumption was made that a systematic set of methods could lead to the triangulation and a provisionally verifiable set of factors grounded within the data. The responses were then coded appropriately into the identified categories.

RESULTS

The pilot interview results investigated the relationship between (Eriksson, 2006) asset specificity types and the form of relationships developed. They provided support for the proposition that a relationship exists between asset specificity and strategic business exchange. Respondents were asked about key factors that influence their approach to subcontracting and ensued relationship. Responses were varied but coded into three main categories. Out of the seven participants, 71% perceived skills and expertise (specialism) as key factor, 57% identified technical nature as essential, whilst 43% were of the view that market environment influenced their choice of approach. It was found that strategy choice was not based on single factor but combination of factors. With projects of more technical nature, specialism (asset specificity) bilateral dependency emerged as a key predictor of subcontracting, the price and availability making small contribution to explain the choice of strategy and business exchange. On the other hand, less specialised construction activities that involve little asset specificity the price and availability were found to be key factors.

DISCUSIONS

This study explores current contractors' procurement procedures of subcontractors from a TCE perspective in order to analyse their fit to asset specificity by providing some initial answers to two research questions: (1) Do varying asset specificities influence contractors' strategy for procuring subcontractors? (2) And how does asset specificity of a subcontractor affects its relationship development in the supply network? Overall, the exploratory interviews suggest that subcontractors with high asset specificities tend to be procured using collaborative arrangements more than their counterparts with low asset specificities.

The procurement of every product or service involves a degree of asset specificity. Where the procurement of a product or service involves low asset-specificity, the business relationships ensued takes the form of arm's length (A and A1). One reason that account for this situation is that, the main contractor would have a pool of potential suppliers due to low entry barriers who are often replaced to facilitate competition (Anderson and Oliver, 1987). The main priority therefore becomes price (cost minimisation) and short-term gains. Thus, the main contractor does not take the opportunity to affect the characteristics of the supplier in terms of earlier experience (Heide and John, 1990). This is exemplified by one participant

"… we try to bring down price as much as we can so we shop around…… after the project has been won we go back to our subcontractors to bring down their cost if possible. If we can get equally good subcontractor with competitive price then obviously those one will be given attention. If we find their quotation interesting, this can lead to the work being awarded to the new bidder."

The easier the supplier can be replaced, the higher the focus on price and the lower the emphasis on soft parameters leading to collaborative working exchange (Eriksson and Laan, 2007). It would appear that the strength of the dependency developed at the tender stage is affected by the ease of replacement which in turn is influenced by trade.

On the other hand, high asset specificity subcontractors tend to develop long-term collaborative relationships with their main contractors. This group of specialist trade contractors are usually highly skilled and high level of competence. Specifying skills and technologies facilitates high emphasis on collaborative parameters (Eriksson and

Laan, 2007), and focus on a number of core activities, in which they can achieve and maintain a long-term relationship. Eriksson (2006) acknowledges that in such conditions, the suitable form of authority is social control which entails more emphasis on trust and less focus on price. Therefore, in situations where asset specificity is high, the best option for the main contractor is to internalise production (C and C1). For high specificity specialised subcontractors the incentives for short-term benefits are removed, but grounds for long-term relationships and expectations of continuance fostered (Aulakh and Gencturk, 2000), due to their potential impact on overall project performance and profitability as well as ability to affect technical specifications and complex projects (Ekström et al., 2003). Consequently, their involvement is sought in both planning and construction stages, and thus, the asset specificity become even higher. These issues were captured by the remarks of some of the participant:

"……..because of their technical competence and criticalness to project performance they are selected on the basis of collaborative ability, rather than on market price."

With these types of trade contractors, relationship development depends on the intrinsic rewards, such as a better working environment and the opportunity for future work with the main contractor."

With these types of trade contractors, relationship development depends on the intrinsic rewards, such as a better working environment and the opportunity for future work with the main contractor.

CONCLUSIONS

The primary aim of this study was to explore the impact of varying asset specificities of s range of trade of subcontractors on their relationship development in the supply networks. In order to realise this aim, the research examined the current contractors' procurement procedures from a TCE perspective in order to analyse their fit to transaction characteristics, which explains contractors' strategies for subcontracting and the ensued relationships. Initial findings suggest that low asset specificity is associated with arm's length relationship, whilst high asset specificity is closely linked with collaborative relationship. Thus, main contracting organisations increasingly pursue core competency strategies and employ collaborative arrangements as a basis for reducing the risks associated with subcontracting. Significantly, these results are consistent with principles of transaction cost theory, suggesting that the use of asset specificity may yield important insights into complex relationship developments.

This study is one of few attempts to asset specificity to explain subcontracting decisions and relationships development in construction. It also provides richer information on how the main contractor establishes working relationships with different groups of specialist trade contractors within the supply networks. Like other literature that uses TCE, the emphasis on theoretical aspects of relationship development could enhance the overall effectiveness and efficiency of construction project delivery team and ultimately transforming business performance.

Limitations and future research directions

The small sample used in the study may not be able to exploit the full benefits of subcontracting due to their scope of operations, and thus, may not represent the true picture.

Aside from the different asset specificities of subcontract trades that have been pointed out in this article, there may be other attributes that affect the relationships development and bilateral dependency between the two actors such as the extent of competition within a group (Ross, 2011).

REFERENCES

Anderson, E. and Oliver, R. (1987), Perspectives on behaviour-based versus outcome-based sales force control systems. Journal of Marketing, 51(4): 76-88.

Aulakh, P. and Gencturk, E. (2000), International principal-agent relationships: control, governance and performance. Industrial Marketing Management, 29(6): 521-538.

Beach, R., Webster, M. and Campbell, K.M. (2005) An evaluation of partnership development in the construction industry. International Journal of Project Management, 23(8): 611–621.

Briscoe, G. and Dainty, A. (2005), Construction supply chain integration: an elusive goal? Supply Chain Management: An International Journal, 10(4): 319-326.

Briscoe, G., Dainty, A.R.J. and Millett, S. (2001), Construction supply chain partnerships: skills, knowledge and attitudinal requirements. European Journal of Purchasing and Supply Management, 20(7): 497–505.

Bryman, A. and Bell, E. (2011), Business research methods (3rd edition). Oxford University Press.

Cheung, S-O., Ng, T.S.T., Wonga, S-P. and Suena, H.C.H. (2003), Behavioural aspects in construction partnering. International Journal of Project Management 21: 333–343.

Cox, A. (2004) Business relationship alignment: on the commensurability of value capture and mutuality in buyer and supplier exchange. Supply Chain Management: An International Journal, 9(5): 410–420.

Cox, A., Ireland, P. and Townsend, M. (2007), Managing in Construction Supply Chain and Markets. Thomas Telford: London.

Creswell, J.W. (2008), Research design: qualitative, quantitative, and mixed methods approaches (2nd edition). London: SAGE.

Dainty, A., Briscoe, G. and Millett, S. (2001) Subcontractor perspectives on supply chain alliances. Construction Management and Economics, 19(8): 841-848.

Dubois, A. and Gadde, L-E. (2000), Supply strategy and network effects – purchasing behaviour in the construction industry. European Journal of Purchasing and Supply Management, 6(3/4): 207-215.

Ebers, M. (Ed.), (1997), The Formation of Inter-organizational Networks. Oxford University Press, Oxford.

Egan, J. (1998), Rethinking construction. HMSO, London.

Egan, J. (2002), Rethinking construction: accelerating change. Strategic Forum for Construction, London.

Ekström, M.A, Björnsson, H.C, Kunz, J.C., Levitt, R.E. and Nass, C.I. (2003), The impact of rating systems on subcontracting decisions: a transaction cost analysis. CIFE, Stanford University, Stanford.

Eriksson, P.E. (2006), Procurement and governance management – development of a conceptual procurement model based on different types of control. Management Review, 17(1): 30-49.

Eriksson, P.E. and Laan, A. (2007), Procurement effects on trust and control in client-contractor relationships. Engineering, Construction and Architectural Management, 14 (4): 387-399.

Eriksson, P.E., Dickinson, M. and Khalfan, M.M.A. (2007), The influence of partnering and procurement on subcontractor involvement and innovation. Facilities, 25(5/6): 203-214.

Errasti, A., Beach, R., Oyarbide, A. and Santos, J. (2007), A process for developing partnerships with subcontractors in the construction industry: An empirical study. International Journal of Project Management, 25 (3): 250–256.

Hartmann, A. and Caerteling, J. (2010), Subcontractor procurement in construction: the interplay of price and trust. Supply Chain Management: An International Journal, 15(5): 354-362.

Heide, J.B. and John, G. (1990), Alliances in industrial purchasing: the determinants of joint action in buyer-supplier relationships. Journal of Marketing Research, 27 (1): 24-36.

King, A.P. and Pitt, M.C. (2009), Supply Chain Management: A Main Contractor's Perspective. In S. Pryke (Ed), Construction Supply Chain Management: Concepts and Case Studies. Blackwell Publishing Ltd, Sussex.

Lee, H., Seo, J., Park, M. and Ryu, H. (2009), Transaction-cost-based selection of appropriate general contractor-subcontractor relationship type. Journal of Construction Engineering and Management, 135(11): 1232-1240.

Mclvor, R. (2000), A practical framework for understanding the outsourcing process. Supply Chain Management: An International Journal, 5 (1): 220-36.

Miller, C.J.M., Packham, G.A. and Thomas, B.C. (2002), Harmonisation between main contractors and subcontractors: a prerequisite for lean construction? Journal of Construction Research, 3(1):67-82.

Ng, S.T., Ziwei Tang, Z. and Palaneeswaran, E. (2009), Factors contributing to the success of equipment-intensive subcontractors in construction. International Journal of Project Management, 27(7): 736–744.

Parker, D. and Hartley, K. (2003), Transaction costs, relational contracting and public private partnerships: a case study of UK defence. Journal of Purchasing & Supply Management, 9: 97–108.

Plowright, D. (2011), Using mixed methods: frameworks for an integrated methodology. London: SAGE.

Prahalad, C.K. and Hamel, G. (1990), The core competence of the corporation. Harvard Business Review, July-August: 79-91.

Rahman, M. and Kumaraswamy, M. (2002), Joint risk management through transactionally efficient relational contracting. Construction Management and Economics, 20 (1): 45-54.

Ross, A. (2011), Supply chain management in an uncertain economic climate: a UK perspective. Construction Innovation, 11(1): 5-13.

Sözen, Z. and Kayahan, O. (2001), Correlates of the length of the relationship between main specialist trade contractors in construction industry. Construction Management and Economics, 19(2): 131-133.

Svahn, S. and Westerlund, M. (2009), Purchasing strategies in supply relationships. Journal of Business & Industrial Marketing, 24(3/4): 173–181.

Tashakkori, A. and Teddlie, C. (1998), Mixed methodology: combining qualitative and quantitative approaches. London: SAGE.

Williamson, O.E. (1975), Markets and Hierarchies. Free Press, New York, NY.

Williamson, O.E. (1985), The Economic Institutions of Capitalism: Firms, markets and relational contracting. Free Press, New York, NY.

Wolstenholme, A. (2009), Never waste a good crisis: A review of progress since rethinking construction and thoughts for our future. Constructing Excellence, London.

A LOGISTICS FRAMEWORK FOR IMPROVING CONSTRUCTION SUPPLY CHAIN PERFORMANCE

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In recent years, attention has been placed on the logistics activities in construction projects in order to reduce total costs. The construction industry is experiencing poor productivity, resulting from an inability of contractors, subcontractors, and suppliers to cooperate efficiently. Research on logistics in construction lacks a holistic perspective and tends to focus on one activity at a time. This research presents the Builder's SCOR model (BSCOR) to be used for logistics improvements in construction. The model is based on the Supply Chain Operations Reference Model (SCOR model) covering the total supply chain. The BSCOR model is empirically derived through five case studies at different construction sites over a period of five years. This has resulted in a model covering the activities Source, Build, and Plan, that describes the flow of materials to and on the site and how ownership passes to the client. With the BSCOR model, contractors can map the material and information flows between supply chain members with standardized process definitions. It is also possible to precisely measure the supply chain performance and to know where to put improvements efforts. The main intention with the BSCOR model is to help the industry reduce costs and increase productivity.

Keywords: construction control, construction logistic, measurement, scor, scm.

INTRODUCTION

Many researchers have for a long time pointed out potential problems in the construction industry, leading to an increase in the construction cost and a decrease in the construction productivity demonstrated by Vrijhoef and Koskela (2000). For example, Laufer and Tucker (1987) and Gidado (2004) stress the deficiencies in planning as a potential cause. In general terms they blame the cost-increase and production problems on a lack of understanding of the role of planning. Other authors such as Latham (1994) and Egan (1998) conclude that the current situation stems from an inadequate way of managing suppliers and subcontractors. If the planning problems, the obsolete supply chain management, and overuse of temporary organisations are not managed they can, according to Fearne and Fowler (2006), not only affect the costs and productivity but also propagate and affect the construction project performance in total.

In this paper, the problems (planning deficiencies and supply chain management issues) are not seen as two isolated areas that should be mitigated solitarily; instead, the problems are dealt with in conjunction. As Cheng et al. (2010) emphasize in their

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Thunberg M and Persson F (2013) A logistics framework for improving construction supply chain performance *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 545-555.

report, many of the existing construction problems (such as planning problems, temporary supply chains, bad performance, etc.) can be eased if greater attention is put on developing a logistics framework for mapping, measuring, and continuously learning from each construction project. Authors such as Bassioni et al. (2005) and Wegelius-Lehtonen (2001) share this view, that a logistics framework can be helpful in order to reap the benefits from better-managed supply chains. The problem with current frameworks, except from being few, is that they tend to focus on one part of the chain and not the complete chain from raw material to finished house (e.g. Wegelius-Lehtonen 2001), or that they are entirely based on existent models developed for other industries without adjusting them to construction contexts (e.g. Cheng et al. 2010). In 2009 a workshop was conducted at a Swedish construction company, presented in Johansson and Persson (2011), in order to identify potential improvement areas (like a need for standardised processes and performance assessment). Except from identifying problems it also conclude that implementing a construction adapted version of the Supply Chain Operations Reference model (SCOR), see (SCC 2013) and section "Developing a Construction Logistics Framework" for more information, can have a positive effect in overcoming many of the problems and to increase the construction performance.

The purpose with the project, reported in this paper, is to fulfil the adaptation of the SCOR model to the characteristics of the construction industry, according to suggestions made by Johansson and Persson (2011), and thereby develop the Builder´s SCOR model (BSCOR). In order to fulfil the purpose the research objective is to identify which parts of the SCOR model that have to be adapted to embrace the characteristics of the acquisition (procurement of materials), construction, and planning processes in the construction industry.

The paper is organised as follows. In order to position the project, section two presents a literature review addressing common problems in the industry. Section three briefly describes the research method applied in this project and what data gathering methods that were used. After describing the method, section four will describe the SCOR model and the work with adapting the model and motivate why the adaptations are deemed necessary. Discussion of potential benefits and deficiencies with the model and the project will be held in section five whilst section six aims to show that the research objective has been fulfilled and present the managerial and research implications with this work.

CONSTRUCTION LOGISTICS ISSUES

The seminal works by Latham (1994) and Egan (1998) demonstrate that the construction industry is in a worrying situation with e.g. decreasing productivity. This is recognised by Vrijhoef and Koskela (2000) who show decreasing productivity and increasing costs in the Finnish and Dutch construction industries. However, they also state that the problems often emerge earlier on in the supply chain and propagate to the construction site. Why the productivity is declining is debatable, but Fearne and Fowler (2006) suggest that the fragmented and temporary nature of the construction industry supply chain is to blame. This view is shared by many authors in the research field (e.g. Fernie and Thorpe 2007), like the view that a proper use of supply chain management (SCM) principles can mitigate the effects of the problems. Vidalakis et al. (2011), for example, suggest that the builders' merchants should receive greater influence in the management of the supply chain, as they possess a natural linkage between the suppliers and the contractors. However, it is questionable how cost-

efficient that might be, as Voordijk (2010) corroborates, an extra node in the supply chain will increase the total cost. It might also lead to a potential risk for experiencing the bullwhip effect when an extra node in the chain is added. Dainty et al. (2001) on the other hand reports on a belief from the subcontractors that the client should take greater responsibility in managing the supply chain. The problem then however is the risk that members who have never worked together feel forced into a new constellation with increasing mistrust and unwillingness to cooperate as results.

Whether to handover the SCM process to the builders' merchant or to the client, the coordination issue is of great importance for the industry. Except from a lack in coordinating supply chains, many authors report a lack in supply chain performance measurement (Wegelius-Lehtonen 2001). Existing literature on performance measurement in construction often focuses on construction project performance and overlooks the importance of measuring the whole supply chain, including the suppliers. This can be exemplified by Bassioni et al. (2005) and Wegelius-Lehtonen (2001) who both emphasize project performance (quality, cost and time aspects) as an important aspect to assess. The view of a lack from the academia in performance measurement of the whole supply chain is also shared by Cheng, et al. (2010), like the absence of performance measurement and logistics frameworks. If members of the supply chain fail to cooperate or other SCM related problems are not remedied they can have a significant effect on the on-site logistics performance. Voigtmann and Bargstädt (2010), for example, identified that a lack of systems thinking results in an increase in the amount of inventory-holding areas on-site. Re-planning the location of these inventory-holding areas (and the movement of material) results in an increased production cost.

Planning the construction project and supply chain is often tainted with problems, which are often divided based on if they stem from the pre-construction or the on-site planning process (Johansen and Wilson 2006). The pre-construction planning process consists of selection of project team; creation of the project documentation system; initiating the purchasing of materials; development of the schedule and milestones; and other pre-project-execution activities; while the on-site planning process consists of more operational activities and focuses on: ensuring that planned activities can be fulfilled; schedule adherence; material procurement; weekly meetings; etc. Laufer and Tucker (1987) pinpoint the fact that much of the literature focuses on the on-site planning process and mostly on the scheduling activity techniques. However, one should not see pre-construction and on-site planning as two isolated processes as the on-site activities are affected by the decisions made during the pre-construction phase (Johansen and Wilson 2006, Laufer and Tucker 1987). Much of the problems reported in the literature regard the lack of sharing information, lack of including supply chain members, not planning resources, and that too great deal of focus is put on planning-technicalities. Gidado (2004), for example, recognises that including subcontractors and suppliers in the planning process is an important factor for performance success. Exclusions might lead to dysfunctional information flows and problems in learning from each other and each project.

RESEARCH DESIGN AND METHOD

The work with adapting the SCOR model started in early 2008 by applying it to a construction project. Outcomes indicated that the model had to be adapted to the industry. In late 2008 a project at another Swedish construction company verified the need for adaptation. The actual adjustment of the model started in 2010, where the

delivery of material process from suppliers to construction site and the procurement (of construction materials) process on-site were analysed and adapted. Two cases in 2012 initiated the work with adapting the production and planning processes. In total five cases over a four-year period were studied. The cases were selected according to three criteria: the projects should be in the framework supplement phase; the budgeted cost should be in the interval of €1–10 million; and the sites should be within geographical proximity for the researchers.

The main method utilised in this study is Case Study Research (cf Yin 2009), and the main data gathering methods used are direct observations and semi-structured interviews with focus on identifying necessary adaptations to the SCOR model. Direct observations made it possible to see what changes deemed necessary. Validation of the observations was performed through interviewing site managers and supervisors, to get their opinions on the suggested changes. By observing the reality as it is, and determine how the model should be developed according to the craftsmen themselves, makes the model adapted to construction industry settings and easier for the construction companies to adopt. Validation of the model as such has been an iterative process, where findings and adaptations from the previous cases have been validated in next coming cases (to see if the changes are deemed necessary in this case too). For example, the deemed changes to the process of procuring construction materials are validated in the case where the changes to the construction process are suggested. A test and validation of the whole model is scheduled as a future research project.

Reasons for choosing the SCOR model as an initial model are threefold: it is proven fruitful for improving profit margins in manufacturing industries (Bolstroff and Rosenbaum 2007); it is well-recognised in other industries and encompasses well-defined definitions of metrics and processes; and the authors are well-trained in the model. Using Case Study Research allows the researcher to observe the phenomenon in its natural setting (Yin 200). This is of importance in this project.

DEVELOPING A CONSTRUCTION LOGISTICS FRAMEWORK

The SCOR model was first released in 1996, developed by two consultant companies to fill the need for a structured supply chain analysis tool (SCC 2013). The model is today maintained by the non-profit organisation Supply Chain Council (SCC). It is used as a reference model for supply chain improvement and consists of three parts: a business process reengineering tool comprising a set of predefined supply chain processes; a set of predefined metrics; and a set of identified best practices.

The SCOR model's supply chain processes consist of six generic process types: Source, Make, Deliver, Plan, Return, and Enable at the highest aggregated level (1), see Figure 1 (the Enable process is not presented as a separate process in the figure). These processes are given more details and meaning in level 2, where processes are distinguished between types of production: make-to-stock, make-to-order, or engineer-to-order type of production. In level 3, the activities in each level 2 process are listed. All level 1, 2 and 3 processes and activities are defined in the SCOR model.

The predefined metrics are used to measure the state of a supply chain and to benchmark it against other chains in the same industry. The metrics in the SCOR model are defined in three levels (not to be confused with the three levels of processes), and the metrics at different levels are structured so that a level 1 metric is an aggregated value of several level 2 metrics. SCC also runs a benchmark database for members of the council.

With the business process-reengineering tool, predefined processes are used to map the as-is and desired to-be states of the supply chain. This mapping, together with the benchmark analysis, results in knowledge where supply chain improvements are necessary. The SCOR model provides a list of best practices for each process that needs to be improved. How this improvement can be achieved depends on the supply chain structure and position, but help can be found in the list of best practices coupled to each process provided by SCC. Originally the SCOR model was developed for manufacturing but there has been an interest among researchers and practitioners to adapt the model to other industries. In di Martinelly et al. (2009) the model is adapted to a healthcare setting and in Legnani (2011) the after-sales service was in focus. It is evident, when analysing the two previous mentioned reports, that their models are adapted with a deductive approach. First, the necessary process are adapted and verified empirically later on. This should be compared with the inductive approach proposed in this paper, where empirical evidence is first collected for justifying necessary changes. These initiatives show that the SCOR model can be adapted e.g. by adding new processes, metrics, and best practices to better fit other industries or activities than manufacturing.

The work with adapting the SCOR model to capture the characteristics of the acquisition, production, handover, and planning processes in the construction industry started with two pilot studies where the SCOR model was used to map and measure the performance of construction supply chains. The results from the pilots were promising but it was evident that the SCOR model was not adapted to a construction setting. This was mostly noticed when studying the process of delivering material to the site and how material was received at the site. The SCOR model basically takes a lot of things for granted, such as a sheltered environment and ready resources for unloading of incoming transports.

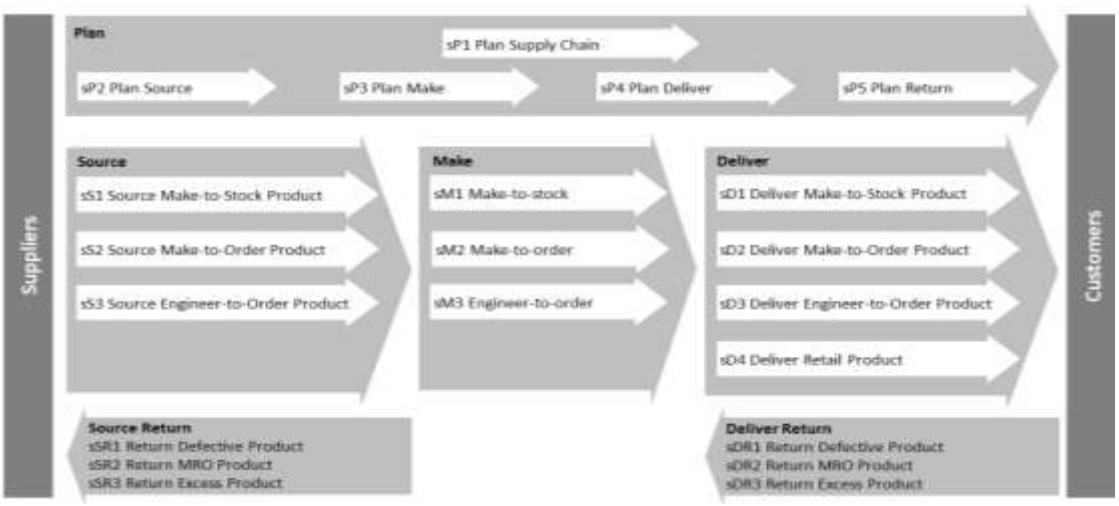

Figure 3: The SCOR model with level 1 and 2 processes, prefixed with 's'.

The first step to adapt the SCOR model to construction settings was to closer examine the Deliver and Source processes. As reported in Persson and Thunberg (2012) the Deliver processes at the suppliers were investigated together with the corresponding Source process at the construction site. In Thunberg and Persson (2013) the Make process at the construction site was studied. This study also led to the examination of the Plan process as reported in Thunberg et al. (2013). The Deliver process where the finished building is handed over to the client and the Return processes are not yet fully examined.

The result of the work to adapt the SCOR model to a construction industry setting is called the Builder's SCOR model (BSCOR). The BSCOR model retains the basic structure of the SCOR model and keep all the processes and metrics from the SCOR model intact but adds new processes and metrics where needed. This way, the BSCOR model can be used to map the supply chain from suppliers of construction materials to and on the actual construction site. The rest of the supply chain, upstream from the suppliers, is still best modelled with the SCOR model.

In level 1, the main flow of material is modelled by Builder's Deliver from the supplier and Builder's Source at the construction site. On the construction site, Builder's Build (Make), Handover (Deliver to the client), Return, and Plan can be used for modelling construction work, the handover process, returns, and the planning processes, see Figure 2.

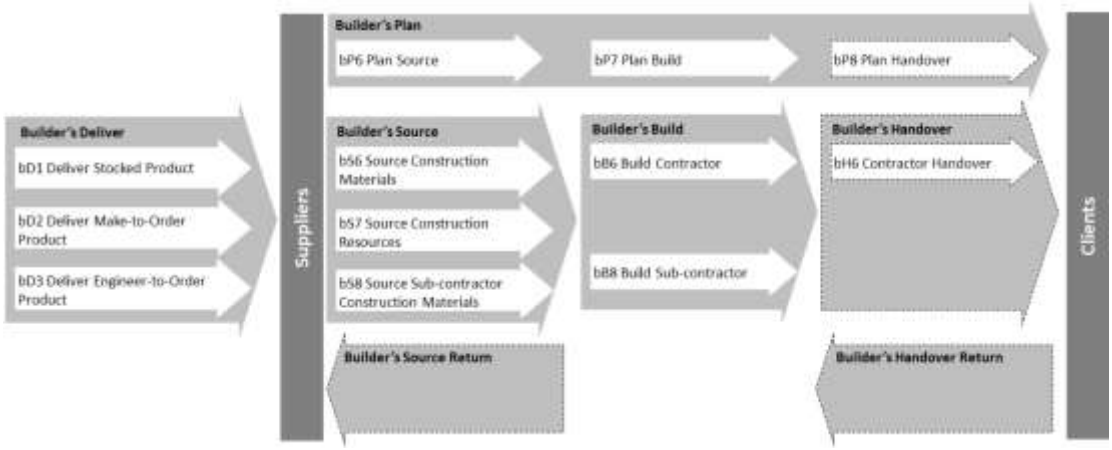

Figure 4: The BSCOR model with level 1 and 2 processes, prefixed with 'b'.

The BSCOR model is created based on two basic principles. First, the material flow is divided into two separate flows depending on who ordered the construction material; the contractor or the subcontractors. The contractor has the whole picture of the project and of the site itself and plans deliveries based on that knowledge. The subcontractors lack the comprehensive view and see only to their part of the project. In Persson and Thunberg (2012) it was clear that this separation of material flows caused problems with deliveries at the site with trucks forced to share unloading areas and waiting for their turn for resources used for unloading such as wheel loaders. In the BSCOR model, the two material flows are kept separated in order to identify the flows and thereby highlight the need for coordination. The second principle is the identification of deliveries of temporary materials that are used for a period of time and then returned. Typically, scaffolding is such a material that is used on-site, stored on-site, and returned after the project is completed. In the BSCOR model, this type of delivery is called a delivery of resources since also wheel loaders and cranes belong to this material type.

Planning on the construction site in the BSCOR model is made in the processes Plan Source (bP6), Plan Build (bP7), and Plan Handover (bP8). These processes, as reported in Thunberg et al. (2013), establish a plan based on the demand for material (or resources depending on the process) and the supply of material (or resources). This is done for both contractor and subcontractors. Then, all these plans are coordinated in a master plan for the whole construction site.

Considering the material flow in BSCOR, the scope starts at the suppliers and ends up on the site. At the supplier, the Deliver process keeps the original division between

make-to-stock, make-to-order, and engineer-to-order products as suggested by the SCOR model. Alterations are made in level 3 of these processes to better follow the suggested Builder's Source processes. The metric that control performance in Deliver is Perfect Order Fulfilment. In BSCOR, a new level 2 metric is incorporated in Perfect Order Fulfilment that measures if a shipment is notified in a proper manner or not. If a shipment is late and the site is unaware of the delay, resources for unloading are reserved for unnecessary amounts of time.

The BSCOR model divide the Source processes in level 2 into three types based on the above mentioned principles. The Source process in level 2 is therefore divided into Source construction materials (bS6) where the contractor source material, Source construction resources (bS7) where the contractor rent resources like crane, scaffolding, and wheel loaders for shorter periods of time, and Source Subcontractor construction materials (bS8) where subcontractors source their own materials, see Persson and Thunberg (2012). These three different types of sourcing processes are often not coordinated at the construction site. The division is made to clearly differentiate between these three types of processes and to make it possible to highlight the need for coordination.

The Builder's Build process is the actual process of erecting a building. Also here, the material flow principle of dividing material usage by contractor and subcontractors is valid. The Plan process has the same coordination problem and creates a master plan for the whole construction site. In the Build process at level 2 both Build contractor (bB6) and Build subcontractor (bB8) are using the material brought there from the Source process. Metrics in the Build process focuses on the logistics of the construction site. That is why a new metric is introduced that measures the number of movements of construction materials at the site. Material should be unloaded on site and transferred to its inventory-holding area and then moved to the place of use. All other movements, if the material is obstructing work or has a high risk of damage, are considered unnecessary.

The Enable, Return, and Handover processes have been left out of the empirical studies made so far. The final definitions of these processes are part of future research. Considering the Return processes, very little evidence has been found to support their existence. Waste is being shipped to special companies that recycle or use the material for fuel in combined power and heating plants. Resources that are rented are being returned to the renting companies. This does not correspond to the definition of Return in the SCOR model, where returns are made of defective, MRO (Maintenance Repair and Overhaul), and excess material. None of these types of returns have been found in any of the construction projects so far. The Handover process has been found to hold very little of logistic activities and is here treated as a simple transfer of ownership from contractor to client.

DISCUSSION

A potential benefit with the BSCOR model is that it offers a structured model for mapping and measuring construction supply chain performance, from suppliers' supplier to customers' customer. Among others, the Plan process specifically pinpoints how subcontractors and their acquisition and production plans should be integrated. The lack of supply chain performance measurement and the coordination issue were identified in the literature section as potential causes for the cost increase.

The BSCOR model in its nature is a normative model developed according to best-case scenarios. Even so, the model also contains some descriptive elements, as the SCOR model in its origin form does. For example, the balancing of production plans among supply chain members is clearly a normative element since this balancing is not done to date and is believed to be of benefit to increase project performance. Also the addition of a notification process in delivery and the associated level 2 metric in the Perfect Order Fulfilment metric, are results of the normative nature of the BSCOR model. The lack of notification is deemed as a problem and should thus be highlighted in the model. Even if the need for notification could be seen as a result of poor communication and lack of trust between suppliers and the main contractor, which should not be highlighted as best case scenario, the notification should be included in order to overcome these problems. The BSCOR model has not been fully tested yet, even if the findings from each case have been tested in succeeding cases. The final test of the model is scheduled as a future project.

Another matter worth discussing is the potential difficulties when implementing the model in the industry and who should lead the work with implementing it. Would it be easy to implement such a structured model in an industry characterised by temporary organisations and fragmented supply chains? Probably not, but that is not a reason for not promoting such a structured model. The problem lies in how the model is promoted and how the work with implementing it is conducted. Regarding implementation, who should lead the overall work with implementing SCM principles? Some authors (cf Dainty et al. 2001) report that many members in the supply chain think that the client should take greater responsibility in this work. However, it is postulated here that the main contractor, as a natural linkage among all members in the supply chains, possesses the greatest potential to effectively manage the supply chain and integrate all its actors. One issue with implementing the model that practitioners might highlight as a problem is the lack of comparable data in the benchmarking tool in the BSCOR model's infancy. Understandably, the lack of comparison data in the outset of a benchmarking tool is salient. Once again, this is an issue of significance when promoting the model and the participating companies must be aware of the situation.

Before concluding this discussion it is worth mentioning the problems encountered during the project. Of biggest concern were (1) the attitude among some of the craftsmen and managers and (2) the availability of documentation. The former could be related to the previous discussion of implementation difficulties. Some managers and craftsmen are happy with how it is now and do not want to change this autonomous nature in the industry. However, the majority of the craftsmen and managers considered the development of the model as important and that the current situation in the field is not of advantageous for anyone. The latter one is a result of not having a standardised system for tracking documentation. Most of the information is saved in the mind of the manager, inaccessible to others. The lack of documentation systems can hamper the implementation of a measurement system.

CONCLUSIONS

The purpose with this study was to present a logistics framework adapted to the characteristics of the construction industry that encompasses the most relevant parts of the construction supply chain. This is fulfilled through the development of the construction adapted and SCOR (Supply Chain Operations Reference model) based Builder's Supply Chain Operations Reference model (BSCOR) presented in this

paper. Logistic frameworks proposed elsewhere in the literature (cf Cheng et al. 2010) often forget to embrace the settings in the industry and the authors suggest that models developed for manufacturing settings are also applicable to construction industries. The risk of not considering contextual differences when promoting improvements is highlighted by Johansson and Persson (2011), who suggest that the models have to be adapted accordingly.

In summary, the BSCOR model starts at the supplier and the Deliver processes are adapted to better fit the way construction materials are delivered. At the construction site, the Source processes are divided into three categories depending on if the materials are ordered by the contractor or by the subcontractors, or if the materials are rented and used for a while and then returned. In the Build processes, the BSCOR model distinguishes between activities done by the contractor and by the subcontractor. This is utilized in the Plan process, which highlights the need to coordinate contractor and subcontractor activities on the site. The Handover process is a simple transfer of ownership and the Return processes handle returns of construction materials.

The practical contribution with this model is a tool for mapping construction supply chains and measuring supply chain performance. By mapping the supply chain problem areas can be detected and acted upon. Vrijhoef and Koskela (2000) identify that problems often arise early in the supply chain while their effects are not seen until later on the construction site. The BSCOR model also offers the construction companies a possibility to assess the problems' effect through a standardised measurement system. If several problem areas are identified the BSCOR model can assist in identifying which problem area that potentially has the biggest effect on overall supply chain performance. In line with the discussion of Vrijhoef and Koskela (2000) about problems propagating to the site, focusing on improving upstream supply chain logistics can have a positive impact on the down stream on-site logistics too. This structured model, used in a logistically unstructured environment, helps the construction companies to start learning from project to project. By mapping the processes and identify problem areas these can be mitigated to the next project. The contribution to the academia is a logistics framework developed to embrace the characteristics of the construction industry, which is missing in the literature to date.

Future work contains to test and validate the model but also to include the return, handover, and enable processes in the model. Even if each constituting part of the model is created through an inductive approach and validated iteratively, the entire model in itself is not tested and validated. This has to be done in order to verify that the model actually do mitigate common problems presented in the literature. Except from that, more attention in the future should be put on to develop construction supply chain metrics, best practices, and how the model should be implemented.

REFERENCES

Bassioni, H A, Price, A D F and Hassan, T M (2005) Building a Conceptual Framework for Measuring Business Performance in Construction: An Empirical Evaluation. "Construction Management and Economics", 23(5), 495-507.

Bolstroff, P and Rosenbaum, R (2007) "Supply Chain Excellence – a Handbook for Dramatic Improvement Using the Scor Model". 2ed. New York: Amacom.

BSCOR (2012) Retrieved 26 April, 2012, from www.bscor.com

Cheng, J C P, Law, K H, Bjornsson, H, Jones, A and Sriram, R D (2010) Modeling and Monitoring of Construction Supply Chains. "Advanced Engineering Informatics", 24(4), 435-455.

Dainty, A R J, Briscoe, G H and Millett, S J (2001) Subcontractor Perspectives on Supply Chain Alliances. "Construction Management and Economics", 19(8), 841-848.

di Martinelly, C, Riane, F and Guinet, A (2009) A Porter-Scor Modelling Approach for the Hospital Supply Chain. "International Journal of Logistics Systems and Management", 5(3), 436-456.

Egan, J (1998) "Rethinking Construction". London: Department of the Environment, Transport and the Regions.

Fearne, A and Fowler, N (2006) Efficiency versus Effectiveness in Construction Supply Chains: The Dangers of “Lean” Thinking in Isolation. "Supply Chain Management: An International Journal", 11(4), 283-287.

Fernie, S and Thorpe, A (2007) Exploring Change in Construction: Supply Chain Management. "Engineering, Construction and Architectural Management", 14(4), 319-333.

Gidado, K (2004) Enhancing the Prime Contractor's Pre-Construction Planning. "Journal of Construction Research ", 5(1), 87-106.

Johansen, E and Wilson, B (2006) Investigating First Planning in Construction. "Construction Management and Economics", 24(12), 1305-1314.

Johansson, M and Persson, F (2011) Towards a Scor-Based Analysis Tool for Construction Management and Logistics. In: Persson, F and Rudberg, M (Eds.), "PLANs FoT-konferens 2011", 31 September 2011, Norrköping Sweden.

Latham, M (1994) "Constructing the Team". London: HMSO.

Laufer, A and Tucker, R L (1987) Is Construction Project Planning Really Doing Its Job? A Critical Examination of Focus, Role and Process. "Construction Management and Economics", 5(3), 243-266.

Legnani, E (2011) "Controlling and Improving the Provision of after-Sales Services", PhD Thesis, Universtà Degli Studi di Bergamo, Bergamo.

Persson, F and Thunberg, M (2012) Adapting the Scor Model to the Construction Industry Settings. In: Töyli, J et al. (Eds.), "24th NOFOMA 2012", 7-8 June, Turku, Finland.

SCC (2013) Retrieved 21st of March, 2013, from http://www.supply-chain.org

Thunberg, M, Persson, F and Rudberg, M (2013) Coordinated Supply Chain Planning in Construction. To be presented at the "7th Nordic Conference on Construction Economics and Organisation", 12-14 June 2013, Trondheim, Norway.

Wegelius-Lehtonen, T (2001) Performance Measurement in Construction Logistics. "International Journal of Production Economics", 69, 107-116.

Vidalakis, C, Tookey, J E and Sommerville, J (2011) The Logistics of Construction Supply Chains: The Builders' Merchant Perspective. "Engineering Construction & Architectural Management", 18(1), 66-81.

Voigtmann, J and Bargstädt, H (2010) Construction Logistics Planning by Simulation. In: Johansson, B et al (Eds.), "2010 Winter Simulation Conference".

Voordijk, H (2010) Physical Distribution Costs in Construction Supply Chains: A Systems Approach. "International Journal of Logistics Systems and Management", 7(4), 456-471.

Vrijhoef, R and Koskela, L (2000) The Four Roles of Supply Chain Management in Construction. "European Journal of Purchasing and Supply Management", 6, 169-178.

Yin, K R (2009) "Case Study Research: Design and Methods". 4th ed. London: Sage.

KNOWLEDGE MANAGEMENT AND INFORMATION TECHNOLOGY

MY COST RUNNETH OVER: DATA MINING TO REDUCE CONSTRUCTION COST OVERRUNS

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Most construction projects overrun their budgets. Among the myriad of explanations giving for construction cost overruns is the lack of required information upon which to base accurate estimation. Much of the financial decisions made at the time of decision to build is thus made in an environment of uncertainty and oftentimes, guess work. In this paper, data mining is presented as key business tool to transform existing data into key decision support systems to increase estimate reliability and accuracy within the construction industry. Using 1600 water infrastructure projects completed between 2004 and 2012 within the UK, cost predictive models were developed using a combination of data mining techniques such as factor analysis, optimal binning and scree tests. These were combined with the learning and generalising capabilities of artificial neural network to develop the final cost models. The best model achieved an average absolute percentage error of 3.67% with 87% of the validation predictions falling within an error range of ±5%. The models are now being deployed for use within the operations of the industry partner to provide real feedback for model improvement.

Keywords: artificial neural network, cost estimation, cost overrun, data mining, decision support system.

INTRODUCTION

The business landscape is continually experiencing a growing recognition of information as a key competitive tool. Companies that are able to successfully collect, analyse and understand the information available to them are among the winners in this new information age (Huang *et al.* 2006). Available computing hardware and database technology allows for easy, efficient and reliable data storage and retrieval. Additionally, widespread use of networked computers and sophisticated database systems enables companies to pool their data together from across different geographical locations using data servers. However, the amount of data generated by these firms presents both a challenge and opportunity - a challenge to traditional methods of data analysis since the data are often complex, and of course, voluminous. On the other hand, construction firms stand a chance of gaining competitive edge and performance improvement in different areas if they are able to make their data work for them using data mining.

As pointed out by Fayyad *et al.* (1996a), the real value of storing data lies in the ability to exploit useful trends and patterns in the data to meet business, operational, or

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Ahiaga-Dagbui DD and Smith SD (2013) My cost runneth over: data mining to reduce construction cost overruns *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 559-568.

scientific goals as well as for decision support and policy making. Present advances in the fields of data warehousing, artificial intelligence, statistics, data visualisation techniques and machine learning now make it possible for data to be transformed into valuable asset by automating laborious but rewarding knowledge discovery in databases (Bose and Mahapatra 2001). Data mining, knowledge discovery in databases, has been extensively used in fields such as business (Apte *et al.* 2002), finance (Kovalerchuk and Vityaev 2000) and medicine (Koh and Tan 2011). However, informal discussions with a number of construction companies suggest that very few take advantage of their data, transforming it into cutting edge business decision support tools. Against this backdrop, the authors have provided an overview of the field of data mining with some specific applications in construction management. The data mining methodology is then applied to the problem of cost estimation in the construction industry using Artificial Neural Networks (ANN). Final cost prediction models were developed using the vast project database of a major water utility provider in the UK. The aim was to convert the experience and knowledge imbedded in past projects into intelligence and decision support systems that could potentially improve the accuracy of construction cost estimation, thereby reducing the problem of cost overruns.

DATA MINING

Data mining is an analytic process for exploring large amounts of data in search of consistent patterns, correlations and/or systematic relationships between variables, and to then validate the findings by applying the detected patterns to new subsets of data (StatSoft Inc 2008). Data mining attempts to scour databases to discover hidden patterns and relationships in order to find predictive information for business improvement. Data mining has been applied to detect money laundry and fraudulent transactions by Senator *et al.* (1995), investigate the effectiveness of sales campaigns by Ngai *et al.* (2009), intrusion detection in computer network administration by Julisch (2002) and for loan repayment assessment (see Lee *et al.* 2006).

Although it is yet to find extensive application in practice within the construction industry, construction management researchers have started investigating data mining's applicability to different problems. It has been applied to improving construction knowledge management (Yu and Lin 2006), estimating the productivity of construction equipment (Yang *et al.* 2003), study of occupational injuries (Cheng, Leu, *et al.* 2012), alternative dispute resolution (Fan and Li in press) and prediction of the compressive strength high performance concrete (Cheng, Chou, *et al.* 2012).

Data Mining Process

Data mining normally follows a generic process illustrated in Figure. It starts with the selection of relevant data from a data warehouse that contains information on organisation and business transactions of the firm (Ngai *et al.* 2009). The selected data set is then pre-processed before actual data mining commences. The pre-processing stage ensures that the data are structured and presented to the model in the most suitable way as well as offer the modeller the chance to get to know the data thoroughly and avoid the curse of 'garbage-in-garbage-out'. Pre-processing typically involves steps such as removing of duplicate entries, sub-sampling, clustering, transformation, de-noising, normalisation or feature extraction (StatSoft Inc. 2011b). The authors however note the issue of unavailable of relevant data as a potential barriers to effective data mining in the construction industry as most firms do not have a culture of storing detailed information about the projects they undertake.

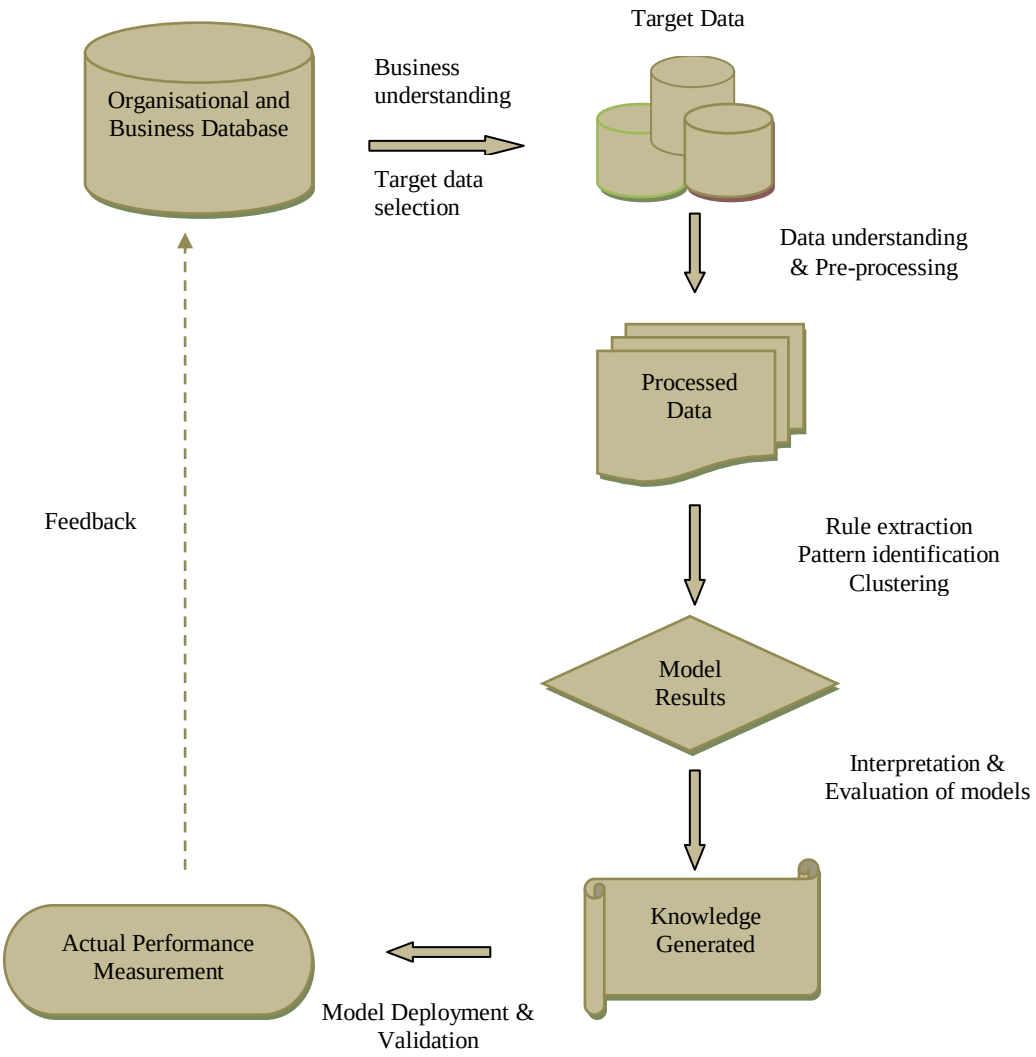

Figure1: The generic data mining process

The next stage involves the actual modelling, where one or a combination of data mining techniques is applied to scour down the dataset to extract useful knowledge. The type of modelling approach adopted would depend on the a number of factors, chief of which would normally be the type and quantity of data available, the aim of the modelling exercise and the predictive performance required (StatSoft Inc 2008). This is often an elaborate process, sometimes involving the use of competitive evaluation of different models and approaches and deciding on the best model by some sort of bagging system (voting or averaging) (StatSoft Inc. 2011a). Some of the available modelling techniques include case-based reasoning, principal component analysis, regression, decision trees, machine learning, genetic algorithm, fuzzy logic, as well as artificial neural networks, which has been used for the experimental part of this paper. The results from the data mining stage are then evaluated and presented into some meaningful form to aid business decision making. This step might involve graphical representation or visualisation of the model for easy communication. The knowledge generated is then validated by deploying the model in a real life situation to test the model's efficacy (Koh and Tan 2011).

It is important to note however that data mining in itself does not guarantee success when the models are deployed. For instance, if one seeks long enough in any database, it is possible to find patterns and seeming interrelations between variables which are

actually not valid (Fayyad *et al.* 1996b), resulting in model failure when deployed in real life. Also, no amount of data will allow for accurate prediction based on attributes that do not capture the required information. Success from any data mining venture is predicated on the availability of quality and quantity of data (StatSoft Inc. 2011a). The data must essentially contain data attributes that are relevant to the problem under investigation.

COST OVERRUNS

Cost performance on a construction project remains one of the main measures of the success of a construction project (Atkinson 1999; Chan and Chan 2004). However, estimating the final cost of construction projects can be extremely difficult due to the complex web of cost influencing factors that need to be considered (Ahiaga-Dagbui and Smith 2012) - type of project, likely design and scope changes, ground conditions, duration, type of client, tendering method- the list is endless. Trying to work out the cost influence of most of these variables at the inception stage of a project where cost targets are normally set can an exhaustive task, if not at all futile. Ignoring most of them altogether creates a perfect recipe for future cost overruns. Also, a high level of uncertainty surrounds most of these factors at the initial stages of the project (Jennings 2012).

Flyvberg *et al.* (2004) report that 9 out 10 infrastructure projects overrun their budgets and that infrastructure project have an 86% likelihood of exceeding their budgets. The on-going Edinburgh Trams project has already far exceeded its initial budget leading to significant scope reduction to curtail the ever-growing cost (Miller 2011; Railnews 2012). The recent 2012 London Olympics bid was awarded at circa £2.4 billion in 2005. This was adjusted to about £9.3 billion in 2007 after significant scope changes. The project was completed at £8.9 billion in 2010 (Gidson 2012; NAO 2012). These statistics have often led to extensive claims, disputes and lawsuits in some cases within the industry (Love *et al.* 2010).

Causes of overruns have been attributed to several sources including improperly managed risk and uncertainty (Okmen and Öztas 2010), scope creep (Love *et al.* 2011), optimism bias (Jennings 2012) to suspicions of foul-play and corruption (Wachs 1990; Flyvbjerg 2009). Another potential root cause of overruns is the lack of adequate information on which to base realistic and accurate estimates. Nicholas (2004) points out that estimators thus have to rely largely on their own experience and historical cost information when preparing initial estimates. Typically, an estimate can only be as good as the information it is based on so that, *ceteris paribus*, the level of accuracy of the estimates produced also increases as more information becomes available. Data mining is thus deemed as a possible way of capturing valuable information within historical data to support the estimation process at the initial stages of project definition.

DATA

The data used for the models in this paper were supplied by an industry partner with its primary operation in the delivery of water infrastructure and utility in the UK. The authors were granted access to the vast database of almost 5000 projects completed between 2000 and 2012. The scope of these projects varied from construction of major water treatment plants to minor repairs and upgrade. Project values ranged from £1000 - £30 million and durations from a short 3 months to 5 years.

The initial analysis involved drilling down into the database to find what might be useful in modelling final cost. First, cluster analysis and purposive sampling was used to create groups of project cases that were similar, without significant missing data or extreme values and representative of the entire dataset. One of the clusters containing about 1600 projects completed between 2004 and 2012, with cost range of between £4000 -15 million, comprising newly built, upgrade, repair or refurbishment projects was used for the models reported in this paper. 15 project cases were selected using stratified random sampling to be used for independent testing of the final models. The remaining data was then split in an 80:20% ratio for training and testing of the models, respectively.

The next stage involved deciding which predictors to use in the modelling exercise. It was easy to remove predictors such as project manager, project ID or year of completion from the set of predictors on precursory examination as they were likely not to be good predictors when the model is used in practice. Redundant predictors, those that do not add new information to the model because they basically contain the same information at another level with other variables, were detected using spearman correlations, bi-variate histograms or cross-tabulation. Further variable screening using scree test, factor analysis and optimal binning in Statistica 10 software was used to reduce the initial set of predictors to six[2]

Cost values were normalised to a 2012 baseline with base year 2000 using the infrastructure resources cost indices by the Building Cost Information Services (BCIS 2012). Numerical predictors were further standardized to *zScores* using

$$zScore = \frac{x_i - \mu}{\sigma} \qquad \text{Equation 1}$$

where: *zScore* is the standardized value of a numerical input, x_i
μ is the mean of the numerical predictor
σ is the standard deviation of the numerical predictor

Since neural networks was to be used for the actual modelling exercise, standardizing either input or target variable into a smaller range of variability would potentially aid the effective learning of the neural net whiles improving the numerical condition of the optimization problem (StatSoft Inc 2008). If one input has a range of 0 to 1, while another has a range of 0 to 30 million, as was the case in the data that were used in this analysis, the net will expend most of its effort learning the second input to the possible exclusion of the first. All categorical variables were coded using a binary coding system.

COST MODEL DEVELOPMENT

Data visualisation using scatter and mean plots in the earlier stages of the modelling suggested non-linear relationships between most of the variables and final cost. Also, most of the predictors are categorical, rather than numerical in nature. It was thus decided to use Artificial Neural Networks (ANN) for the actual modelling because of their ability to cope with non-linear relationships and categorical variables (Anderson 1995). ANN, an abstraction of the human brain with abilities to learn from experience and generalise based on acquired knowledge, is also able to cope with

[2] Initial list of predictors: 1. Delivery Partners - X, Y, Z 2. Purpose - wastewater, water, general 3. Scope of project - newbuild, upgrade, refurbishment, replacement 4. Target cost 5. Duration. 6. Operating region – North, South, East, West;

multicollinearity (Moselhi *et al.* 1991), a characteristic of construction data (Boussabaine and Elhag 1999). Neural networks has already been used to develop prototype models at an earlier stage of the this research (*see* Ahiaga-Dagbui and Smith 2012) and has also been applied to forecasting tender price (Emsley *et al.* 2002) and for identification and quantification of risk by McKim (1993). See Moselhi *et al.* (1991) for a review of neural network application in construction management research.

The final model was developed after an iterative process of fine-tuning the network parameters and/or inputs until acceptable error levels were achieved or when the model showed no further improvement. First, the automatic network search function of Statistica 10 software was used to optimise the search for the best network parameters, after which customized networks were developed using the optimal parameters identified. 5 activations functions[3] were used at this stage in both hidden and output layers, training 2000 multi-layer perceptron networks and retaining the 5 best for further analysis. The overall network performance was measured using the correlation coefficient between predicted and output values as well as the Sum of Squares (SOS) of errors. SOS is defined here as:

$$SOS = \sum(T_i - O_i)^2 \quad \text{.....Equation 2}$$

Where Oi is the predicted final cost of the ith data case (Output)

T_i is the actual final cost of the ith data case (Target).

The higher the SOS value, the poorer the network at generalisation, whereas the higher the correlation coefficient, the better the network. The *p*-values of the correlation coefficients were also computed to measure their statistical significance. The higher the *p*-value, the less reliable the observed correlations.

The retained networks are then validated using the 15 separate projects that were selected using stratified sampling at the beginning of the modelling exercise. See Figure 2 for the overall performance of 7 of the retained networks. This plot allowed for a quick comparison of the average error achieved by the selected models. A sensitivity analysis was performed on each retained network to assess predictor's contribution to network performance. To do this, the model's predictive performance is measured while deleting one input factor at a time, starting from the least important, until the model showed no further improvement or begun to decay.

Table 1 shows the predictions and absolute percentage errors (APE) achieved by model 33, which as the best overall model. The average APE achieved by model 33 was 3.67% across the 15 validation cases. Its APEs ranged between 0.04% and 15.85%. It was observed that the worst performances of the model were achieved on projects with the smallest values in the validation set (cases 13 & 15). This might potentially be because a majority of the projects used for the model training had values in excess of £5 million. However, the real monetary errors on these predictions were deemed satisfactory as they were relatively small (about £3500 & £2500 for models 13 & 15 respectively). 87% of the validation predictions of the best model were within ±5% of the actual cost of the project.

[3] identity, logistic, tanh, exponential and sine activation functions

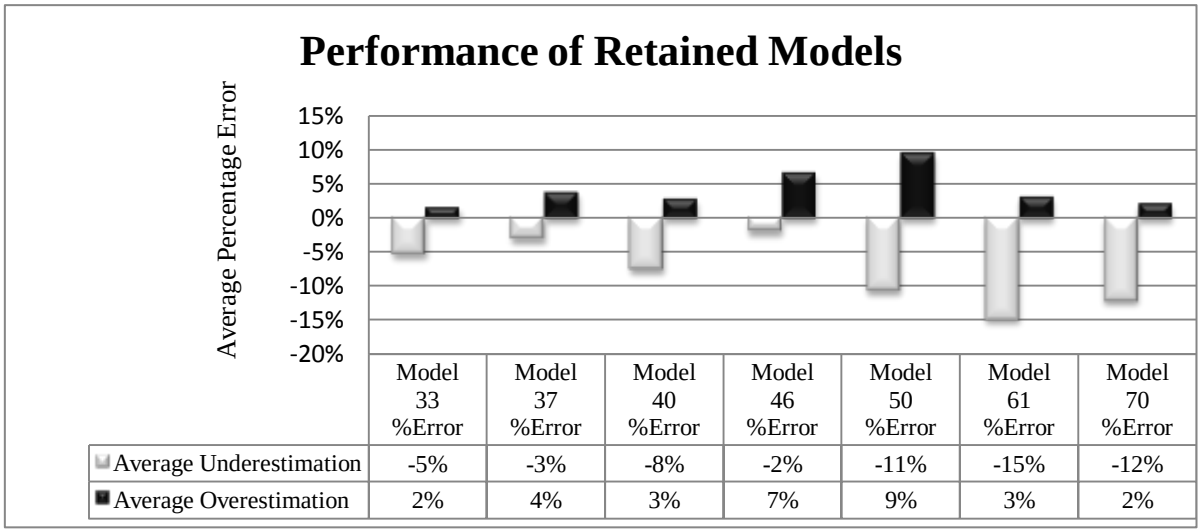

Figure 2: Performance of selected models

Table1: Validation results of the best model (Model 33)

Validation Case	*Actual Final Cost*	*Final Cost predicted*	*Model Error*	*Model Absolute % Error*
1	£ 4,912,649	£ 5,120,943	-£ 208,294	4.24%
2	£ 1,617,225	£ 1,617,805	-£ 580	0.04%
3	£ 11,277,470	£ 10,743,624	£ 533,846	4.73%
4	£ 2,110,260	£ 2,136,125	-£ 25,865	1.23%
5	£ 5,398,965	£ 5,425,142	-£ 26,177	0.48%
6	£ 180,532	£ 181,214	-£ 681	0.38%
7	£ 2,572,564	£ 2,530,178	£ 42,386	1.65%
8	£ 1,440,593	£ 1,372,864	£ 67,729	4.70%
9	£ 3,842,258	£ 3,793,851	£ 48,407	1.26%
10	£ 4,194,219	£ 4,131,285	£ 62,934	1.50%
11	£ 375,170	£ 387,731	-£ 12,561	3.35%
12	£ 50,637	£ 51,502	-£ 865	1.71%
13	£ 24,479	£ 22,017	£ 2,462	10.06%
14	£ 858,112	£ 824,334	£ 33,779	3.94%
15	£ 21,798	£ 18,344	£ 3,454	15.85%
			Average Absolute % Error	**3.67%**

CONCLUSION

The authors make a case for using data mining in modern construction management as a key business tool to improve construction performance. This could essentially help construction firms to transform their data into cutting edge decision support systems for business improvement and gain competitive advantage. An overview of data mining and its methodology, as well as applications have been detailed in the paper. The method was then applied to the problem of final cost estimation of construction project using artificial neural networks. Cost estimation was chosen for this study as one of the main reasons cited for cost overruns is the lack of information at the initial stages of the project for accurate estimation. Data mining thus attempts to exploit

already existing information, in combination with what is known about the new project to make its forecasts of final cost. The best model in this paper achieved an average absolute percentage error of 3.67% with 87% of the validation predictions falling within an error range of ±5%. The authors are now exploring avenues of transforming the models into standalone desktop applications for deployment within the operations of the industry partner that collaborated in this research.

The authors however identify a poor culture of data warehousing in the construction industry as one of the major challenges to effective data mining. For most construction companies, relevant data for modelling construction processes is sparse or even unavailable. Data mining depends heavily on the availability of business, operational and project data, stored in a meaningful and retrieval manner. Also, it is important to point out that the potential benefits of data mining are not overstated or lauded by researchers or practitioners as panaceas in themselves. Its limitations and potential pitfalls must always be clearly communicated to the end user.

REFERENCES

Ahiaga-Dagbui, D D and Smith, S D (2012) Neural networks for modelling the final target cost of water projects. *In:* Smith, S D (Ed.), *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK. Association of Researchers in Construction Management, 307-16.

Anderson, J A (1995) *An Introduction to Neural Networks*. Cambridge, Massachusetts: MIT Press.

Apte, C, Liu, B, Pednault, E P D and Smyth, P (2002) Business applications of data mining. *Communications of the ACM*, **45**(8), 49-53.

Atkinson, R (1999) Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria. *International Journal of Project Management*, **17**(6), 337-42.

BCIS (2012) BIS Construction Price and Cost Indices. In, http://www.bcis.co.uk: Building Cost Information Services, UK.

Bose, I and Mahapatra, R K (2001) Business data mining—a machine learning perspective. *Information & Management*, **39**(3), 211-25.

Boussabaine, H and Elhag, T (1999) Tender Price Estimation Using ANN Methods, EPSRC Research Grant (GR/K/85001). In, Liverpool, UK: School of Architecture & Building Engineering, University of Liverpool.

Chan, A P and Chan, A P (2004) Key performance indicators for measuring construction success. *Benchmarking: An International Journal*, **11**(2), 203-21.

Cheng, C-W, Leu, S-S, Cheng, Y-M, Wu, T-C and Lin, C-C (2012) Applying data mining techniques to explore factors contributing to occupational injuries in Taiwan's construction industry. *Accident Analysis & Prevention*, **48**(0), 214-22.

Cheng, M-Y, Chou, J-S, Roy, A F V and Wu, Y-W (2012) High-performance Concrete Compressive Strength Prediction using Time-Weighted Evolutionary Fuzzy Support Vector Machines Inference Model. *Automation in Construction*, **28**(0), 106-15.

Emsley, M W, Lowe, D J, Duff, A, Harding, A and Hickson, A (2002) Data modelling and the application of a neural netowrk approach to the prediction of total construction costs. *Construction Management and Economics*, **20**, 465-72.

Fan, H and Li, H (in press) Retrieving similar cases for alternative dispute resolution in construction accidents using text mining techniques. *Automation in Construction*(0).

Fayyad, U, Piatetsky-Shapiro, G and Smyth, P (1996a) The KDD process for extracting useful knowledge from volumes of data. *Communications of the ACM*, **39**(11), 27-34.

Fayyad, U, Piatetsky-Shapiro, G and Smyth, P (1996b) From Data Mining to Knowledge Discovery in Databases. *AI Magazine*, **17**(3), 37-54.

Flyvbjerg, B (2009) Survival of the unfittest: why the worst infrastructure gets built—and what we can do about it. *Oxford Review of Economic Policy*, **25**(3), 344-67.

Flyvbjerg, B, Holm, M K S and Buhl, S (2004) What Causes Cost Overrun in Transport Infrastructure Projects? *Transport Reviews*, **24**(1), 3-18.

Gidson, O (2012) London 2012 Olympics will cost a total of £8.921bn. *The Guardian*. http://goo.gl/sxatK. *23 October 2012*

Huang, M-J, Tsou, Y-L and Lee, S-C (2006) Integrating fuzzy data mining and fuzzy artificial neural networks for discovering implicit knowledge. *Knowledge-Based Systems*, **19**(6), 396-403.

Jennings, W (2012) Why costs overrun: risk, optimism and uncertainty in budgeting for the London 2012 Olympic Games. *Construction Management and Economics*, **30**(6), 455-62.

Julisch, K (2002) Data mining for intrusion detection. *Applications of data mining in computer security*, 33-58.

Koh, H C and Tan, G (2011) Data mining applications in healthcare. *Journal of Healthcare Information Management—Vol*, **19**(2), 65.

Kovalerchuk, B and Vityaev, E (2000) Data mining in finance. In: USA: Kluwer Academic Publisher, Hingham MA.

Lee, T S, Chiu, C C, Chou, Y C and Lu, C J (2006) Mining the customer credit using classification and regression tree and multivariate adaptive regression splines. *Computational Statistics & Data Analysis*, **50**(4), 1113-30.

Love, P, Davis, P, Ellis, J and Cheung, S O (2010) Dispute causation: identification of pathogenic influences in construction. *Engineering, Construction and Architectural Management*, **17**(4), 404-23.

Love, P E D, Edwards, D J and Irani, Z (2011) Moving beyond optimism bias and strategic misrepresentation: An explanation for social infrastructure project cost overruns.

McKim, R A (1993) Neural networks and identification and estimation of risk. *AACE International Transactions*(15287106), P.5.1-P.5.1.

Miller, D (2011) Edinburgh Trams: Half a line at double the cost. *BBC*. http://goo.gl/mfr96

Moselhi, O, Hegazy, T and Fazio, P (1991) Neural networks as tools in construction. *Journal of Construction Engineering and Management*, **117**(4), 606-25.

NAO (2012) *The London 2012 Olympic Games and Paralympic Games: post-Games review*, HC 794- Session 2012-13, National Audit Office, UK.

Ngai, E W T, Xiu, L and Chau, D (2009) Application of data mining techniques in customer relationship management: A literature review and classification. *Expert Systems with Applications*, **36**(2), 2592-602.

Nicholas, J M (2004) *Project management for business and engineering: Principles and practice*. Second ed. MA, USA; Oxford, UK: Elsevier Butterworth–Heinemann.

Okmen, O and Öztas, A (2010) Construction cost analysis under uncertainty with correlated cost risk analysis model. *Construction Management and Economics*, **28**(2), 203-12.

Railnews (2012) Edinburgh tram costs soar again. *Railnews*. http://goo.gl/M5uZ7

Senator, T E, Goldberg, H G, Wooton, J, Cottini, M A, Khan, A F U, Klinger, C D, Llamas, W M, Marrone, M P and Wong, R W H (1995) Financial Crimes Enforcement Network AI System (FAIS) Identifying Potential Money Laundering from Reports of Large Cash Transactions. *AI Magazine*, **16**(4), 21.

StatSoft Inc (2008) A Short Course in Data Mining. In: StatSoft, Inc.

StatSoft Inc. (2011a) Electronic Statistics Textbook. In, OK Tulsa: StatSoft, .

StatSoft Inc. (2011b) *STATISTICA 10 (data analysis software system)*, *www.statsoft.com*, Version 10.

Wachs, M (1990) Ethics and advocacy in forecasting for public policy. *Business and Professional Ethics Journal*, **9**(1-2), 141–57.

Yang, J, Edwards, D J and Love, P E D (2003) A computational intelligent fuzzy model approach for excavator cycle time simulation. *Automation in Construction*, **12**(6), 725-35.

Yu, W-d and Lin, H-w (2006) A VaFALCON neuro-fuzzy system for mining of incomplete construction databases. *Automation in Construction*, **15**(1), 20-32.

MESSAGES IN BOTTLES: THE FALLACY OF TRANSFERRING KNOWLEDGE BETWEEN CONSTRUCTION PROJECTS

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Although learning from projects in construction has gained much importance in research and practice, progress in understanding and improving inter-project learning appears to be slight. We argue that the adoption of a sender/receiver approach limits the learning effectiveness in construction. Drawing upon the notion of learning as social activity embedded in organisational context, we develop the argument that learning from projects takes place within projects rooted in the historical, organisational and cultural context of previous and current projects. We underpin our argument with results from a multiple-case study on learning in construction organisations.

Keywords: case study, construction project, knowledge transfer, learning.

INTRODUCTION

Since more than a decade, learning from projects in construction has received much attention in practice and research. Driven by the intention to improve the performance of an industry that has continuously been blamed for its poor performance – and thus learning culture – numerous studies have been conducted to identify barriers and enablers for learning from construction projects (e.g. Kumaraswamy and Thorpe, 1996; Paranagamage et al., 2012). Yet despite the efforts made, progress in improving the learning from projects appears to be slight. As a project-based industry, construction seems to be caught in the learning paradox of projects (cf. Bakker et al., 2011). Due to their fluid, temporary and interdisciplinary nature, projects are seen as suitable organisational units for stimulating learning and creating knowledge (Schindler and Epler, 2003). However, it is also argued that the ephemerality and discontinuities of projects restrict the assimilation of the created knowledge by other organisational units and its enhancement over time (Bresnen et al. 2003).

Besides identifying problems and difficulties in cross-project learning in construction, previous studies investigated a number of tools for extracting and disseminating lessons learned such as post-project reviews, company intranet or face-to-face meetings (e.g. Paranagamage et al., 2012). The majority of these studies, often implicitly, adopt a sender/receiver perspective on learning which assumes the possibility of engineering communication channels for transferring knowledge between projects and "lubricating their operation with the proper tools and motivated

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Hartmann A and Dorée A (2013) Messages in bottles: the fallacy of transferring knowledge between construction projects *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 569-578.

context" (Kasper et al., 2013, p.334). We argue that particularly this core assumption accounts for the little observable progress in understanding and enhancing learning practices in construction. To be clear, we do not reject the sender/receiver approach, but we argue that within the contextual boundaries of construction with its prevalent business paradigm, production structure and management style, the sender/receiver conceptualisation of learning has its limitation and calls for alternative approaches.

Drawing upon the notion of learning as a contextually embedded social activity, we propose such an alternative approach. Although the social and situated nature of learning has received much attention in research on knowledge creation in organisations and projects, its role for the learning between construction projects is less understood. Clearly, many previous studies revealed the importance of social practices and processes for the knowledge transfer in project environments (e.g. Paranagamage et al., 2012). However, from the perspective of these studies, social practices are still channels or tools for the transmission of knowledge between one project (sender) and another project (receiver) (Noorderhaven and Harzing, 2009). Unlike the sender/receiver perspective, we regard social interactions as contextually embedded and collaborative efforts in projects from which learning occurs. From our point of view, learning from projects takes place within projects as a social activity rooted in the historical, organisational and cultural context of previous and current projects (the imperative of continuity). We specifically argue that strategic objectives of construction organisations can and should serve as contextual binders between projects giving the social interaction within projects focus and orientation for the learning from projects.

In the following we develop our argument based on the project-based and situated learning literature. By referring to the results of five case studies on learning from projects in construction organisations, we then intend to show the limitations of the sender/receiver approach and the potential of the social learning approach for understanding and enhancing learning from and between projects. Based on that, practical implications and further directions for research are discussed.

CONCEPTUAL BACKROUND

The limitation of the sender-receiver approach

The sender-receiver approach is based on communication and information theories that suggest the existence of source, channel, message, recipient and context (Noorderhaven and Harzing, 2013). It is much connected with the concept of knowledge transfer that depends on the characteristic of the sender unit, receiving unit, relationship between sender and receiver, and the knowledge transferred. The approach implies that under certain conditions, knowledge will flow from one unit (project) to another unit (project). These conditions are: (1) the sender unit is knowledgeable and willing to share its knowledge, (2) the receiving unit possesses the capacity to absorb the knowledge, and (3) the appropriate transmission channels between sender and receiver for the flow of explicit knowledge and tacit knowledge (which can be converted to explicit knowledge) exist. Transmission channels are appropriate if they allow the development of a common lexicon between sender and receiver that “sufficiently specifies the differences and dependencies of consequences at the boundaries" (Carlile, 2004, p.558). The sender/receiver approach relies to a great extent on the storage and retrieval of explicit knowledge and reverts to transmission channels such as electronic and document-based knowledge repositories. It also makes use of social interaction (e.g. meetings, face-to-face conversation) as

channels for the externalisation of tacit knowledge and the transfer of this knowledge from an organisational unit that has the knowledge to another unit that does not have it (Kasper et al., 2013).

The notion of transferring knowledge appears to be appealing, since many studies on learning from construction projects adopted the sender/receiver approach and investigated the effectiveness of channels for the management of knowledge and the transfer of lessons learned between projects. At the same time barriers of knowledge transfer are well documented. Reported problems include lack of time to capture lessons learned (Paranagamage et al., 2012), lack of usefulness of captured knowledge (Newell et al., 2006), focus on failures (Carrillo, 2004), lack of purpose (Ruikar et al., 2007), and commitment of staff and management to knowledge sharing initiatives (Bishop et al., 2008). We argue that these barriers represent major limitations rather than unresolved problems for the learning from projects. The prevalent production structure, business paradigm and management style in construction evoke these limitations. For example, lack of time can be traced back to the very limited ability of construction firms to balance demand fluctuations (through e.g. stock-keeping of creating markets for their services). Since it is the demand that directly determines the utilisation of resources, people are often involved in several projects and face time pressure. As a response to a changing demand rate, construction services, technologies and equipment are often outsourced and subcontracted per project. Many construction firms follow a business paradigm of trade rather than production and are technology-wise empty firms, which makes it difficult for them to define a clear purpose for learning from projects. In addition, many construction projects not only entail a variety of components and equipment, but also have to process a wide range of technical, legal, environmental and organisational information that, to some extent, varies within and between projects. This makes it questionable whether a sender project is able to articulate the knowledge that might be of value to a future, but yet unknown receiving project and to generalise lessons learned to an extent that makes them digestible but still useful for several receiving projects (Bresnen et al. 2003).

The potential of the social learning approach

The social learning approach recognises the social nature of learning and has its origin in social learning theory. Social learning theory claims that learning is not something that solely takes place in the human mind but occurs through the interaction of people (Easterby-Smith et al., 2000). Knowledge emerges from collective actions. It is enacted through the participation of individuals in social processes. It is socially constructed and becomes the active process of knowing rather than being an object that can be transferred between organisational units (Plaskoff, 2003). Consequently, learning is regarded as a situated process in which "a situation posits certain possibilities for some action and not for others depending on individuals' former experiences and power in a specific context. Individuals are at one and the same time to be regarded as 'products' of their social and cultural history and 'producing' situations mirroring that. The individuals interact with selves, others, artefacts and contexts as just that, 'products' and 'producers' of situations" (Elkjaer, 2003, p.43).

We argue that the social learning approach has certain potential for enhancing our understanding of learning from construction projects. Our argument seems to be supported insofar as previous studies emphasise the important role of social practices and processes for learning within and from projects (e.g. Bakker et al., 2011). However, in many studies, social interaction remains a channel in the tradition of the

sender/receiver approach that accommodates the flow of knowledge "produced at one location and consumed at another" (Noorderhaven and Harzing, 2009, p.720). From the social learning point of view social interaction is learning, i.e. the application and, thereby, creation of knowledge in context. In construction the learning context is mainly related to projects which cannot be seen as "islands" (Engwall, 2003). They are history-dependent and organisationally-embedded and, as such, are constituted in and through the context they are producing. In other words, learning from projects takes place within projects through organising the project context which includes organisational procedures and tools, symbolic artefacts, organisational rules and norms, experience and competence of individuals. If projects are perceived as sender/receiver islands, then lessons learned remain “messages in bottles”- freely afloat on the ocean of knowledge, arriving at new shores by chance.

RESEARCH METHOD

Over the years we have been approached by a number of construction organisations with requests to analyse and improve their intra and inter-project learning. That included contractors, engineering firms and public agencies, and we were asked to study the learning between project phases and projects and the effectiveness of project evaluations (Table 1). Since we followed a qualitative approach to better understand the specific circumstances of the learning within the different organisations, the series of studies merged into multiple cases which, in line with Yin (2003), replicated previous results but also provided contrasting findings. The five cases presented here allow us to underpin our argument that the sender/receiver approach is limited and may be fruitfully extended by the social learning approach. Thus, the focus of our analysis was on identifying the channels used in the organisations for (a) the transfer of knowledge and (b) the extent to which construction-specific conditions were limiting the knowledge flow. We characterised tools, measures or organisational structures as channels to determine if they connected organisational units to support the transfer of knowledge between these units. We also explored the case material to determine indicators for social learning and conditions conducive to it. Here, we focused on interactive and social mechanisms through which knowledge was enacted and thus exchanged. The materials that were analysed included transcripts of semi-structured interviews held with employees from the different organisations, project documents and evaluations, and summaries of group discussions which were used to discuss research results and develop improvement measures (Table 1).

FINDINGS

The findings of the five case studies are summarised in Table 2. We elaborate more on them in the next sections.

Case I

Observable limitations from the sender/receiver perspective

Within the contractor organisation a number of channels were established to support the exchange of knowledge and lessons learned between employees and projects. One is the organisation's intranet which provides access to standardised work procedures, and general documents about procurement and quality management. Another channel is ERP software which stores all project documents such as procurement and planning documents. In addition, it includes checklists for purchasing, work preparation and execution and enables employees to make recommendations and give tips related to checklist items.

Table 1: Investigated cases

	Case I	Case II	Case III	Case IV	Case V
Type of organisation	Contractor	Contractor	Engineering Corps	Contractor	Public Agency
Organisational unit	Regional business unit	Regional business unit	Support unit	Functional business unit	Regional business unit
Number of employees - total (business unit)	280 (120)	2200(120)	800(70)	2800 (200)	9000(250)
Research focus	Learning from project	Knowledge sharing between project phases	Learning from out-of-area projects	Effectiveness of project evaluations	Effectiveness of project evaluations
Data collection	Document analysis	Document analysis	Document analysis	14 project evaluations	4 project evaluations
	15 interviews	12 interviews	19 interviews	12 interviews	11 interviews
	Tool evaluation	Questionnaire		1 group discussion	1 group discussion
		1 group discussion			

Table 2: Case findings

		Case I	Case II	Case III	Case IV	Case V
Sender/ receiver approach	Channels used	Intranet	Project documents	Evaluation documents	Evaluation documents	Team building sessions
		ERP software	Transfer meetings	Evaluation presentations	Evaluation workshops	Evaluation
						Project documents
	Inhibiting conditions	Time	Time	Time	Time	Time
		Relevance	Location	Relevance	Relevance	Relevance
				Accessibility	Accountability	
Social learning approach	Project learning context	Project meetings	Estimator/ planner interaction	Project meetings	Project start-ups	Team interaction
		Pull planning meetings		Tender manager interaction		Transfer meetings
	Enabling conditions	Planning orientation	Location	Specialisation orientation	Evaluator involvement	Change of personal
			Planning orientation		Problem orientation	Location

The information is accessible for all employees. The employees also have the possibility to make improvement suggestions via a central e-mail address. Despite the existence of these channels for the dissemination of lessons learned, the exchange of knowledge remains limited. The EPR software is rarely used for suggestions or tips, evaluation of projects are incomplete or not stored. One reason for the ineffectiveness is time pressure due to project-based work, which often causes resource allocation problems. Any activity such as evaluations and improvement suggestions that does not contribute to the immediate success of the current projects is given less priority. Moreover, employees perceive knowledge obtained in projects as not relevant for their colleagues and thus do not share it. They either believe that their colleagues already possess the knowledge or they think project peculiarities make the knowledge less relevant for other projects.

Observable potentials from the social learning perspective
In this case study meetings on different levels and with different communities are arenas for social interaction of people active in different projects and organisations. This includes weekly meetings of construction foremen and pull-planning meetings of the contractor with its subcontractors. Through the discussion of cross-project related issues and problems such as resource allocation and planning bottlenecks, these meetings become integral parts of the working process. The clear focus of the meetings on planning coordination between projects stimulates the integration of knowledge from different employees and projects for the progress of the specific project. The willingness to engage stems from the immediate benefit of the discussions for the projects.

Case II

Observable limitations from the sender/receiver perspective
From the sender/receiver perspective the case study revealed two channels for the transfer of knowledge between project phases: project documents and transfer meetings. Project documents include tender documents, calculations, work preparation, drawings and project evaluations which are built up during a project and handed over to the next project phase. The documents are standardised and maintained through the quality management system. The transfer meetings are especially established for the time after winning a tender when the entire project team is expected to meet and transfer the knowledge from the tender and calculation phase to the work preparation and execution phase. However, the transfer meetings appear to be ineffective. Employees do not participate, meetings are cursory affairs or are completely cancelled. Likewise, project documents are incomplete, not up to date, or not even used (e.g. project evaluation). The case revealed that project-based working leads to time pressure, which decreases the use of project documents and transfer meetings for knowledge transfer. Unlike the meetings in case 1, the transfer meetings are regarded as extra workload with little added value for the on-going work. In addition, the geographical separation of project team members and projects inhibits the knowledge flow within and between projects.

Observable potentials from the social learning perspective
An indication for the ineffectiveness of the transfer meetings, as well as for the potential of social learning is the estimator/planner interaction during the work preparation phase. For the planners, assumptions made during the tender and calculation phase are not always comprehensible. From tender and calculation documents alone the chain of thought is not visible to them. It only becomes clear

through discussion with the estimator, preferably supported by the close proximity of the estimator and planning engineer. This again indicates that the ineffectiveness of the transfer meetings, although meant to support the transfer of knowledge from tender to work preparation phase, is related to their decoupling from the immediate working process.

Case III

Observable limitations from the sender/receiver perspective
There are several channels in place to support the knowledge transfer between employees and projects such as team building sessions, project evaluations and project documents. Team building sessions are annual meetings at which specific engineering topics and new developments are discussed. These sessions are regarded as beneficial, since they stimulate social interaction. However, they are seen as insufficient to regularly update the knowledge base. Project evaluations are done on an irregular basis. Their outcomes are centrally stored, but although employees know that evaluation results are available, they have difficulties finding them and rarely make use of them. Reasons that are mentioned include the outdated knowledge of evaluations, their unstructured storage, and the difficulty of extracting and transferring the knowledge in a new project context. Another channel are project documents which capture design knowledge from previous projects and are used as basis for the design in new projects.

Observable potentials from the social learning perspective
Social learning is much connected with team interaction due to changes in team composition. On the one hand, for every project a new team is constituted. On the other hand, project team members change every few years. Despite the risk of losing knowledge, this is also perceived as chance of new perspectives and different experiences which are unfolded in project work. This is additionally supported by the close proximity of team members over longer periods during base design and construction. The regular change of personnel in out-of-area projects becomes part of the working process and the needed transfer meetings are regarded conducive for the exchange of knowledge around the specific circumstances of the out-of-area project.

Case IV

Observable limitations from the sender/receiver perspective
This case organisation follows a very structured and standardised evaluation process of tenders and projects that makes use of evaluation documents and workshops as channels for knowledge exchange. Steps are described, responsibilities are appointed and topics to be evaluated are mentioned. An evaluation form is provided, but its use is not mandatory. Despite the existence of a detailed evaluation procedure with a number of guiding protocols and forms, evaluation reports of only a third of the annual projects could be found in the central quality management system. Reasons behind this include insufficient time for conducting and accessing evaluations, low relevance of generally described knowledge for future projects, and difficulties in accessing very detailed knowledge about previous projects.

Observable potentials from the social learning perspective
The case study showed that social learning in project evaluations is connected to the application of evaluation results which are not stored in reports but which are made available during regular project meetings. Discussions of current project issues are supported with results from evaluations of previous projects. The benefit and thus willingness to use evaluations emerged in the direct working process through their

confrontation with context specific problems and challenges. Here, it was mentioned that in order to be beneficial, evaluations should focus on specific disciplines.

Case V

Observable limitations from the sender/receiver perspective
Project evaluations are very prominent within the agency which can be traced back to the accountability as public organisation. They are regarded as tools to check the efficiency of the agency's work processes and the effectiveness of change programmes. Evaluations of regular infrastructure projects particularly aim at improving work processes. Although many project are evaluated, there is no clear evaluation procedure, evaluation goals are rather general or cloudy, and concrete outcomes are often missing. Evaluations become goals of their own and thus less relevant. Not surprisingly, there is the perception within the agency that results of evaluations rarely find their way into new projects. Yet, evaluation results are disseminated first of all within the own business unit and channels used to transfer these results are reports, workshops and meetings. Employees find it difficult and time-consuming to search for evaluation results from other agency units, but also to make their results available to these units.

Observable potentials from the social learning perspective
An indicator for the existence of social learning can again be found in the application of evaluation results. Evaluations become relevant at the start-up of new projects or if problems are encountered during projects. Employees then revert to evaluations of previous projects to make lessons learned available for the new project or the solution of the problems through the discussion with colleagues. What this distinguishes from the sender/receiver approach is the point that these employees were often involved in the project evaluations which are referred to. Learning does not occur through the extraction of knowledge from an evaluation report but rather through socially unfolding experiences from an evaluated project in the context of a goal-oriented activity.

DISCUSSION AND CONCLUSION

The fallacy of transferring lessons learned

The five cases are very much in line with previous studies in terms of problems related to the sender/receiver approach. It became apparent that the transfer of knowledge from one project to another project via several channels is impeded by characteristics that seem inherent to the contextual nature of construction. Two of these characteristics are particularly prevalent and appear to be interlinked: time constraints and obscured relevance or unclear purpose. In all cases employees lacked time to either adequately capture and store lessons learned or search and extract useful lessons from evaluation documents. Even channels like project transfer meetings are vulnerable to time constraints, as the second case revealed. At the same time the relevance and purpose of particular knowledge for subsequent projects is difficult to determine for the sender as well the receiver. That is, the sender needs time to capture and store lessons learned in a way that they can become relevant for the receiver who needs time to determine whether the provided knowledge is relevant for his/her project. From our perspective the limitations of the sender/receiver approach emerge from the attempt to remove or at least to reduce constraints. The fallacy of the approach lies in the assumption that the transfer of knowledge can be easily improved by making more time available and providing adequate tools for collecting and

disseminating lessons learned. We suggest that time constraints and unclear relevance will remain typical characteristics of a project-based industry limited in its ability to balance changing demand rates. Of course, approaches to enhance the learning between projects in construction need to address these characteristics, but they should be careful in trying to overcome and deny an industry's production structure and conceptually and practically separating the learning from its context. Rather, they should consider learning as an evolving process embedded in context and facilitated through the organising context.

Goal-oriented learning from projects in projects

The social learning approach regards learning as a contextual emerging practice, and the five case studies could provide indicators for its theoretical and practical potential. In all five cases the ineffectiveness of learning from projects can be related to the separation of the learning from the immediate project work. Capturing, disseminating and determining lessons learned were not part of the working process. In the light of time pressure and obscured relevance, these activities were perceived as extra workload and their contribution to the direct project was hardly recognised. As a consequence, the willingness to conduct them was very low; they received low priority or were completely dismissed. However, the five cases also showed that learning occurred when employees were engaged in project work. From the social learning perspective that is not surprising, since learning is seen as something that is "ubiquitous and part of human activity as such"(Elkjaer, 2003, p.43). It was the project context that triggered this learning through posing problems and questions, and offering opportunities and challenges. Particularly the orientation towards the goals of a project or single project activities enabled learning which then also made use of knowledge generated in previous projects. Instead of purely transferring this knowledge, it was unfolded through the interaction of employees directed by goals of the specific project. The transfer meetings used in case II and V point to this learning mechanism. In case II the transfer meetings were organisationally separated from the work process by transferring the outcomes of one project phase to the next phases. In case V the transfer meetings were organised as part of the regular change of staff in projects where in bilateral discussions about project issues the handing over is facilitated. Based on these findings, we see our initial argument supported that learning from construction projects is taking place within projects and that, given the contextual nature of learning, it seems essential to give the learning in projects more focus and orientation so that the learning between projects is further facilitated. A main implication for construction organisations is that they can support inter-project learning by linking projects through strategic objectives which are then translated to the specific project. That such deliberate coupling of sequential projects may improve the learning between projects is indicated by Dorée and Holmen (2004). In their study on technology innovation they could show that a contractor followed a path-dependent process for developing a bridge technology through a number of sequential projects, but without having an explicit technology development strategy. They suggest a more proactive stance of contractors to become aware of their project-crossing trajectories. A possible avenue for future research is to investigate the formulation and translation of cross-project trajectories and how these can impact the inter-project learning. Further areas for research are other contextual aspects of construction projects and their interrelatedness with learning.

REFERENCES

Bakker, R. M., Cambré, B., Korlaar, L., & Raab, J. (2011). Managing the project learning paradox: A set-theoretic approach toward project knowledge transfer. International journal of project management, 29(5), 494-503.

Bresnen, M., Edelman, L., Newell, S., Scarbrough, H., & Swan, J. (2003). Social practices and the management of knowledge in project environments. International Journal of Project Management, 21(3), 157-166.

Bishop, J., Bouchlaghem, D., Glass, J., & Matsumoto, I. (2008). Ensuring the effectiveness of a knowledge management initiative. Journal of Knowledge Management, 12(4), 16-29.

Carrillo, P. (2004). Managing knowledge: lessons from the oil and gas sector. Construction Management and Economics, 22(6), 631-642.

Dorée, A. G., & Holmen, E. (2004). Achieving the unlikely: innovating in the loosely coupled construction system. Construction Management and Economics, 22(8), 827-838.

Easterby-Smith, M., Crossan, M., & Nicolini, D. (2000). Organizational learning: debates past, present and future. Journal of management studies, 37(6), 783-796.

Elkjaer, B. (2003). Social learning theory: learning as participation in social processes. The Blackwell handbook of organizational learning and knowledge management, 38-53.

Engwall, M. (2003). No project is an island: linking projects to history and context. Research policy, 32(5), 789-808.

Kasper, H., Lehrer, M., Mühlbacher, J., & Müller, B. (2012). On the different “worlds” of intra-organizational knowledge management: Understanding idiosyncratic variation in MNC cross-site knowledge-sharing practices. International Business Review.

Kumaraswamy, M. M., & Thorpe, A. (1996). Systematizing construction project evaluations. Journal of Management in Engineering, 12(1), 34-39.

Newell, S., Bresnen, M., Edelman, L., Scarbrough, H., & Swan, J. (2006). Sharing Knowledge Across Projects Limits to ICT-led Project Review Practices. Management Learning, 37(2), 167-185.

Noorderhaven, N., & Harzing, A. W. (2009). Knowledge-sharing and social interaction within MNEs. Journal of International Business Studies, 40(5), 719-741.

Paranagamage, P., Carrillo, P., Ruikar, K., & Fuller, P. (2012). Lessons learned practices in the UK construction sector: current practice and proposed improvements. Engineering Project Organization Journal, 2(4), 216-230.

Plaskoff, J. (2003). Intersubjectivity and community building: learning to learn organizationally. The Blackwell handbook of organizational learning and knowledge management, 161-184.

Ruikar, K., Anumba, C. J., & Egbu, C. (2007). Integrated use of technologies and techniques for construction knowledge management. Knowledge Management Research & Practice, 5(4), 297-311.

Schindler, M., & Eppler, M. J. (2003). Harvesting project knowledge: a review of project learning methods and success factors. International Journal of Project Management, 21(3), 219-228.

Yin, R. K. (2008). Case study research: Design and methods (Vol. 5). SAGE Publications, Incorporated.

A KNOWLEDGE MAP OF SUSTAINABILITY FOR URBAN REDEVELOPMENT PROJECTS

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This paper presents and evaluates the application of a transparent knowledge elicitation and decision mapping method that has been developed as part of a sustainability assessment and enhancement framework for a major urban redevelopment project. Sustainable Urban Development requires the effective engagement of a wide range of stakeholders such as planners, landscape architects, engineers, policy makers and the members of wider communities. These stakeholders will contribute to different stages of the development process and require information and data in a diverse range of forms to ensure that they are adequately informed and therefore able to make an effective contribution. It is clear therefore that there is a need for a method that enables the identification of key decision points throughout the project development stages. This requires the application of a combination of techniques drawn from the information technology, knowledge management and business process mapping fields to provides a full understanding of the ways in which decisions are made throughout the project and enables the information needs of key decision makers to be determined. This ensures that information on the potential impact of decisions or actions that will influence the overall sustainability of the project can be provided to the right stakeholders, at the right time and in the right form. The paper will explain and justify a three stage method that has been developed and tested on the £1 Billion 30 year Dundee Waterfront redevelopment project. Conclusions are drawn on the effectiveness of the method and on the impact of its application to the Dundee Waterfront development project.

Keywords: decision making processes, decision mapping, knowledge management, sustainable development.

INTRODUCTION

There is a wide awareness of sustainable development in the built environment (Walton et al., 2005) however it is generally accepted that the real challenge lies in understanding how to put it into practice, i.e. to "operationalise" sustainability (Parkin 2000; Lamorgese and Geneletti 2013). This "operationalisation" of the principles of

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Gilmour D, Blackwood D, Falconer R, Isaacs J and Taylor A (2013) A knowledge map of sustainability for urban redevelopment projects *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 579-588.

sustainable development within the urban design and development process must be fostered at a number of levels and requires a number of approaches. Tools, techniques and guidance documents have been produced to support decision makers, however decision making in practice is seldom structured and that often "satisfactory" solutions are reached in an ad-hoc basis (Simon 1972). Walton et al., (2005) examined the extent to which current methodologies meet the need for integration. They identified a number of shortcomings including the need for an integrated multi-dimensional tool that could bring existing approaches together.

The SAVE theoretical framework (Blackwood et al., 2012) promotes an integrated and iterative approach to inclusive decision making for Sustainable Development, involving three inter-related components; Assessment, Visualisation and Enhancement. The Enhancement Component identifies opportunities to positively influence the sustainability of developments and to devise and implement appropriate activities and actions. The Enhancement Component requires an understanding of the ways in which decisions are made throughout the project to enable the information needs of key decision makers to be determined. Key decision points in the process, the stakeholders involved in these decisions, their functions and their information needs require to be identified. This is to ensure that information on the potential impact of decisions or actions that will influence the overall sustainability of the project can be provided to the right stakeholders, at the right time and in the right form. A number of authors have effectively used decision mapping or knowledge mapping to document and understand organisation knowledge management and decision making (Snowden 2000; Egbu et al. 2006; Driessen et al. 2007; Yasin & Egbu 2010). A review of literature concluded that an appropriate knowledge a mapping technique needed to do the following:

- To identify key points in the decision process and elicit knowledge used to make decisions
- To be dynamic and represent relationship between knowledge and process flows
- To be simple, transparent, pragmatic and illustrate why, who, what and where of knowledge mapping

A knowledge elicitation and mapping method was therefore developed which addressed the above requirements. This was then tested on the £1 Billion Dundee Waterfront redevelopment project.

METHOD

The method developed enhanced previous work by the researcher and extended the approach used in development of the SAVE Monitoring Framework (Gilmour et al. 2011).The knowledge elicitation and mapping method utilised a combination of techniques drawn from the information technology, knowledge management and business process mapping fields. These were developed into a three stage process:

1. Knowledge Elicitation: Knowledge elicitation and process mapping to identify and classify knowledge
2. Knowledge Map of Sustainability: The creation, through stakeholder workshops, of a verified knowledge map of sustainability
3. Integration of sustainability into decision making: Interviews with key process owners to map existing management systems, identifying opportunities to

ensure the full integration of sustainability issues into the project decision making process

Figure 1 illustrates diagrammatically how each stage in method interconnects. The Knowledge Map of Sustainability draws together the Output of Stage 1 Process Owner Interviews and Stage 2 Workshops.

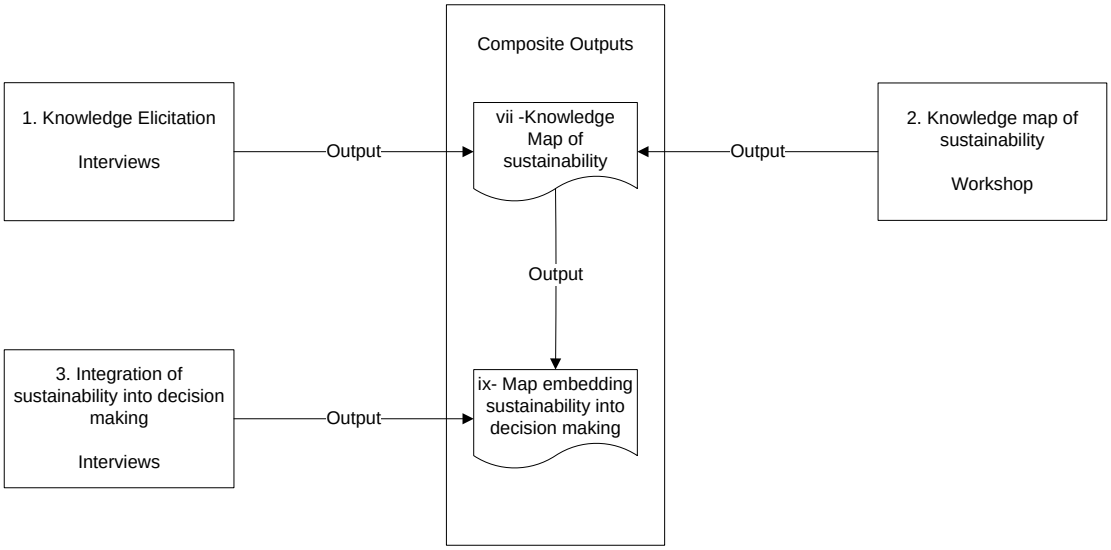

Figure 1 Method

The resulting knowledge map presents the key Knowledge Objects, flows and process in relation to sustainability across infrastructure provision. The third stage (not covered in the scope of this paper) maps existing management systems, identifying opportunities to ensure the full integration of sustainability issues into the project decision making process. The research has been conducted from an interpretive research paradigm (Dainty, 2008), with a non-experimental qualitative research model using semi structured interviews and workshops.

Stage 1 Knowledge Elicitation

Process mapping has been used effectively across many fields. Common to this wide application is that process mapping creates a diagrammatic understanding of the activity, people, data, objects involved in the process. Techniques of representation however vary between process mapping methods and what is represented or captured is bounded by the constructs of the language used for mapping (Biazzo 2002). In this study, an Organic Knowledge Management approach (Snowden 2000) was adopted to elicit and categorise knowledge. The premise to Snowden's approach is that knowledge is only known when it is needed to be known triggered by events and need, therefore you cannot ask someone to list everything they know (Snowden 2000). The human mind needs to be stimulated and therefore recalling the points that we use knowledge, is a method to recollect the use of knowledge. Snowden (2000) terms these as Knowledge Disclosure points (KPDs) such as decisions, judgements, problem resolution or learning. In this study process mapping concepts have been used together with Snowden's Organic Knowledge Management linguistic framework to develop a technique which allows the Knowledge Disclosure Points to be identified during each process, for all stages in infrastructure development. This approach also recognises a key finding of the literature review that you cannot map knowledge without understanding of the process (Egbu et al. 2006).

Process Owner Interviews
Mapping was undertaken by interviewing key individuals responsible for a task or process. These individuals are termed 'process owners' and have a deep understanding of the section of infrastructure or process under investigation. The Interviewees were asked to talk about the design and phasing process for Dundee Waterfront and explain what process was involved, what information used, what knowledge what needed to make judgment or decision. Process Maps were developed with the process owners during 10 interviews which were tape recorded for accuracy of the records. Maps were developed and subsequently verified through a series of further interviews with each participant. Each of the interviews built up a set of Process Maps and associated Knowledge Objects, based on Knowledge Disclosure Points. The method employed a 3 level hierarchy of diagrams which allows process to be mapped at appropriate level of detail. Level 1 which presents high level process and high level Knowledge Objects, Level 2 which present activities within each process and associated Knowledge Objects, Level 3 which present the workflow within the Level 2 diagram processes. The workflow diagrams provided the correct level of detail to allow Knowledge Disclosure Points (decisions) and associated Knowledge Objects used in the process to be identified and catalogued. Knowledge Objects used in the process were then collated for categorisation and analysis.

Knowledge Categorisation
The concepts of Tacit and Explicit knowledge (Nonaka and Takeuchi 1995) are widely recognised in knowledge management. Nonaka and Takeuchi (1995) developed the influential knowledge creation and transfer SECI model, where the four transitions between tacit and explicit, namely socialisation externalisation, combination and internalisation were identified. Snowden (2000) contends that the manager's day to day desire in calm and rational moments is to want information written down, leading to an idealised rational decision making with access to all information required. This is contrasted with real life under pressure decision where the problem moves from "structured explicit, pseudo rational decision making to, simple rules and values, tacit empowerment based on trust and experience" (Snowden 2000, p3). Simon (1972) identifies decision making in practice is seldom structured and that often "satisfactory" solutions are reached in an ad-hoc basis and concludes that most human decision making is concerned with the discovery and selection of satisfactory rather than optimal alternatives and describe this process as "satisficing". An approach was required to identify knowledge used in decision making which recognised the human interaction with process, and the concept of satisficing whilst providing some form of categorisation. Snowden (2000) presents a method of categorising knowledge whilst maintain sense of what information is used in decision making. Knowledge Disclosure Points were identified and mapped in interviews during process map. Knowledge Objects associated with Knowledge Disclosure Points were then collated in tables. The Knowledge Objects were then categorised based on ASHEN categorisation (Snowden 2000) as follows:

- Artefact: the term encompasses all existing explicit knowledge and /or codified information within an organisation e.g. documents, databases, processes.
- Skills are those things we can identify tangible measure of their successful acquisition: expertise, practised ability, dexterity, tact
- Heuristics are the effective way by which decisions are made when the full facts are not known: rules of thumb.

- Experience: actual observation or practical acquaintance with fact or events and the knowledge resulting from this.
- Natural talent: special amplitude, faculty, gift

The nature of the Knowledge Objects associated with each process can be used to inform mechanisms developed to embed sustainability within processes.

Stage 2 Knowledge Map for sustainable decision making

ASHEN workshop

Process Owners who had participated in the Process Owner Interviews were invited to participate in a workshop. The workshop enabled the collective identification of Knowledge Objects based on a number of Knowledge Disclosure Points identified in process mapping. This had two purposes, firstly to confirm Knowledge Objects identified during process mapping and secondly to draw out as a workshop group any clusters of Knowledge Objects used during the Design & Phasing and Construction stages. The workshop was led by the researcher at City Development Offices, Dundee City Council. Following a brief introduction, the workshop was anchored around meaningful questions on the context of the Knowledge Disclosure Points:

- When you made that decision what artefacts did you use or have access to?
- What skills had you acquired that were necessary?
- What heuristics have you developed that enabled you to make that decision quickly on the basis on incomplete or unarticulated inputs?
- What experience have you had which are essential or just plain useful in making that decision?
- What natural talent is necessary and can you give examples of signs that such talent exists as potential in others?

The participants worked as a group to agree what Knowledge Objects where used at Knowledge Disclosure Points during Design & Phasing and Construction phases in the Dundee Waterfront project. The ASHEN Model was presented to workshop participants on flip chart and Knowledge Objects were placed in the categories by the workshop participants. The workshop was tape recorded to give a complete overview of what had been said and the context of the knowledge disclosure and any discussion with the participants around this. In addition to the confirmation of Knowledge Objects identified during Stage 1 Process Mapping, the workshop looked specifically at sustainable development issues. The purpose of this was to draw from the participant's reflection of the sustainability issues relevant to, or contained within, the Knowledge Objects. A portfolio of Sustainability Knowledge Objects were drawn from this and used to create the Knowledge Map.

Creation of the knowledge map

The Knowledge Map for Sustainability draws together the output of Stage 1 Process Owner Interviews and Stage 2 Workshops. The resulting knowledge map presents the key Knowledge Objects, flows and process in relation to sustainability across Design & Phasing and Construction of infrastructure for Dundee Waterfront. Mapping methods for sustainable urban environments were reviewed (Eppler 2001; Egbu et al. 2006; Thomson et al. 2011) and presented a number of mapping techniques and mapping outputs. The review concluded that the important aspect to any map was simplicity, so that the stakeholders or users of these maps understand and can use these outputs. They also need to be able to show key documents, key flows and key

knowledge and to be dynamic to depict information over time. In addition they need to show the why, who, what, where (Egbu et al. 2006). Vail (1999) presents quality criteria to inform the design of knowledge maps as follows:

- Participative- the map is created interactively involving key employees
- Shared - the map represents shared knowledge the all can relate to
- Synergistic- experts contribute their different expertise to the map
- Simple- the map can be overlooked at one glance
- Visual- the map uses a visual framework

Stage 1 produced Process and Workflow Maps for each stage of infrastructure provision under investigation. A challenge in development of the knowledge map was to enable a significant number of processes and Knowledge Objects on to one map without losing the required simplicity and dynamism described above. Buchanan & Gibb (2008) provided comprehensive reviews of commonly cited methodologies from information management fields. Their work concluded that while there is wide commonality within approaches, no method distinguished itself as a preferred approach, therefore emphasis should be on usability of the outputs and organisational requirements (Buchanan and Gibb, 2008). With this in mind, a representation technique was developed using the project life cycle as the dynamic component (Hunt and Rogers 2005; Thomson, Emmanuel and El-Haram 2011) to integrate process, Knowledge Objects and knowledge flows.

RESULTS

Stage 1 Knowledge Elicitation

Process Owner interviews

Twelve Process Diagrams were developed with the Process Owners to map Design & Phasing and Construction stages of Dundee Waterfront Infrastructure Provision. An example of a Level 2 Design & Phasing Process Diagram is shown in Figure 2. The Level 2 Outline Phasing Process Diagram provides an illustration of the process and associated Knowledge Objects identified and used during Outline Design. The Outline Phasing process is shown as a numbered boxes moving left to right. It starts from 'Splitting the master plan into sections' (5.1) to 'Detailed Phasing' (5.7) following initial drawings, revision and design review. Associated Knowledge Objects are shown in open brackets such as Experience, Engineering Judgement. Document Knowledge Objects (Artefacts) are shown at the bottom of the Process Diagram.

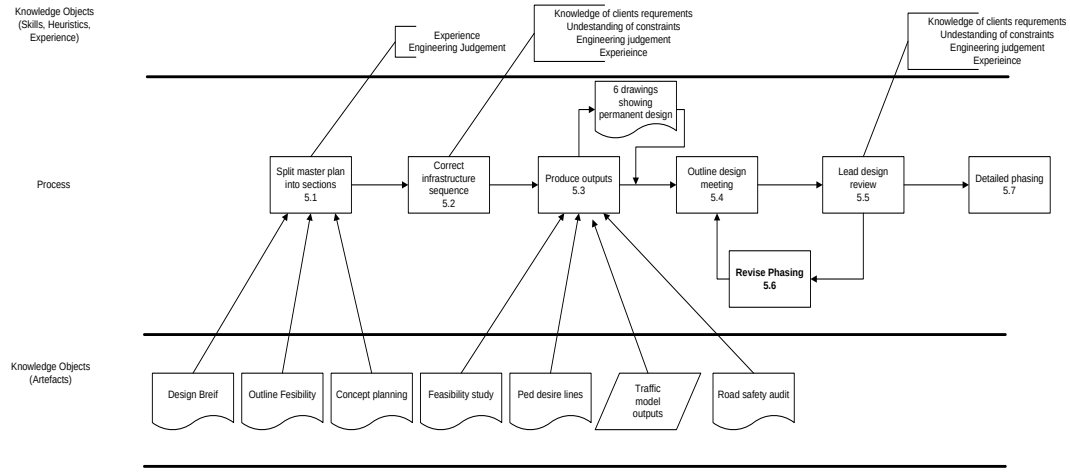

Figure 2 Level 2 Outline Phasing Process Diagram

Knowledge Categorisation

Knowledge Objects associated with Knowledge Disclosure Points were identified during Process Mapping interviews. The Knowledge Objects were then collated into tables and categorised based on ASHEN categorisation (Snowden 2000) as illustrated in Table 1 Outline Phasing Knowledge Objects (extract).

Table 1 Outline Phasing Knowledge Objects (extract)

Artefact object	Skills object	Heuristics	Experience	Natural Talent*
Design brief	Training	H&S implications	Knowledge of the design process	
Outline feasibility	Engineering judgement	Timings	Client constraints	
Concept planning	Knowledge of the requirements	Cost implications	Experience	
Feasibility study	Understanding of constraints	Traffic management implications	Awareness of Previous work	

**Natural talent was not identified during categorisation*

Stage 2 Knowledge Map of sustainable decision making

Ashen Workshop

The ASHEN workshop was held as described in the method section. Five ASHEN model diagrams were produced collectively by the participants during the workshop. Two diagrams identified Knowledge Objects associated with Design & Phasing and Construction and verified the Knowledge Objects identified in Stage 1. Three diagrams focussed on sustainability issues, identifying Knowledge Objects associated with Sustainability in Design & Phasing, Sustainability in Construction, and Sustainability Opportunities. The Knowledge Objects associated with sustainability identified were then used in the creation of the Knowledge Map for Sustainability. An example of AHSEN workshop output is shown in Figure 3.

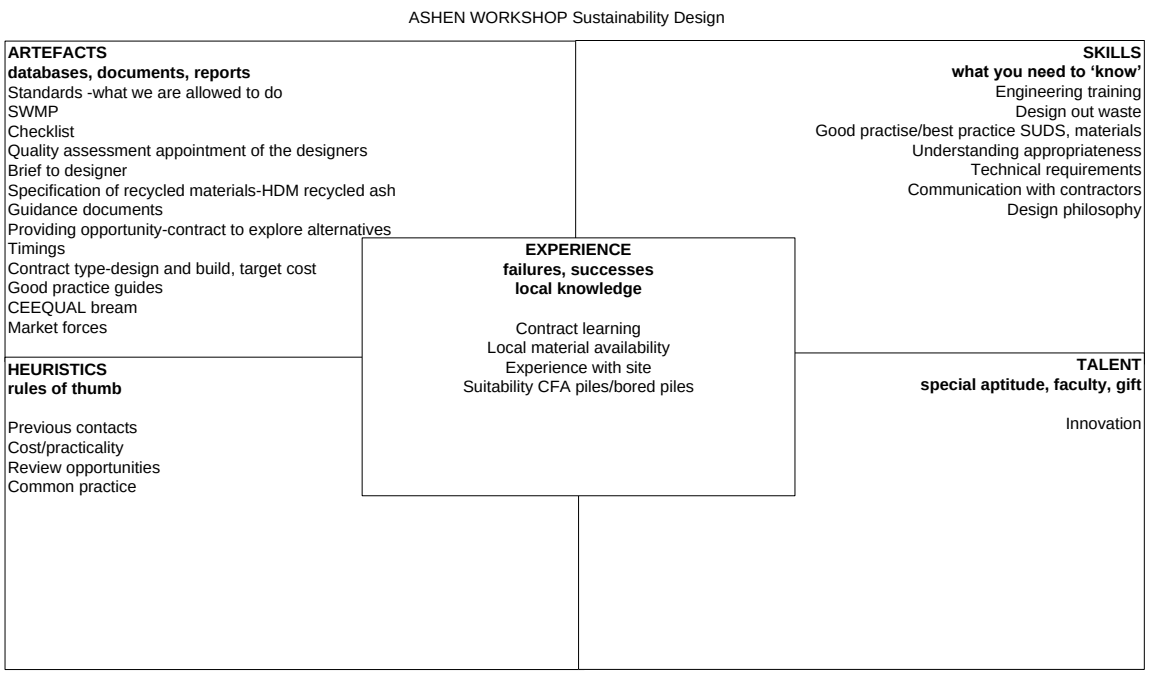

Figure 3 ASHEN workshop Sustainability in Design & Phasing

Creation of Knowledge Map for Sustainability

The Knowledge Map for Sustainability is shown in Figure 4 and presents a distillation of output from Process Owner interviews and ASHEN workshops across Design & Phasing and Construction for Dundee Waterfront Infrastructure Provision. In addition, the map has been extended to illustrate Feasibility and Use to present the flow of sustainability knowledge across the project life.

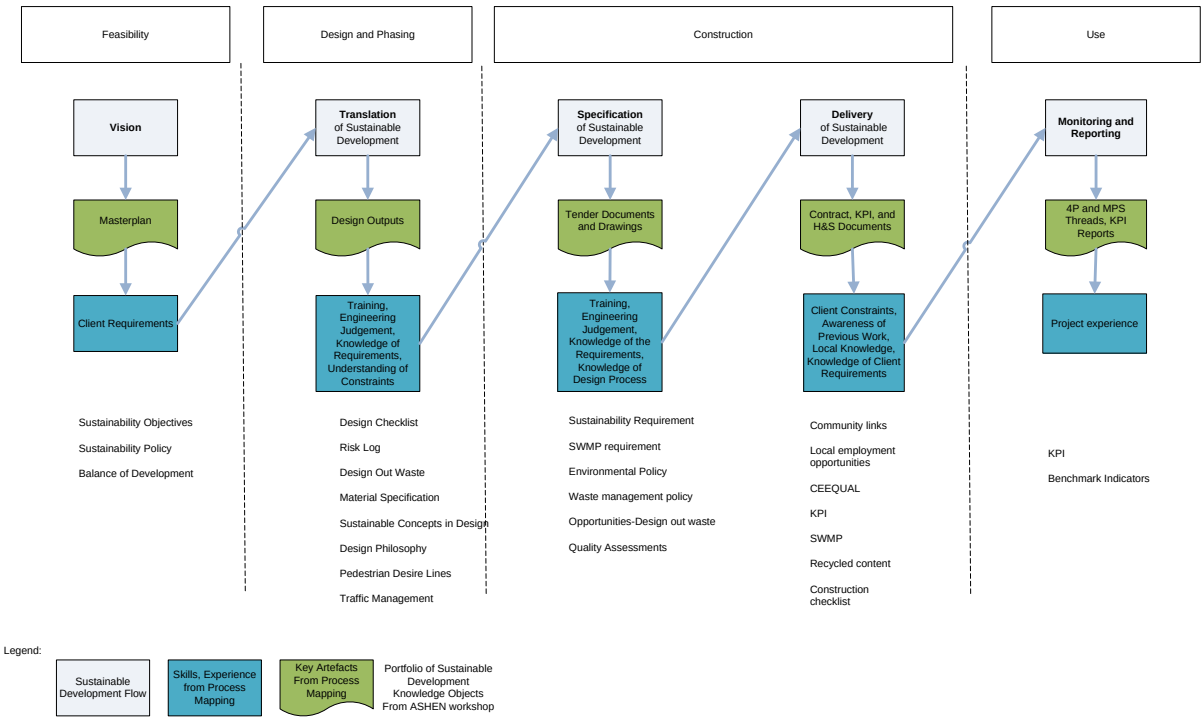

Figure 4 Knowledge Map for Sustainability

The Knowledge Map for Sustainability describes how the sustainability vision flows and transforms from Feasibility through translation of the vision in Design & Phasing, by specification of the vision in tender documents and appointment of contractors, and the delivery of the vision during Construction. The map also shows where the knowledge resides within each of the project stages. Knowledge Objects (key artefacts, skill and experience) and a portfolio of specific Sustainable Development Knowledge Objects which influence sustainable development are identified for each of the project phases.

One of the key challenges of the map presentation was to capture the dynamism and complexity of the real life process while keeping the simplicity and transparency so much desired in knowledge maps. To this end, the iterative nature of the process has been concealed through categorising Knowledge Objects into phases. It is acknowledged by the researchers that in reality these may be quite indistinct or overlapping. The Knowledge Map was verified by Process Owners at Dundee City Council to ensure usefulness, simplicity of representation and effectiveness to represent a Knowledge Map for Sustainability based on Eppler's (2001) knowledge map quality criteria.

CONCLUSIONS

Simple and transparent decision mapping and knowledge elicitation techniques have been successfully developed and applied to Dundee Waterfront to identify key points in decision process, information decision makers need and knowledge objects that they are using to make decisions. This was achieved through 10 mapping interviews, workshops and further verification interviews. The techniques have mapped the infrastructure provision process to identify knowledge supporting the process. This in turn has allowed a Knowledge Map for Sustainability to be developed to identify what information is currently used to influence sustainability and identify future opportunities to enhance practice. The map has been effective in capturing the role of each stage in process to translating the sustainability vision. This map has been useful to the project team to identify opportunities to influence sustainability within the Dundee Waterfront Infrastructure Provision. This understanding provides an insight on how to operationalise sustainability and will be used in Stage 3 of the Method to identifying opportunities to ensure the full integration of sustainability issues into the project decision making process. The mapping approach has only been tested on one case study, however due to the flexibility of approach it is concluded it should be appropriate for the sustainability enhancement of other infrastructure projects.

REFERENCES

Biazzo, S 2002, Process mapping techniques and organisational analysis: Lessons from sociotechnical system theory, Business Process Management Journal, 8, (1), pp. 42–52.

Blackwood, D, Isaacs, J, Gilmour, D and Falconer, R 2012, Integrating Sustainability in Water Sensitive Urban Design Through Dynamic Visualisation & Modelling, WSUD Conference 2012 Building water Sensitive Community. 7th International Conference on Water Sensitive Urban Design. 21 -23 February 2012.

Buchanan, S and Gibb, F 2008, The information audit: Methodology selection, International Journal of Information Management, 28, (1), pp. 3–11.

Driessen, S, Huijsen, W-O and Grootveld, M 2007, A framework for evaluating knowledge-mapping tools, Journal of Knowledge Management, 11, (2), pp. 109–117.

Egbu, C, Quintas, P and Demaid, A 2006, Knowledge Mapping and Bringing about Change for the Sustainable Urban Environment. A report of Transition Project Research Funded by the EPSRC Sustianble Urban Environment Programme.2006.

Eppler, MJ 2001, Making knowledge visible through intranet knowledge maps: concepts, elements, cases, Proceedings of the 34th Annual Hawaii International Conference on System Sciences, IEEE Comput. Soc, p. 9.

Gilmour, DJ, Blackwood, DJ, Banks, L and Wilson, F 2011, Sustainable development indicators for major infrastructure projects, Proceedings of the ICE Municipal Engineer, 164, (ME1), Thomas Telford, pp. 15–24.

Hunt, D and Rogers, C 2005, Barriers to sustainable infrastructure in urban regeneration, Engineering, (June), pp. 67–81.

Lamorgese, L and Geneletti, D 2013, Sustainability principles in strategic environmental assessment: A framework for analysis and examples from Italian urban planning, Environmental Impact Assessment Review, 26 January, Elsevier Inc.

Nonaka, I and Takeuchi, H 1995, The knowledge-creating company: how Japanese companies create the dynamics, Oxford University Press USA, Oxford University Press, p. 284.

Parkin, S 2000, Contexts and drivers for operationalizing sustainable development, Proceedings of the ICE-Civil Engineering, (November 2000), pp. 9–15.

Simon, H 1972, Theories of bounded rationality, R Radner & C McGuire (eds), Decision and organization, North Holland Publishing.

Snowden, D 2000, The ASHEN Model: an enabler of action Part One of Basics of Organic Knowledge Management The ASHEN Model: an enabler of action Part One of Basics of Organic Knowledge Management, Knowledge Management, 3, (7), pp. 1–8.

Thomson, CS, Emmanuel, R and El-Haram, M a. 2011, Mapping sustainability assessment with the project life cycle, Proceedings of the ICE - Engineering Sustainability, 164, (2), pp. 143–157.

Vail, EF 1999, Knowledge Mapping: Getting Started with Knowledge Management, Information Systems Management, 16, (4), pp. 1–8.

Walton, JS, El-Haram, M, Castillo, NH, Horner, RMW, Price, ADF and Hardcastle, C 2005, Integrated assessment of urban sustainability, Engineering Sustainability, 158, Issue, (June 2005), pp. 57–65.

Yasin, F and Egbu, C 2010, Exploitation of knowledge mapping benefits in the facilities performance evaluation process: a conceptual framework, In: Egbu, C. (Ed) Procs 26th Annual ARCOM Conference, 6-8 September 2010, Leeds, UK, Association of Researchers in Construction Management, 799-808., pp. 799–808.

Yoo, K, Suh, E and Kim, K-Y 2007, Knowledge flow-based business process redesign: applying a knowledge map to redesign a business process, Journal of Knowledge Management, 11, (3), pp. 104–125.

ASSESSING THE POTENTIAL APPLICATION OF ONLINE SOCIAL NETWORKS FOR THE CONSTRUCTION INDUSTRY

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The construction industry is said to be slow in adopting new information technologies into their processes. It is also said to be fragmented due to the project based nature of the industry. There is a need therefore for an ICT solution that satisfies both of these constraints. The potential application of social networks to the construction industry has thus far been largely unexplored. The research focuses in on this area by questioning the current understanding of the technology within the sector, the current level of collaboration, the requirements of the industry to fostering greater efficiencies and concept areas beyond collaboration associated with online social networks. The research carried out establishes the level of understanding of social networks and their predecessor technologies. The research also establishes a number of existing concepts. Interviews were conducted both with industry professionals and an industry specialist online social network provider and builds upon these findings extending them into newer concepts beyond collaboration, thus highlighting areas where greater efficiencies can be made by the industry through their implementation. Through habitual and structured use it leads to the naturalisation of knowledge management, virtual teams through remote participation, and social intelligence. The research identifies a natural progression of the online social network to higher levels of conceptualised use leading to enterprise social networks and social knowledge networks. The construction online social network will allow the construction contractor to defragment the fragmented, to empower its employees, to become more efficient both in the field and off while simultaneously naturally building a knowledge base which becomes a source of revenue through its continued and structured use.

Keywords: communication, information technology, knowledge network, project collaboration, social network

INTRODUCTION

Online social networks (OSNs) all have common attributes that are highly transferable to the construction sector. On a daily basis contractors make and receive multiple calls, multiple emails and record and forward images as site work progresses via email and other methods. This is a very fragmented process of communication. The fragmented information shared between these sources can be broken and easily lost and lead to possible further issues for the contractor. There is a requirement for harmonisation between the information carrier sources and OSNs can potentially offer that harmonisation.

Many attempts have been previously been made by researchers to highlight ICT's recognisable values to the construction field of communications. Niche ICT tools have proven their worth in the past for certain contractors which have tended to meet the

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Bartley EA (2013) Assessing the potential application of online social networks for the construction industry *In*: Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 589-598.

specialisations of their needs. Contractors have benefitted immensely by their use but the use of ICTs has still not broken in to the main stream industry. Coupled with the guarded nature of the industry with its information, there is an inherent lack of actual case use by which these construction organisations can make informed decisions to purchase OSN software or similar.

The aim of the research therefore is to provide the industry with up to date and relevant information as to the current demonstrable use of OSNs by those who are taking tentative first steps into OSNs and the means by which they are using the technology and for what purposes.

The central research question for this paper is; what is the current understanding of online social networks in the context of the construction industry, and what effect does it have on project collaboration and knowledge management in the field?

BACKGROUND TO ONLINE SOCIAL NETWORKS

Core function and context

OSNs (Facebook, Google+, LinkedIn etc.) have seen major gains in user numbers over the past ten years and the reason for this can be attributed to the core function of the software and the ease at which it carries out this function. This core function is the sharing of information between individuals. According to Cachia (2007) there is no commonly accepted definition of OSNs and this is perhaps because, the pace at which these platforms have grown beyond their core function in the recent past of simply sharing snippets of daily living. Cachia goes further to define OSNs as having two core functionalities which make them stand out from other related services.

Firstly Cachia describes OSNs as advanced tools for sharing digital objects (texts, pictures, music, videos, tags, bookmarks, etc.); and secondly as advanced tools for communication and socialisation between members. Cachia delivers the point that the combination of social networking and ICT has resulted in applications, referred to as social computing. Technologies that allow multiple participants to collaborate, discuss, edit, capture and disseminate knowledge etc. over the internet in real time are also known as virtual teams.

Building upon the area of social computing, Shih (2011) recognises the potential of OSNs as a collaborative tool as it: enables individuals to build better rapport and, therefore, can contribute to a more trusting and satisfying team environment. Attributing it to three main aspects of casual communication and interaction modes for establishing rapport, the capability to connect with individuals outside your network and the capability to find functional experts and view the expertise of collaboration team members.

ONLINE SOCIAL NETWORKS

OSN Progression

On reviewing the current literature surrounding the area of social networks and construction collaboration technologies there is a clear and definitive path of progression from basic ICT tools to high level use of OSNs. This identification is based largely upon the concepts that are derived from each categorisation of the use of an OSN.

Building Collaborative Technologies

The goal of OSNs is to do more than mere networking with peers - contributing collaboratively often leads to discussions that mature into a project which could lead to a new way of producing a product or solving a problem. In this respect networking is a prerequisite to collaboration, Awad (2011). With this in mind there is a definitive structure or systematic way with which to gain maximum potential from OSNs. In this manner therefore it is safe to assume that the use of any collaborative technology is the prerequisite to OSN use and application. Concepts typically found and associated at this level of use are Networking, Shared Environments, interconnectivity and RTC.

Online Social Networks

The next level of the OSN progression is the OSN and its main concept of knowledge management (KM). KM is often cited among academics and researchers as a major benefit to an organisation when construction IT and adoptions are discussed. Sun (2001) defines it as having two aspects. Firstly, it is managing knowledge itself, typically using some IT technology and secondly managing people who create knowledge and encourage a knowledge sharing culture.

The basis is to capture tacit and explicit knowledge that is stored or locked in the employee's mind. This can be captured in a number of ways either in a structured (formal), semi structured or informal manner. Sun likens it to a form of capital that is capable of exchange between people and be capable of growing. Sun also describes it as intellectual property that adds value to the organisation competitively.

In research carried out by Smyth *et al* (2008), it was identified that both email and project databases are the most common method of knowledge capture. This presents a fragmentation of the knowledge capture process adding to the complexity of knowledge seeking.

OSNs may offer the solution to the building contractor wishing to capitalise on their organisation's fragmented knowledge. In one instance it offers simplicity and a clean user friendly interface. Both of these points Williams (2007) argues are paramount to successful knowledge capture and use. While at the same time it offers a single and central hub from which all information is gathered and shared removing the processes as described by Smyth (2008). Concepts identified at this level are Project Collaboration, Behavioural Based Actions, Remote Participation, Sharing Culture, Knowledge Management and Social Recollection. OSNs adopted not just at the site level but at the organisational level seek to reconnect sites to other sites within the organisation promoting a shared environment.

Combined, this technology emphasises that knowledge is easily shared and retrieved among users but that this process can take time in getting it to that point.

The topic moves away from KM and moves towards project collaboration and the new dynamic that it creates within the organisation. Simply sharing knowledge or information on a particular topic on an OSN where there are multiple viewers almost naturally promotes a discussion. This discussion promotes further knowledge sharing through advice and previous experiences of the contributors and thus expands the knowledge base of the organisation. A layering effect of knowledge to the organisations knowledge base occurs further enhancing the captured knowledge.

Enterprise Social Networks

In a larger organisations or perhaps even a community of smaller organisations, Shih uses the term Enterprise Social Networks (ESNs) as opposed to OSNs and highlights

an important function of OSNs/ESNs is for discovering expertise within the organisation. ESNs are thus the next progression of the OSN. Concepts associated with the use of ESNs are Transparency, Knowledge Based organisation, Self-policing and Naturalisation of Knowledge Management.

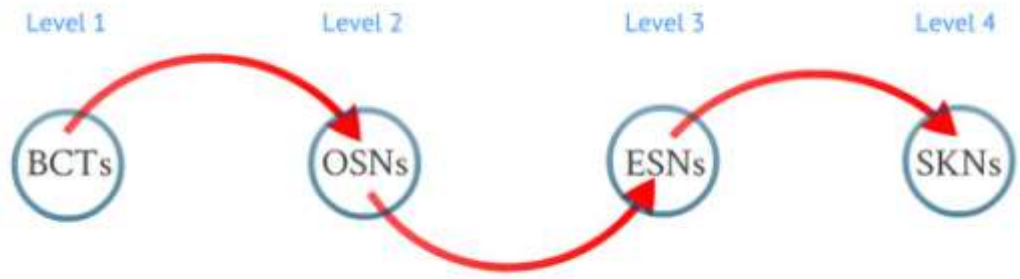
Business intelligence can be compared to a form of data mining or dataveillance. Dataveillance can be seen as a method of intrusion of privacy however here the method is used to the benefit of the end user by collating data and presenting it in a manner that is useful for the business. When used in the right manner dataveillance can demonstrate positive benefits to the user but there is also the addition that it can be used to gather data on the participating organisation without their express knowledge.

Remote participation is also highlighted as a benefit for the contractor. The need to be present on the physical site in order to determine what is going on in real time is no longer necessary. This reduces time travelling and other expenses associated with travelling from site to site.

Social Knowledge Networks

In order for an ESN to become a SKN it must be social, collaborative and ubiquitous on top of which all lower concepts must be previously demonstrated. Figure 1 completes the progression theory. Engagement is therefore critical for not only the successful implementation of an OSN it is also critical for its continued growth from one progression to the next.

Figure 1: Online social network progression



OSN concept hierarchy

By the identification of the functional concepts that are fundamental within the use and application of OSNs a vertical concept hierarchy becomes clearly defined. This hierarchy defines the manner by which a number of concepts need to be achieved/demonstrated prior to proceeding up the hierarchical structure to a more advanced level of OSN use and thus be rewarded by the benefits by the use of that level of OSN.

OSN knowledge spectrum

The OSN knowledge spectrum is a derivative model of the OSN concept hierarchy. It represents how each concept is related to the progression of the social network. Each progression of the OSN requires an organisation to have demonstrated the concepts associated with that progression and thus can be placed on the knowledge spectrum. Lower and easier concepts (from the left) lead to higher concepts and thus in turn are more complex and require a greater effort to attain. Figure 2 show the OSN knowledge spectrum.

This type of transparency opens a number of avenues for the organisation using an OSN. Depending on its level of use and associated rights, an individual can assess the work of another individual over a given duration and assess the true value that the individual is providing to the organisation over that duration. Combine any number of individuals on a site and the data that can be examined allows for any number of strategic business decisions to be made. This will allow contractors to be more responsive and flexible with their mobile workforce and will allow for a more streamlined approach to the sometimes adverse construction business environment.

In order to achieve that level of quality data analysis the contractor needs to have an existing culture of information sharing (sharing culture) throughout every level of the organisation. Which according to Sun (2001) is *the basis is to capturing tacit and explicit knowledge that is stored or locked in the employee's mind*. There must be frequent updates made to the OSN by every individual and these updates must contain some business activity information i.e. current activities, duration, number of personnel etc. This will depend on where the organisation wishes to take its interests along the OSN knowledge spectrum/benefits.

The transparency effect also empowers individuals to be more vigilant in what they do, and in some cases it may inspire a more productive workforce.

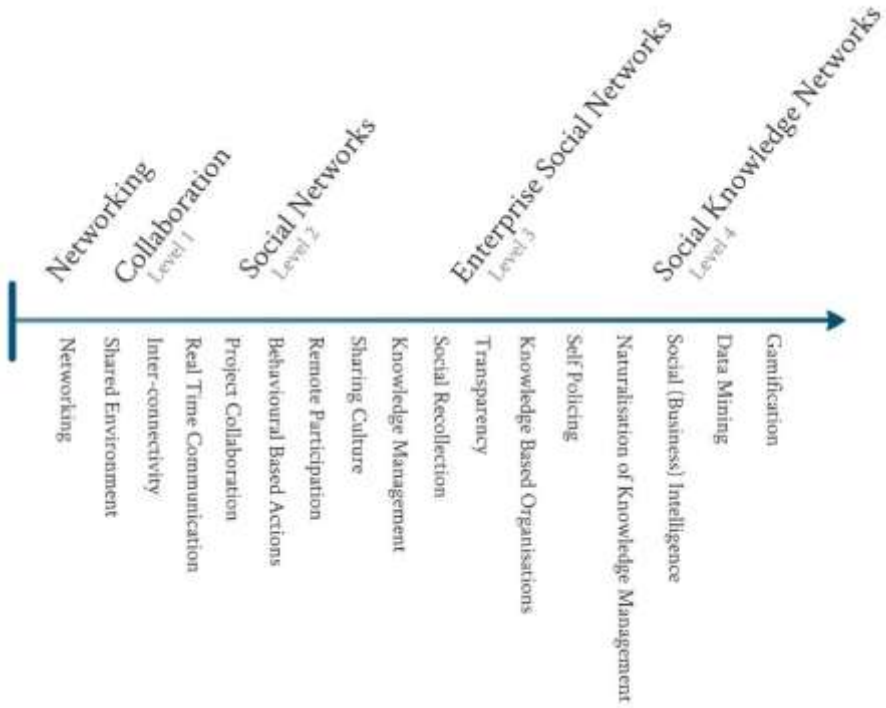


Figure 2: OSN knowledge spectrum ,relationship of conceptual use to OSN hierarchy.

CASE STUDIES

The case study methodology was chosen primarily as a means to justify the research aims by which to provide solid examples of use within the industry while simultaneously providing an opportunity to delve into the modes of conceptual use as demonstrated by the contractors.

Case study number 1:

Company A have had Senubo (a construction industry specialist OSN) within their organisation for approximately six months but it was not used extensively on any project or with any goal in mind. A decision was made to introduce Senubo with the view point of testing the software extensively during this project.

Prior to adopting Senubo on the project site, Company A relied solely on hardcopy site diaries for the recording of daily information. The site diary was not used as much until nearing the end of a job to return over previous entries and retrospect particular elements of work. The interviewee states that on using a hard copy diary that no one else would have picked it up to view entries for any particular purpose unless it was absolutely necessary. Thus the information contained within is never viewed by anyone but the owner.

The decision to use this technology was based on the rapidly evolving IT sector and the desire to keep apace, Company A considered Senubo as a tool that enhanced mobility within the construction environment. There was also the identification that Company A wanted to see if the tool would allow communication within the site in itself or be more broadly interlinked between sites.

Company A are currently using Senubo mainly as a substitute for their site diary, by recording daily tasks, number of operatives, plant and machinery, weather conditions etc. to the platform. That is all recorded via SMS text messaging as the participant walks the project site. Updates are then posted and those posts then appear on the web application for off-site viewing. Company A also use the OSN to report on any safety issues when they are encountered immediately on site during daily site inspections and also demonstrate how the transparency of the technology has enabled behavioural based safety on the project *"anyone can see that the [safety] checks have been carried out, it's up there, it's all there for everyone to see".*

Recollection at the end of a day's work was commonplace among company A and there is an admission that such recollection is not truly accurate of actual events. Procrastination is replaced by prioritisation by using the OSN. There is also recognition that the benefits of OSN real time updates and OSN transparency have had on the process of reporting in that there is no worrying associated about having not reported an issue to a particular individual. It appears to all on the main web application within seconds of sending the SMS update.

This eager adoption approach has allowed company A to clearly demonstrate a number of intermediate concepts that are associated with the use of OSNs. This would point immediately to a clear understanding of the technology and of what it can actually do. This demonstrates a championing approach to the technology.

A single site was used to begin the adoption of this technology. This targeted project site use implies a structured adoption approach by upper management and strategic decision making. There is awareness within the project team that technology is now more mobile and that this connectivity between people is making it easier to communicate. There is excellent understanding of the project team in terms of project collaboration and the sharing of update posts between team and organisation members and they even use terms such as interlinked which demonstrates further their understanding of the OSN.

Project collaboration is mainly carried out via sharing site diary updates using text and photographs. They also demonstrate the concept of remote participation by external

team members based in head office who can view the live feed and contribute remotely all of which adds naturally to the organisation's knowledge base.

Examples of using Senubo for safety updates and issues as and when they are spotted and this emphasises the technology as a live reporting tool that informs other team members of current issues who can then take appropriate action without delay.

There is also an awareness of the limitations associated with using hard copy diaries in that they have no social aspect unlike Senubo. This awareness further highlights Company A's understanding of the technology in terms of project collaboration. By highlighting the links between individuals on the site the team have become more aware of what is occurring on site at any given time.

Similarly the comparison between real time updating and retrospective writing into a site diary highlights time savings and more accurate knowledge management due to the ease of use of the OSN itself as there was an admission that having to retrospectively update a hard copy diary may lead to accidental knowledge loss.

Adding to the aforementioned point, the site team also demonstrate social recollection by the process of project collaboration and reading what other team members are doing. This also improves knowledge capture and management. Company A also show acute awareness of OSN security and privacy issues as the interviewee reassures that they were fully knowledgeable as to what the technology was capable of doing or not doing. This may have some links to previous use of other open OSNs (Facebook, Google+ etc.) by the interview and would thus skew the result.

Finally a link is highlighted that describes the relationship between a social network and proficiency of use and the age of the individual. The older an individual is the less proficient he or she is at using such technologies and vice versa. This is an expected result among the general population. The reaffirmation here highlights that more awareness of the OSN technology should be made to those who may not be as familiar with the technology and provide more care and attention. Without this care and attention the implementation process could run in to some issues reducing its capability to show increased performance or perhaps lead to its rejection. Perhaps Company A chose this project site due to its relatively young team members and as a result has proved implementation success over a relatively short period.

Figure 3: Position of company A on the OSN knowledge spectrum

By having this understanding and building the technology into a core function/process of the construction site has allowed company A to reap many of the benefits associated with an organisation. Figure 3 finds company B located to the middle section of the spectrum due to the manner by which they are using the technology.

Case study number 2:

Company B have had Senubo within their organisation for approximately one year specifically on a trial basis purpose only, thus there was no direct decision behind adopting the technology. Company B has no specific use for the technology thus far but has demonstrated minor collaborative use and data retrieval as the interviewee who is office based would notify some of the site team on a monthly basis to gather information for the monthly application process. It is also used by the interviewee to monitor progress out on the site and any other problems that may occur.

Previous to adopting Senubo all data retrieval processes were organised and collected by email. OSNs are seen by company B as *"more open and easier to use than email"* and that it is *"there in front of you… an open page and everybody can see it. So if someone has a comment to make they can make it."* With email the interviewee admits that there was always the possibility of missing someone's name during a circulation or not send the email to those who need to know.

Company B's approach to OSN use is extremely limited however there are clear and good examples of how it can be used both in project collaboration and disseminating information to the site team. There is however a distinct lack of strategy towards its implementation and notable absence of any attempt to embed the technology into any existing current process. There is nevertheless, comparative recognition of the benefit of the OSN over email in terms of disseminating information accurately to the correct individuals.

While it is not stated specifically by the interviewee, the concept of remote participation is clearly evident as he is office based and remote to the site relaying information back to the site team in real time.

On discussing the benefits of the technology to the organisation a number of OSN related concepts are also displayed by the organisation and particularly by the site team namely real time communication, shared environment, knowledge management and project collaboration. There was no recognition by the interviewee that they were active in these OSN areas. Even with the absence of strategic implementation of Senubo a number of low level concepts occur naturally as the OSN is being used at the basic level.

A point is made by the interviewee when he explains that the usefulness of the OSN reduces as the project nears completion. This is to be expected as the technology is being used mainly as a collaboration tool in this instance. As site activities decreases so do the number of personnel on site and thus the use of the OSN falls in correlation. In terms of disadvantages there is a level of awareness of the future potential of Senubo through data processing and data mining and that the lack of these tools with the OSN is seen as a disadvantage. This further highlights a poor level of strategy of implementing the technology into the organisation.

Having an OSN available to use for almost a year, company B do not show any high level use of the technology that would be expected after such a period in time. The interviewee does state that the adoption process was relatively quick and attributes

that to the young age of the site team. Again imposed limitations of use may be a reason for the natural under development of the technology.

There is a link made by the interviewee where due to the young age of the team and their previous familiarity with open OSNs the process of implementation was smoother. Inferring that OSNs are best used by younger as opposed to older individuals. Figure 4 finds company B located to the lower end of the spectrum due to the nature by which they are using the technology.

Figure 4: Position of company B on the OSN knowledge spectrum

Comparison

The benefits that OSNs provide as described by both organisations are unique to their respective circumstances. This proves that OSNs have multiple uses and benefits derived from those uses for each particular organisation. This demonstrates OSN flexibility within project collaborations while also demonstrating a number of concepts derived from OSN use that either occurs naturally or by design.

While discussing security and privacy both organisations believe that there were no real issues in relation to that area and that it was not an issue. Company A show that there is real trust in the OSN and thus prove that trust by exhibiting higher lever of OSN concepts while Company B show levels of mistrust impacting on their use of the technology. While there is little evidence to conclude that there is a correlation between organisational trust of the technology and benefits derived from the technology's use it does highlight its existence. Also the brief comparison shows that every organisation will have its own unique issues when implementing OSNs.

Adopting the OSN into the organisation for both organisations show further examples of the impact poor adoption strategies can have on the overall benefits of and OSN and its associated benefits. This is borne from the comparison between Company A and Company B wherein Company A show structured implementation and thus place higher on the OSN knowledge spectrum while Company B show little or no structure and thus place much lower along the OSN spectrum in relation to Company A.

Individually, both case studies highlight areas where OSNs have proven to be beneficial to the construction organisation. The grouping of legacy communication tools, while cumbersome to use, fail to reach the level of collaboration and knowledge

management that's associated with the OSN knowledge spectrum. The dynamism of the OSN coupled with the fragmentation of the industry put a clear case towards its use within the industry clearly demonstrated by the case studies and the manner by which it is used.

CONCLUSION

The nature of the online social network is one that allows the user to modify his or her use of the technology with great flexibility and thus see the OSN respond in a manner that is both elastic and malleable without the need for other modes of legacy communication tools. The identification of the concept hierarchy and associated level of social network use allows for the contractor to begin using and benefitting from the technology at any point along the spectrum regardless of their level of technological prowess.

The associated concepts of OSNs each have their own benefits that can have potential application to suit and meet the needs of the many facets of the construction industry and their specialisations. Providing accessibility akin to email

The case studies demonstrate that even by simplistic use of the technology have shown and gained benefits and have naturally begun to move along the OSN knowledge spectrum to higher level concepts without their explicit knowledge. This is the naturalisation of knowledge management in that it is occurring without prior awareness. There is however recognition that further research is required as the technology gains traction within the industry. The case study of company B highlights a possible side effects to the natural highs and lows of construction activity on the construction site in that activity also wanes on the social network and associated loss of interest in the technology (and its benefits) as a result making efforts to reignite use in the social network difficult on the next project.

This research finds that there is ample application of social networks into construction industry and that the benefits that are derived from its continuous use will effortlessly defragment the construction communication process while simultaneously providing the construction organisation with a natural knowledge base with which to analyse to further improve physical construction processes.

REFERENCES

Awad, Elias M., and Hassan Ghaziri. *Knowledge Management*. Second ed. Upper Saddle River, NJ: Prentice Hall, 2011. Print.

Cachia, R., R. Compano, and O. Dacosta. "Grasping the Potential of Online Social Networks for Foresight." *Technological Forecasting and Social Change* 74.8 (2007): 1179-203. Print.

Shih, Clara Chung-wai. *The Facebook Era: Tapping Online Social Networks to Market, Sell, and Innovate*. Upper Saddle River, NJ: Prentice Hall, 2011. Print.

Shin, Dong-Hee. "The Effects of Trust, Security and Privacy in Social Networking: A Security-based Approach to Understand the Pattern of Adoption." *Interacting with Computers* 22.5 (2010): 428-38. *Science Direct*. Web.

Smyth, Hedley, and Stephen Pryke. *Collaborative Relationships in Construction: Developing Frameworks and Networks*. Chichester, U.K.: Wiley-Blackwell, 2008. Print.

Sun, Ming. *Understanding IT in Construction*. London: E. & F.N. Spon, 2001. Print.

Williams , Trefor. *Information Technology for Construction Managers, Architects and Engineers*. Clifton Park, NY: Thomson Delmar Learning, 2007. Print.

METHOD-BASED LEARNING: A CASE IN THE ASPHALT CONSTRUCTION INDUSTRY

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As in many domains in the construction industry, traditional working practices lean heavily on the onsite experience and craftsmanship (tacit knowledge) of operators and teams. This results in implicit individualised learning and lengthy learning cycles. To develop a deeper insight into construction processes, this tacit knowledge needs to be made explicit to instigate a change towards explicit method-based learning. For the asphalting industry, Miller (2010) developed a framework to make processes that take place on the construction site explicit when implementing new technologies. To change to explicit method-based learning, the experiential learning model of Kolb (1984) was introduced into current practices and 'explicating the process' was added to the learning cycle. Further, 'reflective observation' and 'abstract conceptualisation' were explicitly incorporated into current asphalting practices using feedback sessions with an asphalting team. This learning cycle was introduced during an actual construction project on a highway in the Netherlands. The adopted learning framework was found to be applicable and useful in the quest for improved process and quality control. By explicating the construction process 'as constructed', it became possible to have a meaningful discussion with operators in a feedback session and unravel their intentions and reasoning with the chosen strategies. Explicit method-based learning, as here, leads to improved quality awareness, better understanding of the processes and their interdependencies, and improved communication with and within the asphalting team.

Keywords: asphalt, experiential learning, feedback, operational strategies, quality control.

INTRODUCTION

Significant changes are currently occurring in the construction industry, resulting in changing roles for agencies (clients) and contractors. Further, agencies are shifting towards service-level agreements with lengthy guarantee periods. Within these new roles and contracts, contractors are directly confronted with any quality shortcomings that appear during the guarantee period. Therefore, it is important for contractors to improve process and quality control during construction.

In the current age of the internet, pervasive networks and rapid progress in technologies, one might expect contractors to embrace the new ICT opportunities for performance enhancement. However, in reality, the construction process is still mainly carried out without the use of high-tech instruments to monitor key process

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Bijleveld FR and Dorée AG (2013) Method-based learning: a case in the asphalt construction industry *In*: Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 599-609.

parameters, and little research effort has been put into the systematic mapping and analysis of construction processes. So, contractors hardly know what transpired during construction, and how the operations were carried out, and therefore it is near impossible to identify poor and good operational practices. Further, if the construction process is not explicit, the causes of any failures to meet the required specifications cannot be traced back to operational strategies on the construction site. The current operational strategies in the construction industry lean heavily on the skills and experience of operators on the construction site. Operators may implicitly learn based on experience from previous construction projects, but this is based on limited observations and data. Operators also receive little feedback on their work or the work and results of others, resulting in implicit learning (i.e. tacit knowledge) and lengthy learning cycles.

To enhance learning and improving the construction process in order to achieve better process and quality control, it is essential to move away from the current implicit individual learning towards explicit method-based learning. Given that current asphalting practices largely lean on the onsite experience of operators, it seemed appropriate to adopt and introduce the experiential learning lens of Kolb (1984) to current practices. This paper discusses a method to instil a change towards method-based learning and demonstrates its merits during the construction of an asphalt highway in the Netherlands.

The next section of the paper hones in on learning in the construction industry, followed by the research's aims and methodology. Next, the various phases of the learning model will be described for the highway project. Finally, the main conclusions and suggested directions for future research, specifically for the road construction industry but also the construction industry in general, will be discussed.

EXPERIENTIAL LEARNING IN CONSTRUCTION

Current operational-level learning practices in the construction industry are mostly based on the hands-on experiences of operators, and these experiences amount to active experimentation on how various strategies influence quality parameters (Figure 1). This is a form of individual and implicit learning, and results in lengthy learning cycles because of limited experiences and projects, and many changing variables. This characteristic of the construction industry makes learning and improving difficult, especially as the variables are often only implicit. To improve process and quality control, a change is needed, from the described individual implicit learning towards explicit method-based learning.

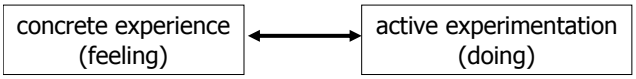

Figure 1: Individual implicit learning in the construction industry

The experiential learning cycle of Kolb (1984) was adopted in an attempt to move from individual implicit learning towards explicit method-based learning. In experiential learning theory, experience plays a central role. This is different from the cognitive view that emphasizes acquisition, manipulation and recall of abstract symbols, and from the behavioural view that denies any role for consciousness and subjective experience. According to Kolb (1984), experiential learning centres on the transformation of information into knowledge, an event that takes place after a situation has occurred and entails a practitioner reflecting on the experience, gaining a

general understanding of the concepts encountered during that experience and then testing these general understandings in a new situation. Several other authors have also argued that learning takes place in this order (Brock and Cameron 1999, Daft 2000). For the construction industry, reflective practice models are seen as necessary but often found to be lacking (Orange et al. 2000). Several researchers have confirmed the importance of reflection and stress that reflection is an important facilitator and contributor to learning (Schon 1983, Boud and Walker 1998, Harrison et al. 2003).

Current learning processes mainly concentrate on the 'concrete experience' and 'active experimentation' parts of the experiential learning cycle, while 'reflective observation' and 'abstract conceptualization' are neglected. This neglect is mostly because the operational strategies and key parameters are not explicit, and not systematically monitored and mapped. Therefore, in this research, we have added monitoring (i.e. explicating) the process to the experiential learning cycle of Kolb (Figure 2). Further, a comparison can be made between the concrete experience (feeling) of the operators and the monitored process (data). In addition, 'reflective observation' and 'abstract conceptualisation' should be added to the learning cycle in order to improve quality and process control and to develop additional learning and reflective competencies within construction teams.

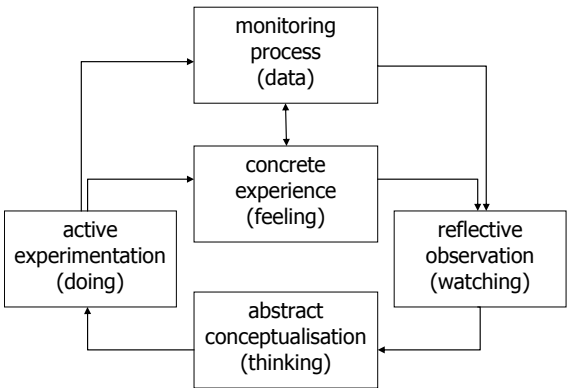

Figure 2: Monitoring (explicating) process in the experiential learning cycle of Kolb (1984)

AIMS AND RESEARCH METHODOLOGY

The aims of this research are firstly to include ‘reflective practice’ and ‘abstract conceptualization’ in current learning practices through conducting feedback sessions with operators to reflect on their work and their collaboration with others and, secondly, to enable explicit learning for operators based on the monitored process and the subsequent feedback session. The goal of this paper is to demonstrate the adopted method-based learning framework in use in an actual road construction project. During the construction of the a Dutch highway, the learning phases were incorporated into current practices and the full experiential learning cycle was monitored. Two nights of asphalting were monitored and observed, with a one-week gap between during which a feedback session was held.

Before the construction task started, a questionnaire survey was conducted with operators on how they planned to conduct their tasks. Next, the actual working methods were mapped 'as constructed' (concrete experiences). In mapping the actual working methods and making the construction process explicit, we used a previously developed measurement framework: 'Process Quality improvement' (Miller 2010). The operational activities were made explicit using several technologies, such as D-GPS to record machinery movements and a laser line-scanner, infrared cameras and thermocouples to record the asphalt temperature during the construction process. Both

of these are important parameters in determining asphalt quality. In certain locations, the changes in density after every roller pass were measured. More information about the technologies that were used in working with this framework and the systematic way in which data were collected, analysed and mapped are described in Miller (2010) and preliminary results were presented at ARCOM 2008 (Miller et al. 2008). This data was used to make the process explicit, and a feedback session was then organized with the asphalt team. In this session, the intentions and reasoning of the operators regarding the process 'as constructed' were made explicit (reflective observation). Based on the 'as constructed' process and the feedback, a list of possible learning aspects and improvements were addressed (abstract conceptualization). During the second asphalting night any changes in strategies, quality and process awareness, and learning effects were experimented with and monitored (active experimentation).

LEARNING-CYCLE RESULTS DUTCH HIGHWAY PROJECT

Project description

The object of the case study was the construction of the A15 highway as part of improving the connection between the Port of Rotterdam and the rest of the country. A consortium of three contractors was responsible for the construction, and also for maintenance until 2035. Therefore, controlling the process and the quality was essential in order to prevent problems during the maintenance period. The construction work took place overnight (between 11 pm and 6 am). During the two measurement nights, the same team was working on the asphalting. The full experiential learning cycle is discussed below based on the explicated process.

Concrete experience

The laying temperature of the asphalt mixture, the cooling process and temperature variability are key quality parameters (Miller 2010). Despite this, during the construction process, operators receive virtually no information about these temperatures and their variability. So, in general, the operators have to estimate the temperature at a certain time based on their experience, relate this to the weather, the specific mixture and layer thickness. Before the measurement process, questionnaires were distributed among seven operators to seek their estimates of the temperatures. Then, during construction, four sets of measurements were made using thermocouples and IR-cameras to monitor the cooling process 'as constructed'. The operators' predictions and the measurements are shown in Table 2.

Table 2: Predicted and actual asphalt temperatures and cooling rates (measurement 1)

Parameter	Predicted range (7 operators)	As constructed (4 measurements)
Cooling until 120 °C (min.)	10-30	8-17
Cooling until 90 °C (min.)	24-60	22-38
Cooling until 60 °C (min.)	30-90	57-80
Difference surface and in-asphalt temperature (°C)	17-25	8-15
Temperature drop truck change (°C)	5-8	5-10
Temperature drop 3 min. paver stop (°C)	10-12	10-20
Temperature drop 7 min. paver stop (°C)	14-20	25-35
Temperature drop 15 min. paver stop (°C)	20-30	35-50

Interestingly, the measured cooling times to 120, 90 and 60 °C all correspond reasonably well with the operators' predictions. However, the range of predictions is certainly wide, for example one operator predicted that cooling to 60 °C would take 30 minutes, while another predicted 90 minutes. The difference between the surface and the in-asphalt temperatures was slightly overestimated by the operators. Further, the temperature drops during truck changes and paver stops were accurately predicted for the short stops, but underestimated for the longer (7 and 15 minutes) stops.

Additionally, the planned operational strategies regarding the number of roller passes and the temperature windows in which one could compact were sought before the measurement phase. During the construction process, the actual number of roller passes and the temperatures present when compacting were determined via D-GPS, infrared cameras and thermocouples. The results of the planned operational strategies and the actual operational strategies are shown in Table 3. From the data, it is clear that operators were able to predict the number of roller passes quite accurately for their own roller, but predicting the number of roller passes of their colleagues seems difficult. For example, operator 3 expected to make five or six roller passes himself, and during the measurement night he made between four and seven on the various parts of the new surface. However, operator 3 predicted that the other operators would both complete ten roller passes, but in practice operator 1 made four to six roller passes and operator 2 made seven to nine passes. The data also show that the temperature windows were somewhat difficult to predict.

Table 3: Expected and actual number of passes and temperature windows (measurement 1)

Parameter	Prediction operator 1	Prediction operator 2	Prediction operator 3	As constructed (4 measurements)
Number of roller passes Roller 1	2-3	2-3	10	4-6
Number of roller passes Roller 2	4	6-8	10	7-9
Number of roller passes Roller 3	3-4	2-3	5-6	4-7
Temperature window Roller 1	150-120 °C	140-120 °C	145-90 °C	150-125 °C
Temperature window Roller 2	130-90 °C	110-80 °C	90-70 °C	130-95 °C
Temperature window Roller 3	90-60 °C	70-50 °C	70-50 °C	90-60 °C

As such, the analysis shows that the estimates based on 'concrete experience' by the operators correspond quite well with the process 'as constructed' regarding their own operations (albeit that the estimates covered wide ranges). However, it was clearly difficult for operators to estimate what their colleagues were doing during the construction process. This makes it difficult to anticipate during the process and, as asphalting is a collaborative process, this will negatively influence the process control.

Reflective observation

A key step towards explicit method-based learning is providing feedback to the operators of the asphalt team and for them to learn from this feedback (Kolb 1984, Miller 2010). During the feedback session, the measured data were provided to the asphalt team so that they could reflect on their own operations. These sessions enabled teams to determine improvements in the asphalting process in both their individual tasks and their collaborative work. The measured quantitative data are used to make the operational behaviour explicit, and the qualitative data from the feedback sessions tells the story from the operators' viewpoints. The session lasted approximately one

hour. The results of the measurements of the process 'as constructed' were printed and given to everybody so they could take a look at the findings themselves. Besides the asphalt team, also project managers, people from the preparation and technologists were present. The observations and reflections are summarised in Table 4.

Table 4: Observations and reflections of the operators of the asphalt team

Topic	Observation	Reflection asphalt team
Initial surface temperature	In general, the surface temperature behind the paver was 160 °C. During a truck change it cools by 5-10 °C. If the paver has to stop, the temperature decreases quickly (by up to 40 °C).	It is well-known that the temp. decreases by 5-10 °C during truck changes. The rapid temp. drop by 40 °C during paver stops was more than expected. If they are aware of lower temperatures, they will start compacting more quickly.
Cooling	The predictions of the operators agreed well with the measured cooling curves. Nevertheless, the range of predictions is rather large.	The differences in predictions are mainly caused by the variations in experience. Predictions by inexperienced operators are the least accurate.
	The variability in the cooling curves is rather large, making it difficult to predict the temp. during the process.	The operators knew this and stressed that this makes their work difficult. Real-time temp. information would certainly help.
Compaction strategy	Operators can fairly accurately predict the passes they will have to make but are less good at predicting the passes their colleagues will make.	It is difficult enough to do their own compaction consistently with so many changing variables. Real-time info about their colleagues could improve quality.
	The influence of the third roller on the final density is unclear. There is hardly any change in density despite the large number of roller passes.	Normally only two rollers are used in such projects rather than three. However, here, the project consortium insisted that three rollers were used to compact the asphalt.
	Rollers 1 and 2 were used consistently, but the spread in the number of passes by roller 3 is rather large.	The reason for the variability with the third roller is that the operator cannot see where the roller has been. The first and second roller operators can see this in the asphalt.
Cores and quality	The correlation between the onsite nuclear measured density and the core density determined in the laboratory is good (within 1%).	The correlation is rather good, but a technician is not always present at the site and sometimes at the wrong times, such the end of the night. This can be improved.
Paver speed	The speed of the paver is higher than in many other projects and above the expected speed.	The increased speed of the paver is not the operators' choice, but stipulated by the consortium due to production pressures.
	If the paver increases speed, the rollers have to work faster, but should be further away from the paver to operate in the same temp. window.	The asphalt team found this reasoning difficult to understand. Training that address various scenarios could possibly help improve this understanding.
Monitoring	The measurements provided the asphalt team with more information and formed a good basis for reflecting on the process.	The data often confirmed the team's gut-feelings. To understand the process better, more measurements should be conducted with various mixtures and ferent conditions.

Abstract conceptualization

The observations and reflections were distilled into 'abstract concepts' that produced plans for action which could be 'actively experimented' with during the second night

of study. Plans at the operational, project, organizational and research levels were distinguished:

Operational level (asphalt team)

- The asphalt temperature throughout the whole construction process is important. Therefore, asphalt temperature information should be available in real-time and communicated between the technologists and the operators.
- Currently, asphalt technologists only systematically measure the density during compaction, plus ad-hoc temperatures. These technologists should also systematically measure the temperature and the number of roller passes and communicate these with the operators.
- The three-drum roller (the 3rd roller) is used to create an even surface. However, it hardly influences the density of the asphalt mixture and sometimes even compacts it at too low temperatures creating micro-cracks. Therefore, making fewer roller passes with the three-drum roller should be tried during the next measurement.

Project management level (work preparation and coordination)

- The managers realize that asphalt temperature is important for the operators. They also acknowledge that real-time information is essential to improve the process. The managers now consider buying infrared pistols for every roller operator (a low-cost option) and will try to convince the company to buy high-end equipment to continuously monitor real-time temperatures.
- The managers also recognize that it is difficult for the 3-drum roller operator to see where he has been. They acknowledge that GPS-based equipment could help with this problem, but argue that this is a significant investment and that more support from within the consortium and company is required. The data collected could help convince people about the need for new equipment.

Organizational level (company)

- At the organizational level, it is acknowledged that production pressures can lead to communication and quality issues, especially if there is little feedback. For example, while a higher speed may be possible, the previous experience of the operators is not based on higher speeds. Training and scenario-playing could possibly improve this understanding and experience.
- There is hardly any feedback between the laboratory and the technologists, despite both conducting density measurements. Feedback cycles should be included in quality control to compare the onsite nuclear-measured density and the lab-determined density in order to improve instructions for roller operators.

Research (R&D)

- The data collected should all be geo-referenced. Using geo-referenced data, a historic record of the road can be assembled, such as how it was constructed, how it behaves during usage, and where early damage might originate.
- Using the PQi framework, only density measurements are taken after every roller pass. However, using this strategy, it is not possible to understand what happens with the asphalt between operations. Therefore, during the next testing night, measurements should also be taken between the roller passes.
- Providing the individual operators with the graphical data on paper in front of them in the feedback sessions worked well. Previous feedback sessions were held using a beamer, but operators seem more focused if they have all the graphs and information in front of them.

The action plans for the project management and organizational levels have more of a mid- to long term perspective, whereas most of the operational-level plans could be quickly operationalized. During the second night of measurement, some of the short-term action plans were actively experimented with, as discussed in the next section.

Active experimentation

During the second measurement night, questionnaires were again used to establish how the operators planned to conduct their work, and again the construction process was monitored and observed. These plans were compared to the predictions for the first night. Two plans drawn up during the abstract conceptualization phase were actively experimented with during the second night: (1) fewer passes with the three-drum roller combined with density measurements between roller passes; and (2) feedback and greater communication during the process to see if this leads to improved predictions and understanding of the process.

Figure 3 shows the roller passes and density progression using the various rollers on measurement night 1 (left) and measurement night 2 (right). These figures demonstrate that many fewer roller passes were conducted with the three-drum roller during the second measurement night (two compared with seven on the first night), an aspect discussed during the feedback session. The figure also shows the density measurements made between the roller passes (the non-coloured blocks). This shows that, even between the roller passes, the asphalt mixture is still settling and expanding. As such, measuring between the roller passes also provides valuable knowledge about the asphalt behaviour during compaction.

We do not know which compaction strategy is better since no mechanical properties were determined (this was not the focus of the research). However, this example does show that, based on the explicated process, it is possible for operators to change their behaviour and to actively experiment. Based on the operators' experimentation, the new process can then be either adopted or rejected.

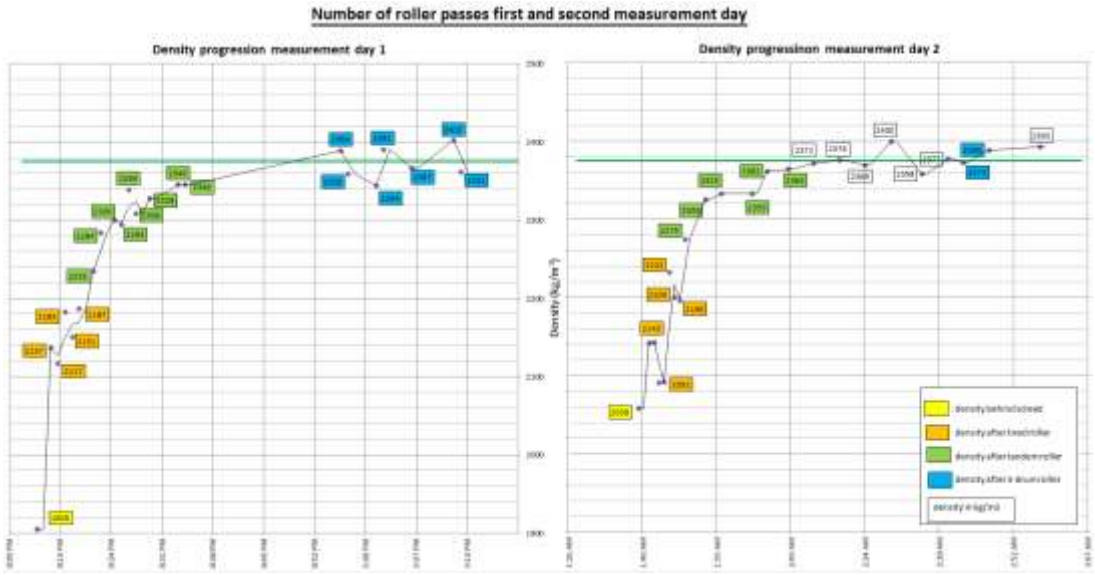

Figure 3: Density after each roller pass: first night (left) and second night (right)

The second element of active experimentation was to test if feedback and greater communication during the process would lead to improved predictions and understanding about the process. During the second measurement night, more intensive communication was observed (mainly as a result of being recognised as

valuable during the organized feedback session rather than through instructions to operators). Roller operators communicated about temperatures and the number of roller passes. The technologist also communicated in more detail: in addition to the traditional density, the number of roller passes and the temperatures were also communicated. The results related to the predictions of the operators and the actual constructed process on the second night are shown in Tables 5 and 6. Based on these questionnaires and measurements, it can be concluded that, following the feedback session, the operators have improved their predictions of temperatures, cooling and number of roller passes compared to the first measurement night. The predictions made by the operators regarding temperature and cooling are now all within the range of those measured during actual construction and also within smaller bands. In terms of the number of roller passes and the temperature windows for compaction, most of the predictions corresponded with the actual construction process or were very close.

Table 5: Predicted and actual asphalt temperatures and cooling rates (measurement 2)

Parameter	Prediction range (7 operators)	As constructed (4 measurements)
Cooling until 120 °C (min.)	10-20	12-17
Cooling until 90 °C (min.)	20-40	19-29
Cooling until 60 °C (min.)	40-80	47-56
Difference surface and in-asphalt temperature (°C)	10-20	7-15
Temperature drop truck change (°C)	5-10	5-10
Temperature drop 3 min. paver stop (°C)	10-20	10-20
Temperature drop 7 min. paver stop (°C)	20-40	20-30
Temperature drop 15 min. paver stop (°C)	30-60	30-50

Table 6: Planned and actual number of passes and temperature windows (measurement 2)

Parameter	Prediction operator 1	Prediction operator 2	Prediction operator 3	As constructed (4 measurements)
Number of roller passes Roller 1	6-7	3-4	5	4-7
Number of roller passes Roller 2	7-8	5-6	6	6-7
Number of roller passes Roller 3	4	2-3	2-3	2-4
Temperature window Roller 1	150-120 °C	150-130 °C	150-130 °C	150-125 °C
Temperature window Roller 2	130-80 °C	130-90 °C	130-90 °C	135-90 °C
Temperature window Roller 3	70-50 °C	70-50 °C	70-50 °C	70-60 °C

CONCLUSIONS AND FUTURE RESEARCH

Given the various changes taking place in the construction industry, it is becoming increasingly important to control the process and improve quality control. Current construction processes however lean heavily on the skills and onsite experiences of operators. This essentially results in individual implicit learning and lengthy learning cycles. In this paper, the experiential learning theory of Kolb (1984) was introduced to usher in a change towards explicit method-based learning. Explicating onsite construction processes was added to the learning cycle, and demonstrated in the

asphalt industry. To enhance the learning process, more explicit operational data were provided to the operators.

Transparency in the process and operational choices were created using new technologies that provided understandable visuals that helped in the sensemaking by individual operators and the team. The adopted learning framework was shown to be applicable and useful in a Dutch highway project. By explicating the process 'as constructed', it became possible to have a meaningful discussion with the operators of the asphalt team in a feedback session and so unravel the intentions and reasoning of the chosen strategies. This explicit method-based learning led to improved awareness, of both quality and in general, and communication with and within the asphalt team. It helped to fill the gap in 'explicit learning and reflection' in the construction industry and offers a method for developing the learning and reflective competencies of teams such as those investigated here.

This explicit method-based learning approach may also be applicable to other traditional experience-driven practices in the construction industry. For example, in the sub-surface domain (i.e. laying cables and sewers), where the process is similarly not explicit, multiple stakeholders influence the process and coordination is becoming increasingly important. Also, further research is planned to study behavioural changes after a second or further learning cycle. The learning styles defined by Kolb (1984) for various types of people could be useful in studying these learning cycles. Knowing and understanding the different learning styles could shorten the learning curve. It has also been observed that certain asphalting teams perform better than others under certain circumstances. Further research is planned to understand why certain teams perform better than others. A possible lens through which to investigate this is the perspective of ‘High-Reliability Crews’ (Mitropoulos 2009). Identifying the rules and work practices of high performing asphalt crews could help to achieve higher levels of production, quality and safety across the sector. This would be a valuable step in the quest towards improved process and quality control.

REFERENCES

Boud, D and Walker, D (1998) Promoting reflection in professional courses: The challenge of context. "Studies in higher education" 23(2): 191-206.

Brock, K L, and Cameron, B J. (1999). Enlivening political science courses with Kolb’s learning preference model. "Political science and politics" 32: 251-256.

Daft, R L (2000) "Management". Harcourt College publisher.

Harrison, M et al. (2003) Reflecting on reflective learning: the case of geography, earth and environmental sciences. "Journal of Geography in higher education" 27(2): 133-152.

Kolb, D A (1984) "Experiential learning: Experience as the source of learning and development". Englewood Cliffs, New Jersey, Prentice-Hall.

Miller, S R, ter Huerne, H L, Dorée, A G (2008) Towards understanding asphalt compaction: A Dutch case study in innovation and process control. In: Dainty, A (Ed.), "24th annual ARCOM conference", Cardiff, UK. Association of researchers in construction management, p. 381-390.

Miller, S R (2010). "Hot Mix Asphalt Compaction - Towards a more professional approach" PhD thesis, Department of Construction Management & Engineering, University of Twente.

Mitropoulos, P and Cupido, G (2009). Safety as an emergent property: Investigation into the work practices of high-reliability framing crews. "Journal of Construction Engineering and Management", Vol. 135, No. 5, May 1, 2009.

Orange, G et al. (2003). "The facilitation of organisation learning and knowledge management to foster partnering within the UK construction industry". Leeds Metropolitan University.

Schon, D (1983) "The reflective practitioner" New York, Basic Books.

SITE MANAGERS' USES OF BUILDING INFORMATION MODELING ON CONSTRUCTION SITES

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During the past decade the development of building information modeling (BIM) has seen as a possible catalyst for fostering the development of construction industry and as a solution for the some of the challenges in the industry. (Eastman *et* al. 2011; Li et al, 2009). Uses of BIM have lately expanded from design activities to construction site management activities. Still BIM is a new tool for site personnel and there are still few studies of real-life uses of BIM on sites (Davies et al 2013). In this paper, we present an analysis of BIM use on two different renovation sites in Finland. The method of our study is shadowing. Based on our data we have reconstructed the working days of the site managers minute-by-minute. In our analysis, we zoom into their work and into how they use BIM as part of their work. We focus on the following questions 1) what are the daily tasks of a site manager or a site engineer 2) how, for what tasks or purposes, or with whom they use BIM. We also study the communication practices of the site personnel.

Keywords: activity theory, construction site, site management, building information modeling (BIM), shadowing.

INTRODUCTION

Proponents of the new modeling technology promise that the adoption of BIM increases performance, accuracy and quality in a design and construction process (Eastman et al. 2011; Hardin 2009). It is also expected to increase collaboration and communication between the project stakeholders. BIM technologies enable construction project partners to 3D visualize the designs, to integrate the designs of different design disciplines and automate some functions, such as clash detection, simulations or quantity calculations (Li et al 2009, p. 365).

However, implementing BIM as a new tool to the construction projects is challenging and happens step-by-step. Due to the traditional work and collaboration practices, using BIM may remain within the professional communities (Neff et al 2010). It may also result to only reactive communication between different professionals. Dossick et al (2011) have argued that BIM does not replace verbal communication in the cases when tacit knowledge is needed to solve a problem.

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Mäki T and Kerosuo H (2013) Site managers' uses of building information modeling on construction sites *In*: Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 611-621.

BIM software and technologies, primarily developed as tools for designers, have only lately been extended to other processes of construction projects, such as construction management, bidding or client services. As BIM tools tend to be well-known and widely used among design disciplines, they are still quite new for site managers. There are still only a few studies focusing on BIM uses on real-life sites (Davies et al 2013).

In this paper, we study the daily work and the uses of BIM on construction sites. We focus on the actual uses and the communication practices of site managers. To conclude our paper, we discuss our analysis in light of Styhre's (Styhre et al 2006) organizational learning concepts of 'writing' and 'non-writing communities of practice' and Dossick's description of messy talk (Dossick et al 2011).

The implications of the paper are intended to contribute to the knowledge of site management, the uses of BIM and the BIM-related communication practices between site managers, designers, and other project partners.

THE WORK OF A CONSTRUCTION SITE MANAGER

According to Styhre's (2006; 2011a; 2011b; 2012) analysis, construction site managers are omnipresent paternal 1ures having full control of both the foreseen and the unforeseen situation. Unexpected situations are accepted as part of a normal project work, and the managers do not think they could be avoided by anticipating. They see work as skillful, improvisational problem-solving ('muddling through') where the unforeseen events require immediate attention and quick decision-making. While the work practices may vary, the site managers share a common goal to keep the production going, no matter what the circumstances are. They are committed to their work and spend long hours on site, and occasionally do more overwork at home.

Site managers consider documentation, designs and plans to be important yet an imperfect source of information for solving problems and carrying out the work. Instead, personal work experience is highly valued. Long work experience helps them act proactively. When they need help, they rely on their contacts, i.e. experienced colleagues, even colleagues in a different company, for advice.

Site managers have a position between the top management and the workers, but they feel having only a little support from their organizations. Sometimes their work is considered highly stressful, especially because the schedules of projects, quality standards and cost pressures get more and more demanding. They are generally satisfied with their jobs and feel professional pride, when they "see something grow out there, a physical effect" and they feel like being in the center of the activity. They are in charge and no day is like another. (Styhre et al 2006; 2011a; 2011b; 2012)

Styhre and his colleagues (2006) divide the communities of practice into writing and non-writing communities, from which the designers represent the former and the builders the latter. According to them "the designers on the design phase are a community of practice relying on writing, whereas the community of practice of the construction phase is dependent on talking". In the non-writing communities communication and learning are based on speech, telling war stories and sharing experiences. It is not documented and kept visible for outsiders like communication in the writing communities. Problem-solving and decision-making in the project is interpersonal and verbal. Transferring of learning from a project to another relies on the individuals' memory, experience and story telling. (Styhre 2006)

In their article on communication and collaboration with the help of BIM, Dossick et al (2011, p. 87) emphasize the importance of 'messy talk' in their article about communication and collaboration with the help of BIM. According to them, "BIM excels at helping people to find problems, but does not support the dialogue needed to solve many problems encountered in complex design and construction."

According to our study, the construction site management and the collaboration between the managers and the designers include a lot of verbal face-to-face communication. There are also other forms of communication, in which verbal and written communication merge. The site managers spend a lot of time on the phone, which can be considered as verbal, while not face-to-face, communication. If the other person cannot be reached by a telephone, the site manager sends him an email message. So, the previous verbal message is forwarded in a written form.

Communication and collaboration between the site manager and designers emerge particularly when BIM-related errors are encountered. Solving the errors or creating new design solutions typically requires face-to-face meetings on site. BIM-related communication emerges also when a site manager and workers use the BIM-models to look for information from them. The retrieved information, written or symbolic, is found in the model and shown on the computer screen. While looking at the symbolic information, the site manager and workers discuss the model and the future execution of work. The information is not only received from the models, but it is also adapted and further developed in the face-to-face discussion.

CASES OF THE STUDY: TWO RENOVATION SCHOOL PROJECTS IN CENTRAL FINLAND

The cases of our study are two Finnish school renovation projects in which all the design disciplines utilized modeling. The main users of the models were managers on site both of whom had some years of experience as site managers and good IT skills. The models and the software in use were architectural models (by ArchiCAD) and combined models (by Solibri). Site manager 2 used only the combined model even though he also had ArchiCAD software on his computer.

The site managers were the only users of the models on the sites. Site manager 1 who also worked as chief manager disseminated knowledge on the model to other site managers and workers. Site manager 2 instead used the models purely for his own work. The models were utilized solely in the site offices. When needed, information was transferred to the site with the help of printouts of blueprints or other documents printed out of the models. No mobile devices, such as iPads or laptops, were in use in these projects.

METHODOLOGY OF THE STUDY

According to cultural historical activity theory (CHAT) the relationship between a subject and an object is mediated by cultural means (tools and signs), division of labor, and rules in an activity (Engeström 2001, Miettinen 2009). The adoption of building information modeling (BIM) to construction management involves implementation on the elements of the construction management activity.

The construction management activity can be analyzed as interconnected to other activities such as the activity of designers. The site management can be seen as a "down stream activity" for the design activities. The design activities produce design documents, models and other tools for site management activity.

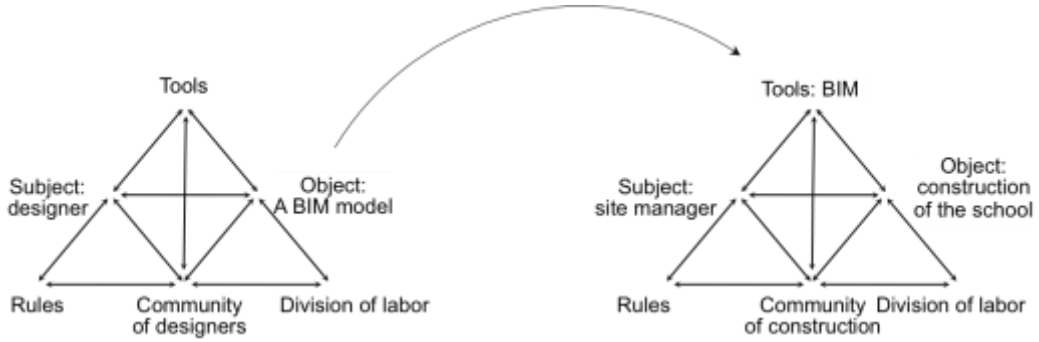

Figure 1. A Simplified picture of two interconnected activity systems: the activity system of design and the activity system of site management

DATA AND METHODS OF THE STUDY

The ethnographic method of our study is shadowing. Shadowing is a research technique which involves a researcher closely following a member of an organization over an extended period of time. When a person being shadowed goes to a construction site, the researcher follows him. When the site manager has a project meeting or meets with a partner, the researcher sits in. If he has coffee with his colleagues, the researcher goes along, too (McDonald 2005; Reder 1993, Czarniaswska, 2007). I, as the first author, followed both site managers step-by-step for three days and audio- and video-recorded what they were doing during their working days. I also made field notes on an observation template and took some photographs. If the purpose or meaning of their task or an act was unclear to me, I asked some additional questions, such as “with whom or concerning what were you talking on the phone?”

One three-day shadowing period generated 14-16 hours of audio- and video-recorded material, dozens of photographs and the field notes (204 rows of entries) depicting the everyday activities on the sites. The length of data collection period was agreed with the site personnel. It was their wish for the researcher not to extent the data collection period over three days.

Based on the shadowing data of site managers’ or site engineers’ work, I have reconstructed the working days of the site managers minute-by-minute. In our analysis, I zoom into their work and how they use BIM as part of their work. Shadowing the site personnel in natural work situations is needed to discover the actual uses and collaboration in every day working life. This follows the insight of the tradition of ethnography of design engineering; interviews and surveys are insufficient to uncover problems or challenges or the emerging innovative uses of tools (Buchiarelli 1988, Henderson 1999, Miettinen et al 2012).

ANALYSIS OF THE DATA

After each data collection day I entered my hand-written field notes into an Excel-document. Later, after each field period, I watched and listened to all the recorded data and complemented the Excel-document by the data, mostly concerning the site manager's task description; the starting and finishing times of the tasks; discussions carried on in relation to the tasks; relevant activities, circumstances, participants of events, utilised tools and the location of the work.

I first categorized the site managers’ tasks into six main types of tasks. I coded the different types of tasks, locations and the BIM tools used in the Excel-document using

different colors. Then I selected the events where the BIM software were used for further analysis. I analyze those events from the point of view of participation of different project partners and from the point of view of communication, whether it was verbal, written or other type of communication.

THE DAILY WORK OF SITE MANAGERS

The daily tasks of the site managers are presented in Table 1. Site manager 1 spent most of his working time, in work planning and briefing (42 %). This task included both the planning of the forthcoming construction work and briefing or re-planning the on-going work on site. Every morning and every afternoon Site manager 1 had so-called 'site rounds', during which he visited every work group and task in-progress on site and discussed the on-going work with workers and foremen. When needed, he commented on possible needs for making changes and planned together with the sub-contractors' workers and the other managers how or where to continue the work. In addition to the site rounds, he visited the site several times a day to solve different problems or to plan for forthcoming tasks. Most of 'work planning and briefing' took place in face-to-face discussions. At times the drawings at the walls on site were used to facilitate the discussion. For example, while planning the partition wall installation, the site manager and the carpenter had printed layout drawings, where the locations of the walls were visible. They discussed and measured the locations of the walls in the existing building, and marked down the corrected locations on the drawing. Work planning and briefing also took place in the construction site office by the computer. In such cases the discussion referred to the model, construction schedule or other documents visible on the computer screen.

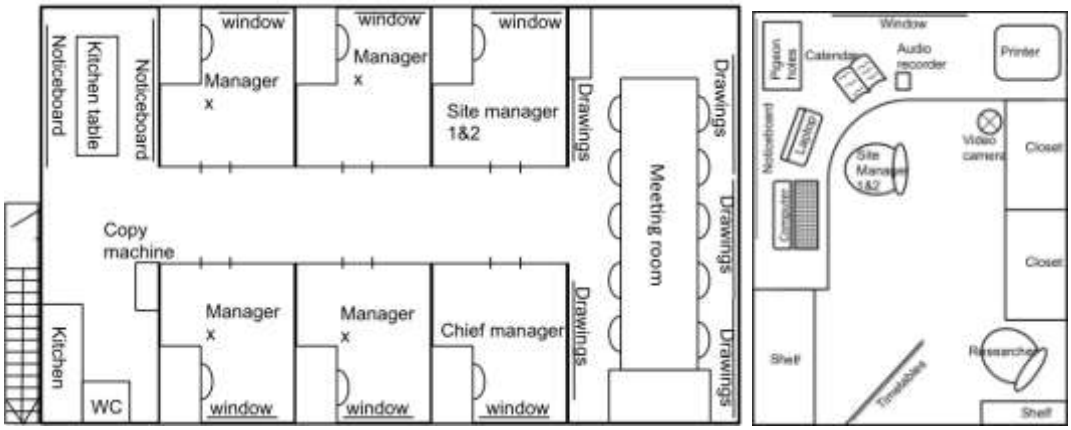

Figure 2. Layout of the site office and the site manager's room.

Site manager 2, instead, spent most of his preparing calls for bids and procurement (88 %). This included e.g. defining the initial data, like quantities of the work, writing calls for bids and sending them to the subcontractors. Preparing for bids and procurement was mostly conducted by himself alone and the needed information was gathered from the models, other project documentation or from the company's documentation system. However, after sending the calls for bids via email to the subcontractors, he called each of them by phone. He ensured that the subcontractor had received the email message and they discussed the details of the work, such as content and timetable. He negotiated on the phone with all the subcontractors to find out if the subcontractors were going to give their bids and to ensure that they were aware of the strict work timetable.

Another type of tasks emerged, when the site managers solved problems for the others or answered questions put forward by the other foremen. As a chief foreman Site manager 1 was higher in the site hierarchy than the other foremen. Given his position, he had the most accurate perception of the overall situation on the site on the whole so he was consulted in decision-making or problem-solving situations. The site manager's IT skills also invited people to ask him for more detailed information on the models when needed. Site manager 2 had only a few occasions in which he was needed to answer the questions of the other workers. ‘Solving problems for others’ usually started with a face-to-face discussion. Typically somebody walked up to the door of the construction site office (or gave a target person a call) and asked for a solution to a problem. The site managers answered the question orally and possibly searched for additional information from the model, in which case the discussion was continued alongside the model. If a problem needed to be solved by a person outside the construction site, the site manager made a call and the discussion continued via telephone. If the person could not be contacted even by phone, the discussion was conducted via e-mail and also the response was typically obtained via e-mail. When needed the site manager sent an attachment from the model or some other document and received as response an email message, an updated picture or a document. This was how verbal and written communication merged.

Both site managers did also some ‘paper work’, which they did on their own, working on a computer, in the office. Paper work included taking care of the project's invoicing and making entries to the site diary and keeping other documents updated. Then the principal type of communication was writing. Typically, the site managers worked alone on their computers, but occasionally they discussed face-to face an issue related to the task with their colleagues.

Site manager 1 spent some time looking for the information missing in the model and distributing the information to the other parties involved. This type of task was not the situation of someone asking him for information or presenting a problem. Instead, anticipating certain situations or promoting collaboration between the different parties, he looked for and distributed information from one person to another. In such a situation, he could say: “the designer actually has this model himself, but things get ahead quicker if I send him this image myself". ‘Looking for initial data and design details’ combined verbal and written communication similarly to problem-solving. When additional information was required from designers, the e-mail messages and the attachments were sent to support the discussion.

Both site managers also spent some time in attending or preparing the pre-scheduled meetings. The data include two scheduling meetings with contractors and one meeting related to briefing the safety issues on site. The meetings were based on verbal communication to a great extent. The meetings could possibly have an agenda, but the agenda did not function as mediator of information from a person to another, but as a memory back-up for the addressed topics. In the briefing meeting for example, the site manager reviewed orally all the topics written down on the paper document, but did not hand out the paper to the workers.

Table 1: Different types of daily tasks of the site managers

Type of task	Example	With whom	Percentage of time	
			Site manager 1	Site manager 2
Work planning and briefing	Planning a door installation at site	Subcontractors, other site managers, workers	42 %	_
Preparing for bids and procurement	Writing a call for bids of window blind installing	By himself, other site managers, sub-contractors	_	88 %
Solving prob-lems for others	Answering ad-hoc questions	Site managers	19 %	9 %
Paper work’	Invoicing, making notes to a site diary	By himself	18 %	6 %
Looking for initial data for design	Calling a curtain supplier to find out the suspension requirements	Designers, material suppliers	11 %	_
Scheduled meetings	Briefing safety meeting, contractor’s meetings	Workers, contractors,	10 %	9 %

USES OF BIM ON SITE

In this part of analysis, I, as the first author, focus on in what situations, and with whom the site managers used the BIM sofware and what kind of communication emerged during using the models and encountering errors in them. In these construction projects, each design discipline produced their native models. In addition, a so-called combined model was drawn up to combine the separate native models. The models could be viewed on a computer screen using a suitable software program, in this project ArchiCAD and Solibri respectively. Documents, images or other plans of the building were printed out from the models on paper. In our analysis, I focus on how the site managers used the digital BIM models (Solibri or ArchiCAD models). For the closer analysis I have selected all the events in which the modeling software were in use.

Table 2 depicts the BIM software use events, and with whom and how long time the site managers used the BIM software during a three-day shadowing. When the site managers used BIM software, they were either ‘looking for existing information for his own work’, ‘looking for or sending existing information to the designers or other site managers’, ‘encountering an error or a missing information in a model and asking for a new design solution’, or ‘work planning and briefing and updating a model’.

In addition to the uses mentioned above, Site manager 2 had a habit of "wandering in the model" while he was, for example, speaking on the phone. However, the issue discussed on the phone and the contents of the model were not connected.

Table 2: BIM uses of the site managers

BIM uses	With whom	Time used	
		Site manager 1	Site manager 2
Looking for information for his own work (e.g. calls for bids)	By himself	42 min	1 h 32 min
Looking for/sending information to designers, other site managers	A structural designer, curtain supplier, other managers, carpenter, door carpenter	39 min	_
Encountering an error in a model, asking for a new design solution	An architect, a structural designer, HVAC-designer, maintenance manager, plumber	34 min	_
Briefing construction work	Other managers, workers	24 min	_
Updating a model	By himself	5 min	_
Browsing a model while e.g. making a phone call	-	24 min	_

The uses of ‘looking for information for his own work’ and ‘updating the model’ did not include verbal communication. In these cases the site manager worked alone on his computer. The needed information either was available and no communication with the others was needed.

As shown in Table 2, Site manager 2 used models solely to get the information for his own work. He worked by himself, but sometimes he asked the chief manager a question. The chief manager was not that eager to use the model, so he might take a glance at the computer screen and say “okey, you look at the model, but…” and then he walked to the meeting room to look at the traditional drawings on the wall. So, the site manager followed the chief manager, and they continued their discussion by the paper drawings on the wall. The chief manager did not seem to find the model a convenient or sufficient source of information for himself.

‘Looking for and sending information from BIM to the others’ -type of uses indicated the importance of the site manager 2’s role as a BIM user on site. He was the only person who knew how to use models on site, hence it was his responsibility to distribute the needed information to the others. Usually these situations started with a verbal face-to-face discussion, for instance someone came to the site manager’s office or called to ask for information in the model. The site manager retrieved the needed information from the model and they continued the discussion alongside the model or on the phone. Here the symbolic documents, models, were used to support verbal communication. Sometimes Site manager 1 solely relied on written or symbolic communication, and, for instance, he sent an excerpt from the model as attachment for a designer.

Missing information and discrepancies in the models generated extra work, so-called ‘encountering an error in a model, asking for a new design solution’ on site. The missing information cases were mostly solved by calling the designers. In some cases, if the designer could not be reached by phone, the site manager sent him an email message, and also got the answer by email. In some cases, the site manager simply notified that “hey, there is something missing or something wrong with the model” but he did not do anything to solve out the problem.

BIM models were rather scarcely utilized in 'planning and briefing construction work'. This was partly due to the BIM models being only available in the site office. While Site manager 2 did most of the work planning and briefing on site, the BIM models were not available for this task. When the planning and briefing took place in the construction site office by the models, it commenced as face-to-face discussion and continued as a discussion alongside the model.

Errors and discrepancies as triggers for collaboration

During both shadowing periods, there were several cases of errors, discrepancies, or some problematic design solutions in the models. The errors, the discrepancies and a problematic design solution were encountered when the site managers were looking at the models as part of their daily work. Those were the occasions when the most vivid communication between the site managers, designers and other stakeholders emerged.

The errors, discrepancies and problematic design solutions were mostly solved in face-to-face discussions or in face-to-face meetings on site, not by the models. The most intensive problem-solving cases took three days to be solved, and involved several managers, designers, workers, maintenance staff and other experts to solve the design problem.

DISCUSSIONS AND CONCLUDING OBSERVATIONS

Shadowing enabled me as a researcher to zoom in to the every-day activities on site and collect rich research data. It made visible the uses of new technologies on site. It also showed the diversity between the different users. To get an access to the field to shadow the daily work practices on site required months of negotiation with the stakeholders in the company, the construction projects and the construction sites. At the same time, I collected other data from the site meetings and visited the construction site on several occasions. The data collection and negotiation process was lengthy, but I believe it helped with how the site staff related to myself and how relaxed they were in having me shadowing their everyday work life on the sites.

BIM was actively used on the sites. During the three days of shadowing, Site manager 1 did not use traditional drawings in the site office once. He got all the design information from the models. The use of models still faces many challenges related to information content and accuracy of designs, lack of mobile computers or lack of people who know how to use the models. To achieve the desired accuracy level of the models, there is a great demand for better collaboration between construction site personnel and designers to ensure the quality of the models. On the other hand, the collaboration between the designers and Site manager 1 was very active, even though reactive, including several e-mail messages, phone calls or face-to-face meetings every day. The collaboration emerged when a BIM-related problem was encountered. The other site personnel represented more reserved attitude towards the collaboration with the designers and the occasions of collaboration were fewer. On that site, BIM was used, as Dossick et al (2011) argue, within only the site manager's own work, not in a collaboration with designers.

Our research supports Styhre's arguments (2006) of site managers' work as skillful, improvisational problem-solving ('muddling through') where the unforeseen events require immediate attention and quick decision-making. Also the argument of a site management activities relying heavily on face-to-face communication seems accurate. However, Styhre's dichotomy between non-writing and writing seems overly simplified. Based on our research it seems that the forms of communication are more

complex and interwined: face-to-face communication proceeds as telephone-mediated and further to e-mail mediated communication. Symbolic or written documents are used to support verbal communication, but the communication is rarely based solemnly on the written documents. So, the written or symbolic documents mediate the face-to-face communication.

Dossick & Neff (2010) describe the communication relationships on construction site hierarchical, such that the main contractor communicates predominantly with the owner, who forwards the information to the designers. This is also the official hierarchy in Finnish construction projects. Our study shows, however, that in some cases, the collaboration and communication between the project manager and the designers can be very active and direct, especially communication related to information in the models.

Based on this study, it can be concluded that BIM models are utilized on site and the models advance the site management. Although, the use of BIM is challenged by the lack of mobile tools and skillful BIM users, insufficient and inaccurate information content of the models and the coexistence of the new and the old tools and related practices. Of these challenges, the most problematic are those regarding the content and accuracy of the models. In light of the current study we see two possible trends. Either the content and the accuracy of the models is developed in the design phase in collaboration with the designers and other stakeholders, such as builders, and the design data is transferred from the design phase to the construction phase as technology- or BIM mediated. Or some of the design details are acknowledged as such, that they are solved in the construction phase, still in collaboration with the designers and other stakeholders, such as builders, but in a premeditated manner, not reactively as is the case at the moment. In both cases the messy talk or face-to-face discussion considering design solutions between the stakeholders is needed.

Because BIM is still relatively new technology on construction sites, the research focusing on how the models are used and what kind of communication or collaboration has emerged are relatively sparse. Further research on BIM deployment, using BIM as a new tool and the changes in collaboration within the project partners is needed.

REFERENCES

Czarniaswska, B. (2007) *Shadowing and Other Techniques for Doing Fieldwork in Modern Societies.* Malmö/Copenhagen: Liber/CBS Press.

Davies, R., Harty, C. (2013) Implementing 'Site BIM': A case study of ICT innovation on a large hospital project. *Automation in Construction* 30 (2013) 15–24

Dossick, C. S. & Neff, G (2010) Organizational Divisions in BIM-Enabled Commercial Construction. *Journal of Construction Engineering and Management ASCE* (April 2010) 459–467.

Dossick, C. S. & Neff, G (2011) Messy talk and clean technology: communication, problem-solving and collaboration using Building Information Modelling. *Engineering Project Organization Journal 1:2, 83-93.*

Eastman, C. Teicholz, P. Sacks, R. & Liston, K. (2011). *BIM Handbook. A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors*. New Jersey: John Wiley and Sons, Inc.

Engeström, Y. (2001). Expansive learning at work: toward an activity theoretical reconceptualization. *Journal of Education and Work*, 14(1), 133-156.

Hardin, B. (2009). *BIM and construction management. Proven tools, methods, and workflows.* Indianapolis, Indiana, US: Wile Publishing, Inc.

Henderson, C. 1999. *On line and on paper: visual representations, visual culture, and computer graphics in design engineering*. Cambridge, MA: The MIT Press.

Li, H., Lu, W., Huang, T. (2009). Rethinking project management and exploring virtual design and construction as a potential solution. *Construction Management and Economics* Vol 27: 363-371.

McDonald (2005). Studying actions in context: a qualitative shadowing method for organizational research. *Qualitative Research 2005*, Vol 5. pp 455-473.

Miettinen, R. (2009). *Dialogue and creativity. Activity theory in the study of science, technology and innovations.* Berlin: Lehmanns Media.

Neff, G., Fiore-Silfvast, B., and Dossick, C.S. (2010). A Case Study of the Failure of Digital Communication to Cross Knowledge Boundaries in Virtual Construction. *Information, Communication & Society 13(4), 556-73*

Reder, S. (1993). Watching Flowers to Grow: Polycontextuality and Heterochronicity at Work. *The Quarterly Newsletter of the Laboratory of Comparative Human Congnition*. Vol 15 (4): 116-125.

Styhre, A. (2011a). In the circuit of credibility: construction workers and the norms of 'a good job'. *Construction Management and Economics* Vol 29: 199-209.

Styhre, A. (2011b). The overworked site manager: gendered ideologies in the construction industy. *Construction Management and Economics* Vol 29: 943-955.

Styhre, A. (2012). Leadership as muddling through: Site managers in the construction industry. Tengblad, S. (Eds.) *In the Work of Managers. Towards of Practice Theory of Management.* 131-145. Oxford and New York: Oxford University Press.

Styhre, A., Josephson, P.-E. and Knauseder, I. (2006). Organization Learning in Non-Writing Communities. The Case of Construction Workers. *Management Learning* Vol 37(1): 83-100

ORGANISATION STRATEGY AND BUSINESS PERFORMANCE

STRATEGY FRAMEWORK FOR POST-CONSTRUCTION CONTRACTOR SERVICES

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In view of UK government strategies concerning the construction industry, there is a need for contractors to reconsider their options regarding the kind of services they may need to offer. Both Building Information Modelling and Government Soft Landings policies imply a shift of emphasis towards contractors providing post construction phase services. By combining a number of approaches to innovation in services, a new theoretical framework, the Pavitt Gallouj Barras model, is devised to assess the capability, capacity and stage of development of any firm as part of its self assessment of its ability to innovate new construction services. The framework is shown to depend on the characteristics of the construction firm or its output and where the firm or its output can be found in terms of its innovation path, its production intensity and its phase of innovation. This a priori research discusses construction performance-based contracting (PBC), and total property outsourcing (TPO) in the light of this theoretical framework. The limitations of PBC and TPO are reviewed and found to be critical in terms of the ownership, control and management of buildings as real estate assets. Both PBC and TPO offer contractors opportunities and incentives to build to higher and more sustainable standards in the long run. By modifying contractors' perceptions of post construction service agreements and contracts, contractors could add value to their output with incentives to build to higher and more sustainable standards. This could herald a shift in contracting culture. However, the conclusion drawn is that although highly innovative, PBC and TPO will only be options for some construction firms, as the additional risks and inflexibility for both contractor and client may be greater than the benefits offered.

Keywords: contractor marketing strategy, performance-based contracting, post-construction management, strategic management.

INTRODUCTION

Ever since Turin (1980), Bon (1989), Ofori (1990) and others, there has been discussion on whether or not contractors provide a product or a service. It can be argued that they provide a product, because developers commission contractors to produce a tangible building by transforming material inputs into a finished physical output. On completion the building is handed over and the contractor's role ends. Alternatively, Ofori (1990) argues that because contractors only assemble the products produced by others, construction is a service. Contractors only provide building services, organising the labour processes, hiring plant and equipment, and managing specialist contractors, subcontractors, materials and components on behalf of their clients. Because contractors bear no commercial risk, only construction risk, they

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Gruneberg S(2013) Strategy framework for post-construction contractor services *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 625-633.

provide a service rather than a product up to the moment of completion and hand-over to the developer.

There is, however, no reason why the role of contractors should not be extended the service they provide beyond the hand-over process. Drawing a lesson from manufacturing, where profit margins have been declining, firms have attempted to differentiate their products through additional after sales service provision. This trend has been identified by Salonen, (2011). A similar trend may be emerging at the interface between construction and property management. Profit margins in construction tend to be low due to low barriers to entry, the use of lowest price tendering and the undifferentiated service, contractors are assumed to provide. This can be seen as driving contractors to innovate in construction services.

As part of developing new business models, contractors need to find new ways of adding value to what they already do. This implies that it is no longer always sufficient to provide a finished building at the end of the construction phase. Instead, one option is for contractors to develop new expanded roles for themselves, involving innovative services after building completion. There is therefore a need to establish a protocol that might be used to identify the types of service that firms could develop to diversify and differentiate their offer to clients, improve their services and add value to their existing output. A potentially useful approach to providing new services by contractors is proposed below, though this protocol also implies that there is no one solution that will be appropriate in all cases.

A shift towards providing a service in the form of long term responsibility for completed buildings and structures is equivalent to service innovation by contractors. As discussion of Building Information Modelling, or more accurately, Management (BIM) becomes ever more prevalent, it is anticipated that BIM 5D, which extends the BIM model to include cost management and BIM 6D, which provides detailed building information for use in the post handover phase, will facilitate maintenance throughout the lifetime of a built structure (Rowsett, 2012). In this theoretical examination of the implications of changes encouraged by government through its promotion of BIM, its Soft Landings policy, (BIM Task Group, 2013), and integrated working, a shift of emphasis towards service provision is considered. Although there are many possible options for developing service provision, only two examples are given below. For example, an integrated approach towards the provision of a built structure could take the form of Performance-based Contracting (PBC), which uses a method of specifying a building, according to its function and how it meets the requirements of users over its life, (RICS 2011).

Although very different in nature from construction, similar developments are taking place in other sectors of the economy. For example, Product Service Systems (PSS) are being adopted to focus supply on the requirements and needs of customers and the environment with a view to improving the service provided (Mont, 2002). This after-sales service can include maintenance, repair and replacement of products and is offered in industries ranging from automobiles to lighting and facilities management. Indeed, in construction this kind of approach was adopted in the balanced scorecard of Purchase and Supplier Engineering (PSE) adopted on the Olympics 2012 programme (Mead and Gruneberg, 2013). The balanced scorecard is used to define objectives not only based on the physical structures produced but also extending the aim of a project to meet the client's priorities and needs, whatever they may be.

The outsourcing of component inputs is common practice in manufacturing. Outsourcing of services has also been adopted for many functions inside manufacturing firms themselves, such as catering, security and cleaning, previously carried out by directly employed staff within organisations. It is therefore not surprising to find that outsourcing by firms extends to facilities management and other building services in the US (Kimbler and Rutherford, 1993) and in Europe and North America (Bon and Luck, 1999).

The concept of PBC is that the contractor assumes responsibility for the provision of building services, whilst retaining ownership of the structure throughout the construction phase and beyond. It is the retention of ownership by the contractor that distinguishes PBC from conventional facilities management. In this way contractors offer a complete service to their clients based on the satisfactory performance of the building in use. PBC may offer those providing BIM 6D the framework for conducting a complete service provision, with BIM 6D being the IT means or tool to create a building's technical data base needed to achieve the objectives of a project. This approach would integrate the design, construction and use of a building in a coherent contractual arrangement. Such innovations in construction services by contractors can therefore be seen in the context of different approaches to innovation in services in manufacturing that have been occurring simultaneously with the changes taking place in the construction sector. At this stage this research is purely a priori and no attempt is made here to test the approach empirically. The next phase of research will involve field studies.

The next section develops a model service innovation framework, which combines a number of approaches taken from service innovation literature. Two examples of post construction service are discussed to highlight the inherent difficulties of offering post construction services even before construction has begun. The following section discusses a possible context for implementing BIM 6D using either PBC or TPO (Total Property Outsourcing). We conclude by considering the implications for construction contractors.

The Gallouj, Pavitt, Barras model

Manufacturers enhance their products either in terms of services that support the product, such as repair and maintenance, or those that support the actions of clients, for example, by providing the financing to purchase the product, (Mathieu, 2001). For those firms wishing to introduce innovative services, Gallouj (2002 p1) reports three possible innovation paths or approaches that depend on the characteristics of the economic activity of the firm. The first approach relies on the technological character of the firm. The second focuses on the organisational aspects of the service. The third approach combines both the technology of the supplying firm's product and the nature of the service it provides and seeks to integrate them. Hence, service innovation emerges out of the technology, the service or a combination of both. In construction the technological nature of the firm might lead some into consultancy services, while other firms may have design facilities they could provide as well as providing the components themselves. Other firms may combine the two and design the components they go on to install on site.

Which of these three approaches is adopted also depends on the size of output, the degree of specialisation, the level of technology used and the dependence on bought-in components from suppliers. According to Pavitt (1984) these factors lead to four corresponding types of production intensity. Firstly, scale-intensive firms are those

engaged in mass production. Second are specialised suppliers, whose activities rely on the skills of their workforce, such as mechanical engineering. The third type of firm is science or technology based, such as firms in electronics and green technology. The fourth category is comprised of supplier dominated firms, found in traditional manufacturing and predominant in construction, where the vast majority of small and medium sized enterprises rely on builders' merchants and other material suppliers.

Production intensity	Innovation paths		
	Technology	Service oriented	Integrative
Scale intensive			
Specialist suppliers			
Science based			
Supplier dominated			

Figure 1: The context of service innovation

Figure 1 is a matrix, combining the approaches of both Gallouj and Pavitt with innovation paths in columns and production intensity in rows. For example, in the technology based innovation path relatively small firms may be dependent on their suppliers and hence supplier dominated. New technology is often outsourced, where the scale of production would not justify investment in new technology. At a slightly larger scale some technological innovation may become viable to undertake in-house. However, even the largest firms often require specialist suppliers to develop particular aspects of their technology. Alternatively, they are able to take advantage of economies of scale that justify investment in their own new technology.

Pavitt's description of production intensity is developed by Soete and Miozzo (1990), who add a number of types of service firms, namely those dominated by their suppliers of technical systems, (for example, electrical engineering firms), those that rely on networks of transport (such as labour suppliers) or information (architect practices), and those specialist firms that are science-based and innovative (tunnelling engineers).

Innovation of services by firms may be seen as an incremental process, dependent on the stage of a firm's development. As a firm evolves, it needs to innovate as part of its problem solving activity, providing new services to meet new or changing circumstances over time. Hence, Barras (1986) introduces time and takes into account the growth and development of firms. He suggests a theory of innovation, which passes through three phases. The first phase of innovation concerns improving efficiency, after which the firm moves on to focus on improving the quality of the service delivered and in the third phase it introduces new services. Although Barras (1990) applies these phases to the banking sector, similar changes can be seen in construction, though not necessarily uniformly. The combination of the work of Gallouj, Pavitt and Barras produces a three dimensional theoretical framework of innovation, as illustrated in Figure 2.

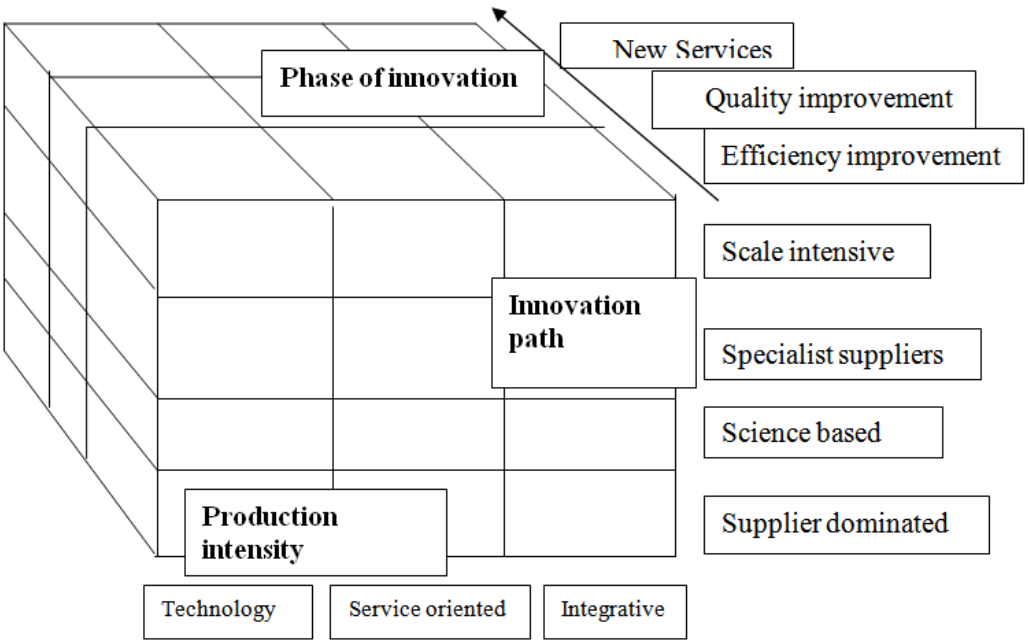

Figure 2: The Gallouj Pavitt Barras model

The three dimensions or vectors in Figure 2 are production intensity, the innovation path and the phase of innovation. This forms a theoretical framework for positioning firms in their service innovation decision making process. Firms can be located in any one of 36 three dimensional blocks in the "Rubik cube" of the diagram by taking each of these vectors into account. However, these three vectors do not take account of some wider market conditions, and further consideration needs to be given to competitors' behaviour and other external factors that may collectively be called a firm's business environment. The business environment is included in a model devised by Belleflamme, Houard and Michaux (1986). In their model each economic activity of a firm, V, depends on three elements. The first is production, P, the second is servuction, S, (a term used to distinguish service production from product production) and the third, I, is the organisation of the firm in its business environment. Hence:

$$V = bP + cS + I$$

The coefficients b and c represent the relative importance of production and servuction in the activity. If b>c then the activity is concentrated on providing a product. If c>b then the activity is largely concerned with providing a service. According to Bellflamme et al., this formulation can be used to identify a new good, an improved process of production or an improved process of servuction or a combination of all three.

Performance-based contracting

In construction, PBC is the introduction of a new service, possibly made viable by the introduction of new technologies such as the digital revolution. The introduction of PBC is consistent with Barras' third phase of innovation as it offers clients an altogether new service. This is reinforced by Gallouj (ibid.), who points out that innovation in services is not the technological change itself but rather the changes in service, which the technology permits as firms learn, adapt and adopt the new possibilities made available.

Applying the approach described by Belleflamme et al. to the concept of PBC, both production and servuction elements are present. The performance of the building may be measured using performance indicators, defined in terms of user requirements. For example, a building may be required to provide adequate ventilation, light and sound insulation, warmth and security and a healthy environment, all with direct measures, such as heat loss or proxy measures, such as user complaints. A service innovation may involve the addition of a new characteristic, such as wireless internet facilities, aesthetics, food and drink provision at certain times of day. Other specifications might include improved traffic flow within a building or improved rest areas and wash room facilities compared to existing facilities. Moreover, the client might wish to convey a successful and welcoming environment for its customers and suitable meeting rooms, in which to transact its business. This could also apply to public sector clients.

A building providing the physical services of PBC may be perceived of as a quasi-good by clients or building users. Gallouj (2002: p 45) defines quasi-goods as devices or capacities placed at the users' disposal. They have two qualities they share with public goods: they are non-excludable in that they are freely available and non-rival insofar as the building facilities remain unchanged although tenants, workers or members of the public make use of them. Examples of quasi-goods include automatic cash dispensers, train ticket machines and information points. Hence, as a result of PBC, a building or a structure, such as a bridge, becomes in effect a quasi-good.

Total property outsourcing

Similar to PBC is total property outsourcing (TPO) but in TPO ownership resides with the developer not the contractor. Nevertheless, TPO extends the role of the building contractor and involves procuring an ongoing service provided by the contractor. The purpose of this is to incentivise the building contractor to consider the longer term issues of a completed building in use.

TPO may be an option, if particular building contractors do not have the financial structure to support the provision of a building as a whole. Alternatively, they may be able to take on smaller packages in TPO. For example, they may be able to provide an on-going service for particular building elements, effectively and efficiently outsourcing specific sub-systems of a building. Similarly, PBC at the sub-component level of construction involves specifying what components are required to do and the most efficient means of achieving the function. As a post-construction-phase service PBC provides suppliers, whether manufacturers, specialist contractors or main contractors, with the appropriate commercial focus to remain responsible for the performance of their components after installation is complete.

From the developers' point of view, if contractors continue to have responsibility for a building or structure after completion, both TPO and PBC may be seen as forms of outsourcing. In terms of property management this may have problematic implications for property owners. According to Gibson and Louargand (2001) outsourcing the property portfolio creates a separation of property asset management from the management and strategic planning of the firm or organisation. This means that the ability to exploit the property market by developers is impaired and the ability to co-ordinate property requirements with the tenant organisation's own plans is reduced. Total property outsourcing is concerned with facilities management, property asset management and property finance. The variety, knowledge and skills

for all of these functions to be adequately covered frequently also require further outsourcing.

Indeed, outsourcing may be used as one method of managing risk. Gibson and Louargand argue that "a key reason for outsourcing is to transfer risks to a third party that can manage the risks more effectively," (Gibson and Louargand, ibid. p50). It follows that there is a need to determine, which aspects of the workplace to outsource and what contractual arrangements to adopt.

DISCUSSION

From the point of view of contractors, PBC is concerned with more than just the delivery of a building or a structure. PBC also involves maintenance and even peripheral functions such as security, cleaning and the total management of built facilities to meet clients' requirements. The number of skills, technologies, management strategies and business models that are required call for the use of additional sub-outsourced combinations of firms to supply the full needs of clients and building users.

Although PBC transfers certain risks to the provider, the client remains exposed to some extent. For example, even a small delay, caused by the building provider, may cost the tenant client a disproportionately large sum in loss of business, due to disruption, which could not or would not be reimbursed by the provider. In addition the client no longer has direct control over the building or the services that the provider supplies. Moreover, changes in requirements would depend on the negotiating skills of managers but would be dependent on the supplier's willingness to comply. A further risk to the client is that the business failure of the supplier would not automatically lead to compensation, although the services would still be required by the building users. Moreover, as Lind and Borg (2010) point out, surprises and future problems cannot be fully anticipated in contracts without large contingencies built into them.

In the public sector the agent-principal paradigm applies to the management of property assets, as the cost of construction comes out of the capital account and the maintenance and service costs come out of a separate revenue account. This therefore divides the responsibility for construction and maintenance between different departments and teams within the same ministry.

Because of the durability of the product, public sector managers may expect not to be in the same post by the time problems arise in a building, due to their own career progression and promotion or changes in the administration or even changes in government policy. Therefore public sector decision makers at the initial stages of a long term project, such as a hospital, may deliberately ignore or disregard future costs, which they see as someone else's responsibility at some point in the distant future.

It is in this sense that game theory plays a part in understanding the motives and incentives for seeking service led contracts (SLCs) in the public sector that offload financial and technical risk onto the private sector. In spite of Lind and Borg (ibid.) suggesting that risk in general and financial risks in particular are the main reasons for SLCs, the motive can be more clearly seen in terms of offloading responsibility from individuals and departments onto others, a concept known as moral hazard. As the public sector is comprised of public servants, who are agents rather than principals by definition, an incentive to avoid personal responsibility is always present. This is

because any large costs or losses are ultimately paid for out of the public purse rather than an individual's own capital unless fraud or other irregularity is identified.

Because PBC and TPO carry inherent additional risks, such as those referred to in the previous paragraphs, it is unlikely that whole service provision of a building by contractors would ever become the norm as a widespread method of outsourcing by developers, even given the existence of a BIM 6D model. Nevertheless, PBC and TPO may well become options under appropriate circumstances.

The Gallouj, Pavitt, Barras model of innovation based on the innovation path, production intensity and the innovation phase of the firm may provide a useful framework for contractors, considering the appropriate provision of new services, tailored to their own capabilities, capacity and stage of development. In this way the firm's own relevant characteristics can be taken into the decision making process.

CONCLUDING REMARKS

A general theory of service innovation emerges from the work of Gallouj, Pavitt, Barras and Belleflamme. This fits in well with the changing role of building contractors that may be brought about by the changing use of technology such as IT in the light of BIM, where contractors may need to offer a post construction phase service rather than just a product. This may open the way for contractors to add value to their output and increase their profit margins. It gives them the opportunity to differentiate their outputs by providing distinct levels of service. As long as contractors concentrate their efforts on only competing on price to construct buildings and structures, clients can only resort to selecting the lowest bid on the assumption that there is no need to consider other value adding factors, if contractors only offer to build a final identical product, regardless of which contractor undertakes the work.

Service innovation offers contractors an opportunity to be innovative. Indeed firms would need to become imaginative and find new ways of satisfying their customers' needs. Adopting the theoretical framework reviewed in this paper and adapting the strengths and weaknesses of each firm to meet its own aspirations and commercial aims, PBC could be used with the innovation model suggested here to become an invaluable management tool in the development of new construction services and attitudes towards buildings and structures by suppliers, clients and users.

Using the Gallouj Pavitt Barras model, innovation in construction is likely to take many different forms. Adding post construction phase services is only possible given the financial resources needed to finance them. It makes little sense for small specialist firms to take on functions outside their expertise. It is precisely that expertise that generates their income. Only general contracting firms with adequate capacity would possibly be capable of undertaking PBC but this might well require them to be vertically integrated with a large number of specialist firms. In this way the extension of their services would be accompanied by a restructuring of the firm and the industry, an option only open to the largest contractors. For smaller specialist contractors with skilled labour their ability to provide a diverse service is limited. They may have to offer virtual supply chains.

Whether any of the government's initiatives regarding BIM, Soft Landings and integrated working are successfully implemented by contractors remains to be seen. However, one thing is certain; the use of digital technology is being rapidly adopted, as those of the digital age enter increasingly senior positions. The question is to what

extent the benefits of digital sharing and working can be translated into collaborative working in the competitive and fragmented environment of the construction industry?

REFERENCES

Barras, R (1986) Towards a Theory of Innovation in Services, "Research Policy", 15, 161-173.

Barras, R (1990) Interactive Innovation in Financial and Business Services: The Vanguard of the Service Revolution, "Research Policy", 19, 215-237.

Belleflamme, C, Houard, J and Michaux, B (1986) Innovation and Research and Development Process Analysis in Service Activities, Brussels, EC, "FAST Occasional Papers", 116.

BIM Task Group, (2013) "Government Soft Landings", London, Cabinet Office, http://www.bimtaskgroup.org/wp-content/uploads/2013/04/Government-Soft-Landings-Section-8-Planning-for-Aftercare.pdf

Bon, R (1989) "Building as an Economic Process: An Introduction to Building Economics", Englewood Cliffs, Prentice-Hall

Bon, R and Luck, R (1999) Outsourcing of property-related management functions in Europe and North America, 1993-1998, "Construction Management and Economics", 17(4), 409-312

Gallouj, F (2002) "Innovation in the Service Economy", Massachusetts, Edward Elgar Publishing

Gibson, Vand Louargand, M (2001) The Workplace Portfolio as Contractual Arrangements. In: Bell, M A and Joroff, M, (eds), "The Agile Workplace". Gartner and MIT

Kimbler, L and Rutherford, RC (1993) Corporate Real Estate Outsourcing: A Survey of the Issues, "Journal of Real Estate Research", 8(4), 525-540.

Lind, H and Borg, L (2010) Service-led construction: is it really the future? "Construction Management and Economics", 28(11), 1145-1153.

Mathieu, V (2001) Product services: From a service supporting the product to a service supporting the client. "Journal of Business and Industrial Marketing", 16(1), 39–58

Mead, J. and Gruneberg, S., (2013) "Programme Procurement in Construction: Learning from London 2012", Oxford, Wiley Blackwell

Mont, OK (2002) Clarifying the concept of product–service system, "Journal of Cleaner Production", 10(3), 237-245.

Ofori, G (1990) "The Construction Industry: Aspects of its Economics and Management", Singapore University Press

Pavitt, K (1984) Sectoral Patterns of Technical Change: Towards a Taxonomy and a Theory, "Research Policy", 13, 343-373

Rowsett, R, Harty, C, Whyte, J, Grant, S and Atkinson, L, (2012) Sustainable Design Benefits and ROI from the adoption of BIM processes and technologies within a Property and Real Estate Business, "Technologies for Sustainable Environments", Reading, University of Reading

Salonen, A, (2011) Service transition strategies of industrial manufacturers, "Industrial Marketing Management", 40(5), 683-690.

Soete, L and Miozzo, M (1990), "Trade and Development in Services: a Technological Perspective", mimeo, MERIT, Maastricht, The Netherlands

Turin, D (1980) What do we mean by building? "Habitat International", 5(3-4), 271-288

SERENDIPITOUS INNOVATION: ENABLERS AND BARRIERS IN THE CONSTRUCTION INDUSTRY

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Serendipity has played a large part in the lives of many successful innovators but has been neglected from traditional neo-classical theories and models of strategy and innovation. Yet as the business world becomes more complex, uncertain and interconnected, there is accumulating evidence that innovation will be just as likely to arise from unexpected serendipitous insights as from deterministically planned innovation strategies. Building on this evidence, the enablers and barriers to serendipity in construction industry are discussed. Through in-depth semi structured interviews with thirty two leading innovators and policy makers in the Australian construction industry, these enablers are tested against the realities of practice in the construction industry. New insights are provided into the potential barriers which could prevent managers harnessing the serendipitous opportunities which lie untapped in the increasing randomness, connectivity and uncertainty which will characterize their future world.

Keywords: innovation, serendipity, risk, strategy

INTRODUCTION

Serendipity means finding something when one is looking for something else and in the context of business involves benefiting from windfalls that were not anticipated in formal business plans (Merton and Elinor 2004, Horrigan 2011). Clegg et al's (2011:33) recent critique of business strategy argued that the role of serendipity "has been largely excluded from formal strategy theory". Clegg et al (2011) showed that there is element of serendipity in the fabric of all organizations and that the neo-classical model of corporate strategy cannot accommodate this reality. This supports Mendonca et al's (2008) and Bungay's (2010) research which demonstrated that in today's increasingly complex, dynamic and interconnected business world, business strategy cannot be perfectly planned in advance as traditional theories of strategy would suggest, but has to evolve in response to continually changing circumstances. Bungay (2010) calls this alternative and contemporary approach to business strategy 'directed opportunism' and argues that the challenge for executives is to build an organization which is capable of executing strategy in a fast changing environment by balancing both high 'alignment' *and* high 'autonomy'.

According to Hamel (2002), traditional innovation theory also has its roots in neo-classical economics and suffers the same limitations. Hamel argues that these theories have produced 'pipeline' models which conceived innovation as a highly deterministic, scientific and pre-planned process of the type undertaken in large manufacturing or laboratory-based scientific organisations. This, he argues doesn't

Loosemore M (2013) Serendipitous innovation: enablers and barriers in the construction industry *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 635-644.

reflect how innovation occurs in service-based industries like construction or in an increasingly networked, complex and dynamic business world where innovation is as likely to arise out of serendipity and happenstances than from any formal planning process. Tidd (2006) agrees and points out that rather than try to eliminate this uncertainty and pretend it is not there, we should develop theories which accept it as inevitable to inform management practices which can manage it more effectively.

Recently, a number of researchers in construction innovation have raised similar concerns by questioning the relevance of traditional theories which promote pipeline models of innovation. For example, NESTA (2007), Abbot et al (2007) and Sexton et al (2008) have argued that these traditional models favour the type of R&D-based innovation that occurs in high-technology, product-based manufacturing type industries and undervalue the type of 'hidden' innovation that tends to occur in low-technology, service-based and creative industries like construction. According to these researchers, hidden innovations are different in a number of important ways to the types of 'planned innovations' detected by traditional innovation statistics. In particular, they do not tend to occur within the confines of one single organization, as they do in many large multinational R&D-based organizations, but tend to happen spontaneously and often serendipitously in collaborative networks of manufacturers, consultants, suppliers, sub-contractors, designers and clients and often in response to unexpected and novel problems that arise on specific projects. Given this confluence of strategy and innovation theory around the need to better understand and recognise the serendipitous nature of the innovation process, the aim of this paper is to explore the enablers and barriers to serendipity in the construction process.

ENABLERS OF SERENDIPITY

As the above argument demonstrates, the dominance of neo-classical approaches to business strategy and innovation means that there is a dearth of empirical research into the enablers of serendipity in organisation. Nevertheless, there are some interesting research projects which have begun to throw some light on this subject. For example, Tjan et al's (2012) interviews with hundreds of successful innovators and entrepreneurs revealed that serendipity has played a large part in their lives. However, while these people may appear to be lucky from the outside, this is rarely the case and their success in harnessing serendipity appears to emerge from seven common attributes: humility; intellectual curiosity; optimism; vulnerability; authenticity; generosity and; openness. According to Tjan et al, these attributes make leaders more 'attractive' or 'magnetic' to others, giving them a greater chance of being exposed to new ideas and insights which might unexpectedly create a new business opportunity. Muir's (2000:8) research supports this idea and shows how entrepreneurs increase the chances of unexpected serendipitous encounters with other people who might have a complementary idea. According to Muir, innovators and entrepreneurs don't live in straight lines but in a "zig-zag". Random interactions, casual conversations and accidental encounters enrich their lives and success is seen as "social" and depending more on relationships than what they know.

Clegg et al (2011) argues that this is an idea which challenges the notions of individualism which have traditionally driven western business teaching, theory and practice. While good strategy in the past has been seen to arise from the rigid and controlled inspirations of great individual leaders, future approaches to strategy will need to be more emergent and to be "constituted and enacted organizationally" (pp 78) in collaboration with internal and external stakeholders. Yet Clegg et al's (2011)

analysis of strategic theory also argues that management theory is currently ill-equipped to conceptualise these ideas and advise managers on how to implement this in reality. This is because the development of management theory has been largely separated from advances in sociology, organizational theory and political analysis. It follows that to be able to embrace a new approach to innovation, managers will have to learn the new language of collaboration and to understand the critical role that 'social networks' and 'social capital' play in achieving personal and business success.

Locke and Spender (2011) have taken the idea of collaboration as the basis of serendipitous discoveries. They argued that in the future, innovation will occur and at the intersection of different knowledge domains and that collaborative environments are the key to these interactions occurring. According to Locke and Spender (2011), tomorrow's breakthrough ideas will be most likely to emerge when innovators bring concepts from one field into a new, unfamiliar territory. Hagel et al (2010) concurs. Their work shows that one of the critical defining factors that distinguish innovative companies from others is that their business networks are often based on deep and trusting personal relationships and their members are drawn from diverse backgrounds.

While serendipity might seem like a random process, creative firms also realize that new insights and connections do not happen by accident and that it needs to be encouraged through deliberately structured processes. Sampson's (2011) cross-sector research shows that the defining characteristic of innovative companies was not their size or function, but a 'systematic innovation capability' which consistently delivers innovations which add business value. Systemically innovative firms back-up their intentions with resources, measure innovation outputs, encourage staff to innovate and reward them for doing so. In these companies, innovation is deeply embedded into the mindset and culture of the business and there are close collaborative relationships with supply and demand chain partners to achieve mutually beneficial outcomes. This research supports earlier work by Sutton (2001), Robbins et al (2003) and Boumol (2010) which has shown that people in innovative firms are provided with many opportunities to be exposed to new ideas and insights from outside their immediate discipline and structured forums are often set up to facilitate these interactions. These types of interaction foster innovation by increasing the chances of unexpected serendipitous insights to arise. These firms also tend to have fluid and organic cellular structures. This structure gives a company a small feel, even if it is very large. It frees people from a single business model and provides opportunities for people to nurture entrepreneurial talent where they are more able control the development of their ideas and benefit from them. To achieve this, innovative firms strategically combine different roles, capabilities and personalities to induce creative tensions in teams. And they empower people to act in ways that are not tightly constrained by traditional competencies, roles and management oversight.

BARRIERS TO SERENDIPITY IN THE CONSTRUCTION PROCESS

The above section highlights numerous organizational attributes which research indicates would enable firms to better harness the untapped serendipitous opportunities in an increasingly uncertain, dynamic and interconnected business environment. However, there has also been significant research which indicates that many of these ideas do not reflect the harsh reality of the construction industry. Prominent examples include the work of Winch et al (1998), Nam and Tatum (1997),

Manley (2006), Barrett (2008), Widen et al (2008), Brandon and Shu-Ling (2008), Sexton et al (2008), Gambatese and Hallowell (2011) and Dainty and Loosemore (2012). For example, while the importance of collaboration to innovation has also been highlighted by numerous authors in the field of construction (Leiringer 2006, Walker and Rowlinson 2008), many barriers to effective collaboration in construction have also been identified. These include: a pervasive risk transfer culture which transfers responsibility for innovation down the contractual chain to those least able to invest in it; long fragmented supply chains which separate responsibility for innovation from the market for innovation; the project based nature of construction which ensures that projects teams rarely have a chance to form long-standing relationships; the use of subcontracting to undertake work; increased workforce casualisation; a confrontational and mistrusting culture; extreme competition which creates the perception that collaboration is bad for competition; an over reliance on clients to foster innovation and; short-sighted client attitudes which put price before relationships. Fundamentally, research shows that construction is organized in a way which is counter-productive to innovation. Building production takes place through a fragmented supply and demand chain which physically and chronologically separates customers from designers, designers from builders and builders from operators. On most projects, these chains are also 'legally fragmented' by the way risks and rewards are distributed rather than being shared between project participants. According to Winch (2008) each firm in the construction supply chain compete to extract the greatest share of the value-stream flowing from the client. In theory this should be shared in proportion to their contribution to that value-stream process. However, Loosemore (1999) found, power differences between the parties ensures that in most projects value may not be extracted proportionately on this basis and this often results in confrontational relationships and a lack of collective responsibility for project success. Gann (2000) argues that this is one of the construction industry's major barriers to innovation.

METHOD

The above research resulted in the model (Figure 1) which in simple terms summarises the opposing forces which appear to enable and prevent serendipitous innovation in the construction industry.

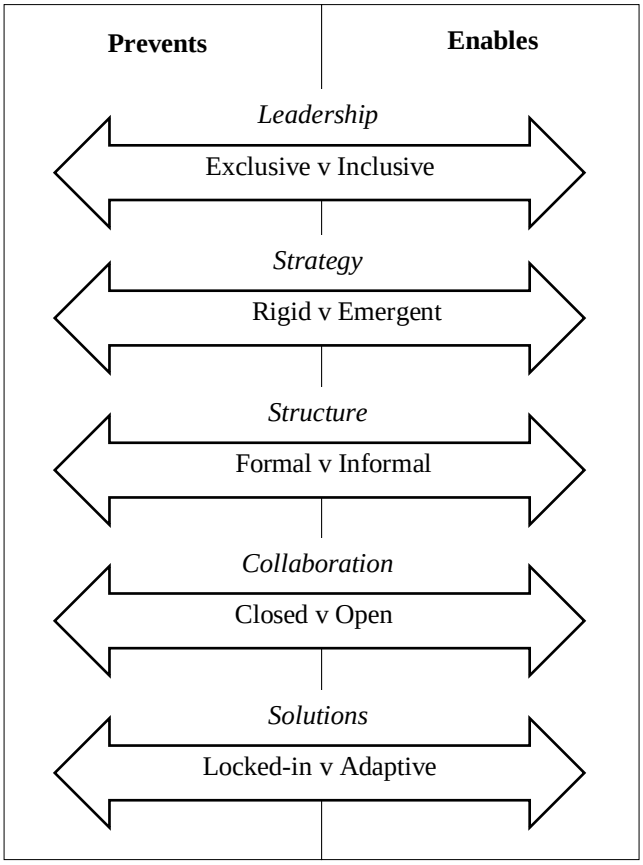

Figure 1 Enablers and barriers to serendipitous innovation in the construction industry

To test this model, semi-structured interviews were conducted with thirty two senior business leaders and government policy makers who have been influential in driving innovation in the Australian construction sector. Respondents were selected by snowball sampling from an initial set of 'first order' actors based on their membership of Australia's Federal Government's Built Environment Industry Innovation Council (BEIIC). This council was established by the Australian Federal Government to advise the Minister for Innovation, Research and Science on innovation policy regarding the construction sector. Nominations of other contacts provided a group of 'second order' actors who sat outside this relatively small core group but who were well known nationally for their innovative achievements. The sample was made up of senior executives from across the entire construction demand and supply chain: Government (5); Clients (3); Consultants (5); Developers (5); Contractors (6); Subcontractors (4) and; manufacturers (4). The interviews were semi structured to enable respondents to describe how serendipitous events had led to innovations in their business and what factors had been instrumental in allowing this to happen. Barriers which could prevent this from happening were also discussed. The role of narrativisation is widely recognised as being important to understanding complex organisational phenomena such as serendipity (Maclean et al. 2012). Serendipitous moments tend to occur as a result of complex events and interactions between numerous people over long periods that come together unexpectedly at a particular moment in time. However, to give some structure to the respondent's narratives of how such events had led to innovative ideas, the enablers discussed above were used to focus the interviews around specific

organisational themes. Selected quotations from the broader narratives are provided below around these key themes.

DISCUSSION OF RESULTS

Formal business strategies

One of the main enablers of serendipity highlighted in the literature cited above is a flexible business strategy which doesn't lock-in predetermined ideas and solutions. However, there were divergent views among the respondents on how important a formal innovation strategy was to predicting innovation outcomes. For example, while some thought that it was key to "*giving people permission to innovate*" [Respondent Gov #4] and communicating that "*innovation matters*" [Respondent Con #2], others thought that statements of strategic intent alone would have little impact on people's receptivity to innovations.. "*just stating that we will innovate is unlikely to change anything. Management statements have to be backed up by leadership, culture and resources"* [Respondent Con #3]. In support of the literature reviewed above, our respondents agreed that serendipitous insights and discoveries are best facilitated by a loose and mobile business strategy which is built around their people's capabilities, desires and passions. To cope with fluctuating workloads and changing markets, most businesses have a flexible business strategy which allows them to shift and adapt to changing opportunities. Likewise, innovation tended be an unstructured process…. "*It just happens*" as one respondent said [Respondent Sub #2].

Organic structures

The literature also argues that flexible business strategies are generally the product of organic organisational structures built on trusting supply chain relationships. Such structures are claimed to be critical in facilitating the informal connections which enable serendipitous opportunities to arise. However, most of those interviewed agreed that while this was a good idea in theory, this was rarely achieved in practice in construction…. "*At the end of the day we have to deliver a building and this takes a highly disciplined and planned approach*" [Respondent Con #4] ….*"there is a danger of being too utopian here - in creating a world where business are too frightened to innovate*" [Respondent Gov #1]. As one respondent argued, "*at the end of the day delivering projects is a highly pragmatic endeavour which requires detailed planning and strong accountability, discipline and reporting lines*" [Respondent Con #2]. "*If you are too open with your subbies then you can lose your competitive advantage. They will take advantage of you and put their prices up. You need to keep a competitive tension*" [Respondent Con #4].

Locking-in solutions

Most respondents agreed that firms were generally very open to new opportunities, especially in the early phases of tendering for a project. However, one of the biggest challenges in managing innovation in construction is that there are permanent business organizations managing temporary project organizations. For example, when a project is won, solutions are locked-in and innovation becomes much more difficult. Innovation during these latter phases mostly occurs out of the necessity, in solving an immediate problem on a project.. "*when you are tendering it opens your eyes and encourages you to go looking for new ideas. Serendipitous insights are much more likely to occur*" [Respondent Con #1]…. "*Once we have started work on site, you*

haven't got the time to innovate. The innovation that goes on here is to solve problems that we encounter to keep the project progressing. People are incredibly creative when the pressure is on to come up with solution. But this isn't serendipity. It takes time for serendipity to happen but solutions here are needed immediately and they are much more individual.." [Respondent Con #1]. As one respondent said, "*Up front innovation is about winning the job and is driven by the need to beat the competition. But once you have the job it switches to how to deliver the project faster and more efficiently….you can be creative up-front but innovation at a project level must be practical…..You can't have too much creativity on site since the concrete has to be poured. This is a different type of innovation – it is reactive not proactive*" [Respondent Con #3]. As another respondent explained, one of the main challenges for the industry in opening-up to opportunities for innovation was that the industry has a stable layer of executives involved in up-front planning which is superimposed on a more fluid layer of project managers involved in delivery to tight schedules and deadline.... "*the top business layer is relatively stable but underneath it is a fluid project-focused undercurrent which is highly dynamic, subject to a lot of uncertainty and unexpected problems which have to be responded to*" [Respondent Dev #5]. Both layers appear to require very different approaches to innovation. The top layer will tend to have a longer time horizon and focus on innovations which span different project boundaries. People operating at this level tend to focus on innovations which can provide a competitive edge. These can be planned in advance. In contrast, the project layer will tend to be very short-term and client focused. People operating at this level tend to focus on innovations which can deliver productivity and cost benefits to deliver the project on time and on budget.

Collaboration

In agreement with the literature on enabling serendipity, collaboration was widely seen as crucial to innovation. However, this is widely seen as being quite difficult, particularly through the construction sector's supply chains. As one respondent argued, "*Collaboration is just a word*" [Respondent Sub #4]. And as another pointed out, most clients opt for lump-sum tenders driven by the belief that negotiation means higher prices… "*More than anything else, clients want certainty of price so there is a mistaken tendency to think that this is best achieved by passing all their risk down the contractual chain which is not conducive to collaboration*" [Respondent Con #1].

Leadership

Most of the people interviewed indicated that business strategy was created and adjusted by a core team of executives which lie at the heart of their business and who have been there for many years. These people form a central "*nest*" [Respondent Con #6] which has a "*deep thirst for knowledge*" [Respondent Con #6] and which is driven by the high levels of competition in the industry and the continual need to create a competitive edge. These were the people who were considered to be most likely to be open and exposed to serendipitous opportunities. However, the opportunities that they afforded to others to be explorative were also seen to be crucial .. "*Leadership is crucial. A good leader leads from the front, they give their staff the space to explore and they trust them..*" [Respondent Dev #2]. A number of respondents felt that the forgotten layer of people in the industry who were largely ignored in the innovation process were the construction workers who undertake the work on site. Interactions between site workers and managers and the potential

serendipities which could arise at this interface were largely lost through the subcontracting model of organising, which most felt damaged innovation in the industry.. "*The structure of employment in the construction industry is all about lowering costs and providing flexibility rather than being about innovation. Contrast this with the manufacturing sector where in a factory of one hundred workers there are all sorts of opportunities for them to contribute ideas and to talk to managers*" [Respondent Gov #3].

It was broadly agreed that clients play a critical leadership role in the innovation process… "*they pay for it*" [Respondent Dev #3]. However, it was also widely felt that many clients are not open to innovation or prepared to pay for it and that this reduces the sensitivity of people in the industry to opportunities to innovate… "*most clients are completely irrelevant to innovation. They have no interest in it what so ever. Unless of course it can reduce costs .. then they have a great desire for innovation.*" [Respondent Dev #3]. However, most acknowledged that there were very few "*willing*" clients who were prepared to test and prototype a new idea on their project. And there are no methodologies for valuing innovation. Submitting a con-conforming bid was therefore a major risk. As one respondent said, "*There is always resistance, because new ideas involve change and the undoing of old systems and ways of doing things. Few people want to take the risk of trying something new and failing. There is no shortage of ideas in the industry but it is the opportunity for application which is often missing. It takes a courageous person to bring a new idea to fruition*". However, government was not seen as a solution to this problem. There was universal agreement that the primary reward for innovation must come from the market not from government incentives. "*If clients do not want energy efficient buildings then the industry won't build them. Similarly, if a firm isn't focused on innovation and set-up to innovate then incentives will have little impact in encouraging them to do so*" [Respondent Gov #4].

CONCLUSION

The aim of this paper is to explore the enablers and barriers to serendipity in the construction process. By drawing on contemporary theories of strategy and innovation which challenge neo-classical approaches which suppress uncertainty, a range of enablers were identified which could enable these serendipitous opportunities to be harnessed. Of particular importance was inclusive leadership, emergent strategy, informal structures, open collaboration and adaptively in problem-solving. Through in-depth semi structured interviews with leading innovators and policy makers in the Australian construction industry, these ideas were tested against the realities of organisational practices in the construction industry. While there are clearly limitations to this research in the lack of previous research in serendipity to inform the model, in the limited sample of thirty two and in the focus on the Australian construction sector, the results nevertheless produce some new and interesting insights which challenge traditional notions of innovation in the industry. In particular, to most of the respondents, many of the ideas were seen as too idealistic. For example, the ideal of organic loose organisational structures which are often advocated to drive innovation would seem to be problematic given the need to deliver projects within extremely tight timescales and budgets. Furthermore, extreme levels of competition within the industry, the subcontracting model of delivery and clients who continue to employ on lowest price, make true collaboration and open trusting relationships difficult to achieve. While these problems are well known and have been widely

written about in other contexts, these new insights provided through the novel lens of serendipity provide a contemporary reason to address them with even greater urgency.

REFERENCES

Abbott, C., Barrett, P., Ruddock, L. and Sexton, M (2007) Hidden innovation in the construction and property sectors, *RICS Research paper series*, 7 (20)

Barrett, P. (2008) A Global Agenda for Revaluing Construction: The Client's Role, In Brandon, P and Shu-Ling, L (eds), *Clients Driving Innovation* (eds) Wiley-Blackwell, Oxford, UK.

Baumol, W. J. (2010) *The microtheory of innovative entrepreneurship*, Princeton University Press, Princeton, USA.

Brandon P and Shu-ling, L. (2008) Clients driving innovation, Wiley-Blackwell, Oxford,

Bungay, S. (2010) What the Prussians could do for us, The Sunday Times, December 5th, 4-5.

Clegg, S., Carter, C., Kornberger, M. and Schweitzer, J. (2011) Strategy – theory and practice, Sage, London.

Dainty, A and Loosemore, M (2012) Human Resource Management in Construction: Critical Perspectives, Routledge, London, UK.

Gambatese, J. A. and Hallowell, M. (2011) Factors that influence the development and diffusion of technical innovations in the construction industry, *Construction Management and Economics*, May, 29, 4, 507-517

Gann, D. M. (2000) *Building Innovation - complex constructs in a changing world*, Thomas Telford, London.

Hamel, G. (2002:10) *Leading the revolution*, Plume, New York

Hagel, J. Seeley Brown, J. and Davison, L. (2010) *The Power of Pull: How Small Moves, Smartly Made, Can Set Big Things in Motion*, Basic Books, New York, USA

Horrigan, D. (2011), *Strategic serendipity: The art of being in the right place at the right time … with the right people*, Australia Business Foundation, Sydney, Australia.

Leiringer R (2006) Technological innovations in PPPs: incentives, opportunities and actions, *Construction Management and Economics*, 24 (3) 301-308

Locke R R and Spender J-C (2011) *Confronting Managerialism*, Zed Books, London.

Loosemore, M (1999) Power, responsibility and construction conflict, *Construction Management and Economics*, 17 (6), 699-711.

Maclean, M., Harvey, C., and Chia, R. (2012). "Sensemaking, storytelling and the legitimization of elite business careers." *Human Relations*, 65(1), 17-40.

Manley, K. (2006) The innovation competence of repeat public sector clients in the Australian construction industry, *Construction Management and Economics*, 24 (2) 1295-1304.

Meisel, Z F and Karlawish, J (2011) Narrative v evidence-based medicine, *Journal of American Medical Association*, 306(18):2022-2023

Mendonça, S, Cunha M and Clegg, S (2008) Unsought innovation: serendipity in organizations, Paper presented at the 25th Celebration Conference On *Entrepreneurship and innovation – organizations, institutions, systems and regions*, Copenhagen, CBS, Denmark, June 17 - 20, 348-359

Merton, R, and Elinor, B (2004) *The Travels and Adventures of Serendipity: A Study in Sociological Semantics and the Sociology of Science, Princeton University Press.*

Muir, C. (2000) *Achieving Success Through Social Capital*, San Francisco: Jossey-Bass Inc.,

Nam, C. N. and Tatum, C. B. (1997) Leaders and champions for construction innovation, *Construction Management and Economics*, 15 (3), 259-270.

N.E.S.T.A. (2007) *Hidden Innovation: how innovation happens in six 'low innovation' sectors*, National Endowment for Science, Technology and the Arts, London, UK.

Robbins, S. P., Bergman, R., Stagg, I. and Coulter, M. (2003) *Foundations of management*, Prentice Hall, Sydney, Australia

Sampson, D. (2011) *Innovation for business success: achieving a systematic innovation capability*, Department of Innovation, Industry, Science and Research, Commonwealth Government, Canberra, Australia

Sexton, M., Abbot, C. and Shu Ling, L. (2008) Challenging the illusion of the all powerful clients role in driving innovation, in Brandon and Shu-Ling (2008) *Clients driving innovation*, Wiley- Blackwell, Oxford,43-49

Sutton, R. I. (2001) The Weird Rules of Creativity, *Harvard Business Review*, Sept. 79, 12-14.

Tidd, J. (2006) *A review of innovation models*, Imperial College London, Discussion paper 1/1

Tjan, A. K., Harrington, R. J. and Hsieh, T. (2012) Heart, Smarts, Guts, and Luck: What It Takes to Be an Entrepreneur and Build a Great Business, Harvard Business review Press, Boston, Massachusetts, USA

Walker, D. H. T. and Rowlinson, S. (2008) *Procurement systems: a project management perspective*, Taylor and Francis, London, UK

Widen, K., Atkin, B. and Hommen, L. (2008) Setting the game plan – the role of clients in construction innovation and diffusion, *in* Brandon P and Shu-ling L 2008, *Clients driving innovation*, Wiley-Blackwell, Oxford, 56-79

Winch, G. (1998), "Zephyrs of creative destruction: understanding the management of innovation in construction", *Building Research and Information*, 26, 268-279.

Winch G M (2008) Revaluing construction: implications for the construction *process, in* Brandon P and Shu-ling L 2008, *Clients driving innovation*, Wiley-Blackwell, Oxford, pp 16-25

STRATEGIC MANAGEMENT COMPETENCIES IN SCANDINAVIAN CONTRACTORS

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Over the past ten years, a series of contractors operating in Denmark, Norway and Sweden have slowly but surely expanded their markets beyond their previous single-country base towards operating in Scandinavia as a whole, and beyond. This expansion has been accompanied by a restructuring of company organisations and associated processes of competency development in senior management. This paper asks the question: How well is top level management prepared to manage and lead these large companies? The paper adopts a multidisciplinary theoretical approach combining international business, strategic management and HR concepts and approaches. Methodologically, a sample of the top level leaders of the hundred largest business units at some thirty Scandinavian contractors has been analysed. The focus is on the 400 top level managers in these organisations. On the basis of a desk study, an analysis of 124 managers from 18 companies has been carried out, providing insight into the basic education and mixing of competences in the top-level boards. More specifically, the areas of operations strategy and IT have been reviewed. The results show that even if the board is mainly composed of engineering competencies, business, legal and HR competencies are also present. Both engineer-dominated and mixed management boards are heading companies which show growth in turnover. This runs counter to a widespread sector perception that management boards in the construction industry are mainly composed of engineers. However, it seems that the managers with business administration competencies are rarely those with responsibility for the central tasks of leadership and strategy. Moreover, very few companies prioritize operations strategy and IT. It is assumed that everybody knows about practical building projects, and therefore that operations strategy will develop naturally. The IT area is viewed as best placed at a lower level of organisation, counter to IT governance and management prescriptions.

Keywords: strategic management, contractor, Scandinavia, competency.

INTRODUCTION

The unsatisfactory performance and development of productivity in the construction sector in Denmark, Sweden, Norway and internationally can be ascribed to a series of factors, the fragmentation of the industry being one. There are however indications that the lack of strategic management competencies among the large contractors is one of these factors (Xia et al 2009) - an element which is under-researched.

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Koch C and Buhl H (2013) Strategic management competencies in Scandinavian contractors *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 645-654.

Corporate management is being challenged by a series of complex issues, and it is apparently common practice to compose management boards with a mixed set of competencies, both among companies generally (Adams et al 2010, Dilling-Hansen 2009, Keller 2009, Wagner 2011) and among contractors. Experience with operations is sometimes emphasised as an important competency at board level (Löwstedt 2012). The makeup of the corporate management and its role in other sectors has been studied in a number of disciplines where economics are particularly important (Adams et al 2010, Dilling-Hansen et al 2009, Hitt and Ireland 1985, Wagner 2011). As this paper represents one of the first steps towards creating a research agenda, the approach adopted here is however open to many possible results on and to more approaches to the role of corporate management.

The aim of the present paper is therefore to investigate Scandinavian contractor's corporate management strategy competencies by

- identifying constellations of competencies in corporate management in Swedish, Norwegian and Danish contractors
- analysing possible indications of links to good performance among the contractors.

The empirical focus is on building contractors from Denmark, Norway and Sweden, and companies which span these and other countries, known here as Multinational Nordic Companies (MNCs). NACE group codes are used, under which the building sector contractors fall into three groups: ‘Construction of buildings’ (group code 41), which encompasses general contractors, ‘Civil engineering’ (42), who are contractors constructing bridges, tunnels and public infrastructure, and ‘Specialized construction activities’ (43), technical contractors involved in installation work.

By developing statistically-based evidence on the composition of boards, our understanding of the role of corporate management in construction contractors can be significantly improved. However, such knowledge has clear limitations in terms of understanding strategic processes and experiential competency development. The underlying idea of the material developed and presented here is therefore to create a research agenda on the strategic development of contractors in Scandinavia.

The paper is structured as follows. Firstly, the theoretical framework is developed, followed by the empirical and analytical methodology. A description is then presented of the data found. This is analysed in the case studies section, and in the discussion, which also suggests some elements of a future research agenda. The paper closes with a conclusion.

THEORETICAL FRAMEWORK

A number of scientific disciplines have studied and conceptualised the contribution of the upper echelons of management to the competitiveness and performance of companies (Acquaah 2003, Adams et al 2010). These include the areas of industrial economy, strategy (Acquaah 2003), econometrics, law, accounting, sociology and psychology (Adams et al 2010). Other approaches, on the other hand, downplay or even dismiss the very idea that management can make a difference. The former would include the organisational politics approach, which underlines the fragmentation into coalitions of managers and employees, often with limited power (Pettigrew 1985), while the latter includes the evolutionary approach, which points to market and structural factors as explanations for enterprise development (Aldrich 1979). An often adopted approach in favour of some influence by managerial action is the resource-

based view (De Wit and Meyer 2010). This approach identifies a number of factors contributing to competitiveness and performance, listing senior management capabilities as just one among many (Acquaah 2003, De Wit and Meyer 2010). The factors listed include a resource base of tangible and intangible resources, in which relational resources and competencies are viewed as being part of the latter (De Wit and Meyer 2010, Dilling-Hansen et al 2009).

In continuation of the resource-based view, management competencies are understood to comprise a blend of personal skills, practice, attitude, basic formal education and later vocational training (De Wit and Meyer 2010, Mintzberg 1973, Wilson et al 2006). This implies that management competencies are usually built up through years of practical experience, in which basic education may form a basis and/or a point of departure. Moreover, when it comes to practising strategy, the scarce amount of empirically-based literature on strategic processes among contractors suggests that these are formed continually over longer periods of time (Löwstedt 2012). In the general literature on strategy processes, it has been established that is usually the higher echelons of management who are active in these processes (Jarzabkowski and Spee 2009), and only to a limited extent middle managers, and rarely other employees (Friis 2012, Mantere 2009).A number of studies of company performance and competitiveness have adopted the resource-based view, investigating a long series of possible contributory factors. These emphasise the strengths of mixed corporate management and/or boards of directors with managers from various different backgrounds (Acquuah 2003, Adams et al 2010), together with the role of incentives for the CEO (Adams et al 2010), and more. The globalization of companies and their markets, in this context spreading from national to Scandinavian, to Nordic markets and beyond, places further pressure on the resource bases of these companies, while also strengthening them through mergers and acquisitions. This involves the development of managerial skills (Lahti 2010, Søderberg & Vaara 2003).

However, the idea that management competencies are important contributors to company development is not uncontroversial. Acquaas (2003: 78), based on his survey, is completely confident that “corporate management capabilities significantly influence the sustainability of a firm's abnormal (high) profits”, while others (Cheah et al 2007, Dilling-Hansen et al 2009) do not share this conclusion. Dilling-Hansen et al (2009:398) thus conclude, in an econometric study of a large sample of Danish firms, that “it shows no effect of the educational level of top management on performance”. Neither are there demonstrable effects from external networking (relational capabilities) (Dilling- Hansen et al 2009:398). Cheah et al 2007 analysed 12 Chinese building contractors and found no support for senior management capabilities being important, while they found that external networks were (Cheah et al 2007:35).In a similar vein, it has been continually debated whether certain managerial areas should be represented or not on the top-level management board. There is a tendency for areas such as operations (Hammer 2004), human resources, accounting, sourcing, and IT all advocate their presence at the top level (Weill & Ross 2009).

There are also studies indicating the importance of project and programme management competencies as vehicles for the delivery of strategy in organisations (Crawford 2011). However, studies of project-based companies and their vertical relations often claim that there is a poor correlation between strategic management and operational (project) management (Ekstedt 1999, Koch 2004). This is mirrored in the emphasis on project management as being important for contractors - something

that Cheah et al (2007) set out to demonstrate, but are unable to establish, and the importance of operational practice among strategic managers (Löwstedt 2012).

To summarise in the context of Scandinavian contractors, the need for strategic management competencies can both be supported and questioned, which provides the starting-point for our explorative empirical investigation. The theoretical framework, too, underlines the fact that the basic education of top level managers, and the composition of the board, whether mixed or monolithic, provide but two possible contributors to corporate competitiveness and performance.

METHOD

The focus here is on the empirical method, which is based on an interpretivist approach. The study covers large Scandinavian contractors, measuring the quantitative representation of educational backgrounds in boards of directors, including CEOs. The gross sample consists of 93 contractor companies: 17 Danish, 26 Norwegian and 23 Swedish companies, and over-layering these, 27 Nordic multinationals. Desk research using web resources such as www.largestcompanies.com initially helped to determine that these companies have 389 managers at board level (see below), of whom a smaller sample of 124 was studied through the web with regard to their educational backgrounds, drawing on publicly-available data such as CVs and personal profiles on company websites. The delimitation of this sample followed these steps: Firstly, it was assumed that the larger companies would be the market leaders in terms of strategy; limitations of resources prevented us from examining small and medium-sized companies, or including consulting engineers or architectural firms. 'Large' was defined as a company with turnover in excess of SEK 1 billion (EUR 113 million) in 2010. The number of employees was also taken into account. Secondly, choosing Scandinavia (Denmark, Norway and Sweden) allowed the authors to access national language material in their desk research. Thirdly, contractors active in the construction industry were understood to cover some of the largest general, earthworks, civil engineering and technical contractors (installations, HVAC), using the NACE sector group codes 41, 42 and 43: ‘Construction of buildings’ (41), ‘Civil engineering’ (42), and ‘Specialized construction activities’ (43).

Since regulatory frameworks in the three countries distinguish between public liability companies, i.e. shareholder companies, and listed public liability companies having shares traded on the Nordic Stock Exchange, this distinction was maintained when gathering data (public liability companies are abbreviated to AS in Norway, AB in Sweden and A/S in Denmark; listed public liability companies are abbreviated as ASA in Norway and AB (publ.) in Sweden, and are designated “listed” A/S in Denmark).The company sample was initially generated using the website "largestcompanies.com" (Largestcompanies 2012), which encompasses data for 100,000 Nordic companies and enables national comparisons. The sample revealed that a group among the largest companies comprised multinationals cutting across all three national markets, with their primary markets in (all) the Nordic countries, and/or having their corporate headquarters there. This group consists of six complex multinational corporations, organized in a large number of shareholder companies (often more than 100 companies per multinational). An evaluation of the corporate structure led to an interpretation of them as 27 primary shareholder companies, (all with a CEO, board of directors and management board) which are interpreted as important decision-making units in the corporate structure. These include holding companies, as well as units with a turnover exceeding SEK 1 billion and many

employees. The Danish, Swedish and Norwegian multinationals' management elements have been studied along with both a national analysis and multinational analysis, in order to compare competing national and multinational institutions. The sample thus consists of 93 legal units/companies: 17 Danish, 26 Norwegian and 23 Swedish,. The 27 Nordic multinationals encompass 6 units in Denmark, 7 in Norway, and 14 in Sweden. The sample is comprehensive as all company units with a turnover exceeding SEK 1 billion in the three sector groups have been covered. In the sample, four Norwegian companies are listed as shareholder companies with special obligations (ASA), while the rest are ordinary shareholder companies.

Three Swedish companies are listed as companies with shares traded on the Nordic Stock Exchange. No large Danish contractors are listed on the stock exchange. For each company, data were gathered on the board of directors, i.e. the CEO and other management board members. A range of material was used including annual reports, research studies and media coverage. For each country, specialized websites were used – e.g. for the thousand largest Danish enterprises – together with websites with information on professionals in Danish, Norwegian and Swedish contractors (proff.dk, proff.no and proff.se). Desk research utilized triangulation (Bryman and Bell 2007) and included both quantitative and qualitative company data. Delimitations similar to those applied to multinationals were necessary in the case of many other investigated companies, in order to determine which units should be counted in a company structure with many shareholder companies and many CEOs, directors and boards. Here, the criteria applied were centrality, turnover and the number of employees. This method has its limitations – for example, using Scandinavia rather than the Nordic countries as the area of study excludes Iceland and Finland. Since almost all of the multinationals also operate in Finland, we label them Nordic multinationals. Another limitation relates to lifelong education for the boardroom. The material used here does not cover more than basic education. Finally, the particularities of corporate governance in Scandinavia are not discussed.

THE CONTRACTORS AND THEIR TOP LEVEL MANAGERS

Table 1 shows the distribution of companies in the NACE groups 'Construction of buildings' (41), 'Civil engineering' (42), and 'Specialized construction activities' (43). It is characteristic that a lot of companies span over more than one type of contracting, for example also including real estate in their business model. The MNCs, in particular, are conglomerates of markets, products and capabilities. The "legal" sector placement is therefore just one way of describing the companies.

Table 1: Company origin and sector

Country | Sector:	Cross	Group 41	Group 42	Group43
Denmark		2	1	1
Sweden		1	1	1
Norway		3	3	1
Nordic Multinationals	4			

The sample encompasses 18 companies, of which four are Nordic multinationals (MNCs) or mega-companies operating in all three Scandinavian countries, and across the three sectors and beyond. In these 18 companies, 124 managers were identified whose educational level could be entered in the table below:

Table 2: Educational background of top level managers

Education	Number
Engineer MSc	44
Engineer MSc and MBA or business training	6
Engineer BSc	21
Craftsman	1
Business administration MSc	28
Law MSc	8
Academic, others	11
BA and Non-academic	5
Total	124

In all cases, it is the most recent education that counts. The category of 'non-academic engineer', i.e. technician, was included in the search but did not produce any hits. Among the social science graduates, it appears that most occupy dedicated specialist positions. The eight law graduates, for example, encompass the position equal to chief legal officer, or work in organisation and communication, whereas only one occupies a position as a line manager. We found three Chief Operation Officers (COO's) and no IT managers among the management board members. Usually, IT management was located immediately beneath the top level. Engineering managers typically have long careers behind them, often starting at the building site. As an example, one CEO from a MNC originally trained as a carpenter. He was 26 years old and engineering student when he was joined the company of which he is now CEO. When he graduated as a construction engineer (MSc) two years later he began work as a site manager, and over the next twelve years he occupied the positions of quantity surveyor, project engineer and regional manager. He then made a major career move by becoming CEO of another large building contractor. In this position, he participated in a management training programme in the US. However, after six years in this position he returned to the “original” company, serving as country manager for seven years before becoming CEO. Another example is the CEO of a national company in a MNC company. He graduated as a construction engineer (MSc), and then began as a single contractor manager. He then became site manager and later project manager at a large joint venture with other contractors, before returning to the company and later becoming CEO. It may be noted that the main similarity between these two examples is their long-term, on-site experience, while the main difference between them is that one started out as a craftsman, whereas the other began as an engineer. The first CEO is one of three managers in the sample who stated their background as 'craftsman', whereas the other 121 had other career patterns (they are entered above according to their most recent qualifications).

Table 3: Educational background of CEOs

Education	Number
Engineer MSc	6
Engineer MSc and MBA or business training	1
Engineer BSc	4
Craftsman	0
Business administration MSc	4
Law MSc	0
Academic, others	
BA and Non-academic	3
Total	18

On the basis of the 18 firms one can identify some characteristic constellations of managers. Firstly, it appears that there is a predominance of technically-educated construction engineers in large groups of firms. In this type it appears that business administration graduates play a more peripheral role. This seems to be the case in seven companies. Secondly, some companies appear to mix competencies: engineers, engineers with management education, and business administration graduates of various kinds. This seems to be the case in seven companies. Thirdly, there are some companies in which business administration-educated managers have come to dominate. This seems to be the case in four companies, some of which have for example a business administration graduate as CEO. Table 4 juxtaposes these types. When we compare trends in turnover for 2009, 2010 and 2011, some companies have experienced what appear to be national market upturns and downturns - a flux that does not appear to be due to the individual company's actions and/or management: 2009 was a bigger market, and 2010 and 2011 provided new growth. This pattern appears to have impacted 8 firms.

Table 4: Management Board composition

Engineer Dominated	Mixed	Business	Admin.
7	7	4	

Another group had continual growth over the three years, a third group experienced decline, and a fourth global upturns and downturns (flux) which were not only Nordic. Table 5 compares the trends in turnover with the management board composition types, we obtain the pattern showed below. This table gives a small hint as to whether a particular composition provides better performance. The result here seems to indicate that both an engineer-dominated board and a mixed board contribute in some way to the most positive trends in turnover, while all three types are involved in companies that follow national market upturns and downturns. Read strongly, there is a hint that management boards with business administration graduates are more inclined to follow the market trends.

Table 5: Turnover and management board composition

National Market Flux	Increase In turnover	Decrease In turnover	Global Market Flux
8	8	1	1
2 Eng	4Eng		1 Eng
2 Mix	3 Mix	1 Mix	
4 Adm	1 Adm		

(Eng = Engineering dominated, Mix= Mixture, Adm= Business administration)

DISCUSSION

The MNCs are conglomerates of markets, products and capabilities. This is a finding similar to that of Cheah et al. (2007), who in a Chinese context show the importance of these profiles, yet with a further differentiation. It was a premise for the investigation that basic education is merely an element in strategic management competencies, and the study also support that assumption. The educational backgrounds of top level managers with a social science education encompass degrees in economics, business administration and law. Quite a large number of these occupy specialist functions in management boards, such as chief financial officer, chief legal officer or communications manager. One cannot, however, infer from this ranking that business administration-educated managers are unimportant in board level strategy-making. At least one chief financial officer in the sample exerts a great deal of influence on the firm's strategy, and more generally it would depend on the kind of collaboration and teamwork exercised by the board of management (Adams et al 2011). There does however seem to be a smaller group of business administration-educated managers who occupy line management positions. This gives them direct responsibility for a value-creating product area and probably more direct influence on strategy making. The CV examples indicate that engineers who enter contracting companies at site level and remain with the company for a long period of time initially develop competencies in construction project management, and later, when they become department or regional managers, are likely to become involved in strategy development processes, and thereby build competencies in that area.

By contrast, some of the social science graduates also received a basic education in strategy, and would be able to build upon that. Others, such as law graduates, would probably not. There are thus indications that basic education is combined with practice over a long period. Gradually increasing participation in strategic development is a likely career path for these managers, whether they come from an engineering and or social science background. All of the MNCs in the sample prioritized having top level managers from different countries, and some also practised mixing the national boards of managers with several nationalities. However, these were for the most part just one or two representatives, along with many national representatives from the country in which the company headquarters were located, and where the company has its historical roots. Very few (three) companies prioritized operations in the gtop level management board by appointing a Chief Operations Officer. It could be argued that it is assumed that everybody knows about practical building projects, and therefore that operations and operations strategy will develop naturally, which could be said to be in line with Hammer's (2004) advocacy of a strong link between top and bottom. The

counter-argument is that operational experiences could hamper strategic development processes (Löwstedt 2012).

Similarly, we found no IT managers at the top level. The IT area appears to be viewed as being best placed at a lower level of organisation, counter to IT governance prescriptions (Weill and Ross 2009). This paper has taken the first steps towards developing an understanding of the strategy competencies of Scandinavian contractors, and it provides elements for the creation of a research agenda. Firstly, it is likely that a larger data set would improve the picture of competencies and backgrounds. A survey would also enable a more precise analysis of the strategic competencies, as well as of the possible links between management competencies and enterprise performance. Combining this with qualitative methods, it would be possible to analyse the importance and role of experiential competency development and thereby acquire an understanding of strategy processes and globalisation in Scandinavia and beyond. We have found indications of the internationalisation of management boards, in the sense of presence of managers from several countries. Søderberg and Vaara (2003) suggest that the formation of a new layer of managers in Scandinavian companies is a rocky process, and qualitative approaches could investigate that for multinational Scandinavian contractors.

CONCLUSIONS

The aim of this exploratory paper was to identify constellations of competencies among the corporate management of Swedish, Norwegian, Danish and Nordic Multinational contractors, and to analyse possible links to good performance among these contractors. We have found that the companies exhibited a diversified set of activities, enhancing the need for strategic management. There was a diversity of educational backgrounds among the sample studied, indicating that the predominance of engineers in the management of contractors was less pronounced than expected. We identified three stereotypical versions of board composition: the engineer-dominated, the business administration-dominated and the mixed. We found indications that engineer-dominated or mixed boards are performing better than business administration-dominated management boards, which deserves further investigation. We suggest using mixed methods with more, and more precise, data, and performing qualitative studies of strategy processes and management boards.

REFERENCES

Acquaah, M. (2003) Corporate Management, Industry Competition and the Sustainability of Firm Abnormal Profitability. Journal of Management & Governance, 7(1), 57-85.

Adams, R.B., Hermalin, B.E., Weisbach, M.S. (2010) The role of boards of directors in corporate governance: A conceptual framework and survey. "Journal of Economic Literature". 48 (1), 58-107.

Aldrich, H. E. (1979). Organizations and Environments. Englewood Cliffs. Prentice-Hall.

Bryman, A. and Bell, E. (2007) Business research methods, Oxford University Press, Oxford.

De Wit B. and Meyer R. (2010) Strategy Synthesis. Cengage Learning. Andover.

Cheah C.Y.J., Kang J. & Chew D. A. S. (2007) Strategic analysis of large local construction firms in China. Construction Management and Economics. 25 (1), pp. 25-38

Crawford, L. (2011) Fitting project management capability to strategy. 8th Annual Project Management Australia conference: Project management at the speed of light. Sydney.

Dilling-Hansen, M., Madsen, E.S., Smith, V. (2009) Top management, education and networking, in Bjuggren P-O., Mueller D. C. (eds)The Modern Firm, Corporate Governance and Investment. Edward Elgar Publishing. Massachusetts.

Ekstedt, E., Lundin, R.A., Soderholm, A.,Wirdenius, H. (1999), Neo-Industrial Organising: Renewal by Action and Knowledge Formation in a project intensive economy. Routledge, London

Friis, O. (2012) Strategy-as-Practice – Involving Employees. Ph.D. Thesis Aarhus University.

Hammer, M. (2004) Deep Change. How Operational Innovation Can transform Your Company. "Harvard Business Review" april.

Hitt, M.A. and Ireland, R.D. (1985) Corporate distinctive competence, strategy, industry and performance. "Strategic Management Journal", 6(3), 273–93.

Jarzabkowski, P. and Spee, A. P. (2009) Strategy-as-practice: A review and future directions for the field. "International Journal of Management Reviews" 11, 69-95.

Keller, G. F. (2009) Assessing the impact of management practices on corporate performance in southeast Wisconsin. Ph.D. Dissertation. NorthCentral University. Prescott Valley.

Koch C. (2004) The Tyranny of projects - Teamworking, Organisational Knowledge and Project Management in Consulting Engineering. "Economic and Industrial Democracy", 25(2), 270-292

Lahti A (2010) Globalization & the Nordic Success Model. Ventus Publishing. Bookboon.com.

Largestcompanies (2012) website Largestcompanies.com accessed in spring 2012.

Largestcompanies (2013) website Largestcompanies.com accessed in spring 2013.

Löwstedt M. (2012) Exploring the concept of strategy using a practice lens: The case of a large construction company. Thesis for Licentiate degree. Chalmers. Göteborg.

Mantere, S. (2005) Strategic practices as enablers and disablers of championing activity. "Strategic Organization", 3(2), 157–284.

Mintzberg H. (1973) The Nature of Managerial Work. Harper and Row. New York.

Pettigrew, A. M. (1985) The Awakening Giant: Continuity and Change in ICL. Basil Blackwell, Oxford

Søderberg A.M., Vaara E. (2003) Merging across borders: people, cultures and politics. Copenhagen Business School Press. Copenhagen.

Weill P., Ross J.W. (2009) IT Savvy: What Top Executives Must Know to Go from Pain to Gain. Harvard Business Press. Boston.

Wagner, A.F. (2011) Board independence and competence. "Journal of Financial Intermediation". 20(1), 71-93.

Wilson A., Lenssen G, and Hind P. (2006) Leadership Qualities and Management Competencies for Corporate Responsibility. Ashridge. Berkhamsted.

Xia B., Chan A.P.C.& Yeung J.F.Y. (2009) Identification of key competencies of design-builders in the construction market of the People's Republic of China (PRC). "Construction Management and Economics". 27(11), 1141-1152.

PROBLEMATISATION OF THE SHIFT FROM PRODUCTS TO SERVICES

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Over half of the top 20 UK construction companies aspire to provide services and solutions to their clients. This is a clear recognition that constructing on time, defect free and within budget is no longer a differentiator; instead competitive advantage can be gained from technical expertise, consideration of whole life costs and delivering the client's whole value proposition. The majority of literature addressing the evolution of products to service is theoretical, proposing strategic models and outlining the key characteristics of being an integrated solutions provider. In reality the transition pathway to becoming a solutions provider is difficult for organisations that have hitherto focused on product delivery. Through semi-structured interviews, observation of management meetings and project feedback, the problems encountered when trying to embed the characteristics of integrated solutions provision are examined within a leading construction firm undergoing such a transition. It reveals a disconnect in approach between head office work-winning teams and regional project delivery teams that has resulted in a lack of continuity of service at crucial pinch-points in the delivery process. A silo mentality, resulting in a lack of common understanding across the team, can be traced to an organisational path dependency that stems from historical decisions, and is therefore very difficult to overcome. The paper suggests practical mechanisms to help the business make changes to their working practices, routines and organisational structures. It is intended that these will drive the development of new capabilities allowing the organisation to break free from the paths it has become locked into to become a true solutions provider.

Keywords: integrated solution, path dependency, service, transition, value.

INTRODUCTION

The move towards service-led construction is becoming increasingly prevalent, with over half of the top 20 UK construction companies describing their intentions to provide services and solutions on their company websites. The service offering, also described as providing integrated solutions, involves "the bringing together of products and services in order to address a customer's particular business or operational requirements. Delivering integrated solutions to meet customer needs

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Morrey N, Dainty A, Thomson D and Pasquire C (2013) Problematisation of the shift from products to services *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 655-665.

involves specifying, designing, constructing, financing, maintaining, supporting and operating a system/facility throughout its life cycle" (Brady et al. 2005b: 572.)

To date, the majority of work in the products-service field has focused on the development of theoretical models and the identification of the key characteristics of solutions provision (Foote et al. 2001; Galbraith 2002; Oliva & Kallenberg 2003; Brady et al. 2005; Gebauer & Friedli 2005; Baines et al. 2009). Empirical studies outlining the issues faced by companies undergoing transition are mostly concerned with the manufacturing and service sectors (Johnstone et al. 2009), with the few construction based examples being Private Finance Initiative (PFI) related (Johnstone et al. 2008; Leiringer et al. 2009). There is little comment on the specific difficulties that construction organisations face when they try to embed these characteristics, the root causes of these problems, or solutions available to enable them to overcome them.

Informed by semi-structured interviews and attendance at management and project meetings, the practical problems encountered when trying to embed the characteristics of service provision are explored in a case study of a leading construction organisation that is currently undertaking the transition from product to service provider. Following a discussion on the existing literature and an explanation of the research methodology, the issues faced by the organisation are discussed along with some practical mechanisms that have been, and continue to be, implemented to drive change in the business.

TRANSITIONING FROM PRODUCTS TO SERVICES

The products-to-services literature originated in the manufacturing and service industries where the primary driver for the move to servitisation was the economic gains to be had through providing services centred on an installed base of products, i.e. service and maintenance contracts for products already sold (Oliva & Kallenberg 2003). The Institute for Manufacturing's high value manufacturing framework (Livesey 2006) classifies the types of manufacturer in a products-service matrix according to whether revenue is being generated by products or services, and whether the majority of costs are associated with production or non-production activities. Manufacturers that have the majority of their costs in production and generate the majority of their revenue from the sales of these products are deemed to be traditional product manufacturers. Those who have begun to generate revenues from services associated with the products they produce, yet whose majority of costs still lie in the production activity, are described as service-led producers. When the majority of costs lie in non-production activities the business is a systems integrator, undertaking the complex activity of organising third party specialists to design and produce components that they must integrate into a functioning product (often a one-off): the sale of which generates the majority of revenue. Finally, service manufacturers have shifted their focus to providing services associated with their products, generating revenue from services and therefore having their costs associated with these non-production activities. Ultimately these companies may sell off their production capability entirely, wholly basing their business on providing support and services across a range of products.

Applying this framework to construction, a product manufacturer would be a company whose revenue is generated mainly through the construction of the product, i.e. the building, with the majority of costs being associated with the production activity, i.e. labour, plant and materials. In other words, a product manufacturer in the

construction industry is a building business that tenders for and builds construction projects, with margin being generated by the act of building alone. Should that type of business then begin to generate the majority of revenue through services associated with that product, for example maintenance of the asset, but with majority of its costs still being associated with the production activity, it would have become a service-led producer. Systems integrators, although still generating the majority of revenue through the production and sale of the building, have the majority of their costs associated with non-production activities, for example consultancy costs and design development costs: "These firms outsource detailed design and manufacture to external suppliers and contract manufacturers while maintaining in-house the systems integration capabilities necessary to co-ordinate a network of external component and subsystem suppliers" (Davies 2004:731).

A systems integrator is therefore a business that tenders for work and uses their expertise to integrate consultants and supply chain members to develop the best product for that customer given the brief, then managing that team to deliver the product. Although value and margin are generated through design and procurement of sub-contract packages in addition to the building, the majority of revenue still comes from the production of the building. As with systems integrators, the majority of costs for a service manufacturer are also associated with the non-production activities, although these activities have now expanded into business consultancy, financing opportunities and engagement of third party experts. Therefore, the key difference for the service manufacturer is that revenue is generated not only from the construction activity, but also from financing opportunities and aftercare services, such as facilities maintenance and operation. Service manufacturers (solutions providers) are therefore businesses that service a client's business needs, not just their building needs, through the provision and maintenance of an asset that has been tailored to let the client deliver their business objectives. Within the case study company, this concept of solutions provision as described by Alderman et al. (2002) is articulated as, for example, a desire to provide education facilities, rather than just building schools, which are designed and operated such that pupils achieve the desired exam results; or to provide healthcare facilities that enable the trust to achieve target waiting times and patient care costs, rather than just building a hospital and handing over the keys. However, questions remain as to whether this approach is viable given that service-led construction projects are not necessarily more profitable (Lind & Borg 2010).

The case study company is currently aspiring to make the transition from product manufacturer/systems integrator to service manufacturer. It would be easy for a business to claim that it develops "solutions" for its clients and is therefore a "solutions provider" or "service manufacturer." However, although companies claim they are delivering solutions, the underpinning requirements of solutions provision are difficult to embed in practice. The case study company is striving to implement these characteristics fully as opposed to creating a veneer of solutions provision through their marketing and work-winning activities: a transition that they recognise will require fundamental shift in the ways in which they mobilise and integrate their collective capabilities.

RESEARCH METHODOLOGY

Since the research aim was to uncover the problems associated with embedding the characteristics of solutions provision, a qualitative approach was taken within a case

study organisation, allowing an in-depth view of life to emerge through observations and the opinions of those involved (Easterby-Smith et al. 2008; Fellows & Lui 2008).

The case study company is a national UK contractor. Originally founded as a local builder, the business now operates from a number of regional offices that are supported by central functions such as procurement, design, finance, information systems and marketing. The business is part of a group of business that, having historically worked independently, are now actively looking for opportunities where they can horizontally and vertically integrate their offering to provide a full service that ranges from financing, design, construction through systems integration, mechanical electrical services, off-site manufacture and facilities management.

A literature review identified the characteristics of solutions provision. Brady et al. (2005b:573) state that firms wishing to make the shift to integrated solutions need to develop capabilities that "coalesce around four areas: systems integration, operational service, business consulting and financing." These four areas have been used as an evaluative framework from which a set of semi-structured interview questions was derived and against which management and project team meetings have been observed and benchmarked.

Fifteen semi-structured interviews were carried out with people from work-winning and project delivery teams, information systems (IS) and senior managers within the case study company. Over the course of twelve months the researcher also attended project launch, post project review and bimonthly management meetings.

The problems uncovered have been considered with respect to a prior study that identified the organisational path dependencies that exist within the business. Path dependency refers to the idea that events and decisions that have taken place in the past continue to influence current decisions and ways of working such that an organisation becomes locked into paths from which it can't break free (David 2001).

THE PROBLEMS ENCOUNTERED IN PRACTICE

Using the characteristics identified by Brady et al. (2005b) as a framework, each of the four characteristics is discussed, along with the problems encountered when trying to implement them in practice. Comments in quotation marks that are not referenced have come from the interviews, visits and meetings observed, and remain unattributed to maintain participant confidentiality.

Systems Integration

Systems integration, deemed to be the core capability (Brady et al. 2005b), concerns the ability of the business to integrate and manage all parties involved, both internal and external, in the design, development and co-ordination of components and systems such that they come together as a functioning asset, i.e. a completed building.

From the 1980s, when the business grew through acquisition from a local, regional builder into a national contractor, it ostensibly became a systems integrator, managing sub-contractors, suppliers and consultants in the delivery of construction projects. More recently, the vertical integration of the construction, mechanical & electrical services and facilities management businesses within the group provided the opportunity for increased integration and whole life cycle offering to the client. Yet, despite, arguably, years of experience in systems integration, there remain challenges in embedding the characteristic to a repeatable standard.

Systems integrators need to maintain relationships with customers and ensure the integration of all parties throughout the project. However, "due to busyness of work-winning teams and time taken to convert projects, work-winning team involvement often ends at handover," i.e. on contract award the team who won the contract hands it over to a new team who are responsible for building it. Project managers, tasked with the construction phase of the contract, speak of feeling "vulnerable as they don't understand the history (of the project to date) whilst others around the table (the client and consultants) do." Clients are therefore presented with a new set of faces at handover, resulting in deterioration of the customer relationship as the delivery team feel they "don't know what they are building" and that "someone else has sold something we can't deliver." In addition, there is duplication of effort as the delivery team re-work activities that have already been done by the work-winning team, but which haven't been communicated to them. Similarly, project delivery personnel are often unavailable to support work-winning teams as they are busy completing their current projects: one senior manager noted that "requests for resources are often made and sometimes given."

Systems integration fundamentally requires continual co-ordination of all parties involved: client, sub-contractors, suppliers, consultants, etc. This disconnect between work-winning and project delivery teams, the "front end" and "back end" business units described by Foote et al, (2001), is therefore an anathema to achievement of systems integration. Inadequate resource planning, lack of resources and transient project delivery teams determined by geography rather than project requirements are all underlying issues which result in inadequate handover and therefore a severing of the flows (Koskela 2000) (of, for example design information) that are critical to systems integration. These issues in turn are reinforced by commercial and accounting practices. For example staff costs have to be recovered to live projects, driving the behaviour of keeping the amount of time spent on work-winning activities to a minimum. Further, in the case study company, the disconnect between work-winning teams, which includes head office staff, and regional project delivery teams, is a path dependency rooted in historical events.

Systems integration with other group businesses is similarly influenced by history and continually reinforced by each business operating its own processes in isolation, having their own project teams that duplicate responsibilities, and having to meet individual company profit and loss targets that drive competitiveness rather than collaboration. There are examples of commercial teams sending letters regarding variations and additional charges to their counterparts at another group business when they are working on the same project, essentially moving money around the group rather than taking an overall project perspective.

Supply chain integration is inhibited by clients influencing forms of tendering, i.e. competitive, which often lead to "solutions" becoming value engineering alternatives that are driven by bid competitiveness rather than client needs. The case study company also reverts to its "builder" mentality: another ingrained path dependency. Intention to collaborate with supply chain members through sharing of future opportunities, open book costing and design development to achieve best solution often resorts to "scoping" of quotes at the last minute in order to ensure a competitive bid, i.e. reducing a sub-contractors quote by a certain percentage without their knowledge at tender stage with the intention to let the work to another sub-contractor/state they have to meet that price to retain the contract.

Business Consultancy

The transition to solutions provision necessitates a subtle but drastic shift in the understanding of what "solution" means. Presently, in the main, the case study company receives a tender enquiry and will work to develop alternative designs and solutions to the specification and drawings developed to date by the client and their team of consultants. Submitting a non-compliant bid, i.e. a building design that is outside the tender specification, is a gamble that may or may not pay off.

However, an organisation that is a solutions provider is not just looking to offer alternative building designs and specifications. Business consultancy capabilities should enable a deep understanding of the customer's business, not just their proposed building specification and use. Business consultancy skills should be used to understand the client's business objectives and fundamentally assess how they might meet these business needs - a new building may or may not be a requirement. Solution refers to business solution, not building solution.

In the first instance, finding clients at this early stage is rare as traditionally they approach contractors at a later stage in the process and then choose forms of tender and contract that require competitive bidding. Much work is needed to enable earlier engagement with clients, along with likeminded clients who are prepared to embrace the aspects of business consultancy required to ultimately enable solutions provision.

Senior managers in the business acknowledge that the ability to resource work-winning teams is an issue as operational pressures take precedence. Despite a core of work-winning staff, additional staff supplement these teams as and when they are released from on-site roles. Work-winning teams therefore become 'jack of all trades and master of none,' with their focus being on design alternatives rather than client business solutions.

This situation is exacerbated by a lack of information and poor feedback and learning loops. Information relating to all aspects of previous projects, including post occupancy data, should be available to all in the group so they can use that intelligence and technical information to shape future solutions. In reality, there are "no real feedback loops, arrogance and availability of previous information is scant" and "post occupancy surveys currently not on the agenda." In addition, the in-house developed IS enterprise management system (used for example for managing project information, customer details and invoicing) is seen as not being user friendly, and since it cannot be accessed by other businesses in the group is a barrier to information capture, sharing and analysis.

The departmental silos, family business heritage and IS infrastructure are organisational path dependencies, uncovered in a previous study (Morrey et al. 2012), that can be seen to be influencing the transition to solutions provision. Historical decisions lead to the creation of separate businesses and regions within businesses that still do not share information. The family business heritage is evidenced in the insular approach and unwillingness to learn, hence the "arrogance" regarding collecting feedback, exacerbated by systems that people are reluctant to use.

Operational service capabilities

One of the group businesses is a facilities management (FM) and interiors refurbishment business. This business has the capabilities to maintain, update and manage the operation of a building and its systems throughout its lifecycle.

The challenges associated with this characteristic of solutions provision are concerned with the ability of the group of businesses to overcome their organisational silos. Presently, information is not shared across the businesses in the group as each has separate systems and processes, and teams are not shared across projects. Involvement of the FM business is thought about as projects delivered by the case study company are coming to completion on site, rather than at the start of the relationship with the client when there is opportunity to use the FM business' expertise to inform the solution. This ineffective "handover" from the team in the case study company to the team in the FM business is the same as that discussed previously where the work-winning team hands over to the project delivery team. The client suffers at this pinch point where information flows are interrupted due to the arrival of new people with no prior experience of the project and a lack of process/mechanisms to enable them to quickly gain the knowledge they require.

Financing

Finally, the capability to "provide customers with assistance in purchasing new systems and in managing their installed asset base" (Brady et al. 2005b: 573) is a characteristic of solutions provision. PFI, a means of procuring public infrastructure developments, are probably the most well-known means of private businesses providing funding for construction activities and the basis of the service manufacturer examples in the construction sector (Johnstone 2008; Leiringer 2009). The challenge within the case study company is finding a willingness to commit resource, and therefore find those with the skills, to proactively look for opportunities for manufacturing service. The wide range of funding opportunities, for example providing loans for construction phase, supporting the client's cash flow or making much longer term investments, on one hand provides plenty of options but on the other can seem daunting. With the business currently winning the majority of its work competitively and therefore reactively, encouraging people to spend more time up front in investment considerations is proving difficult: imminent work takes priority. The subsequent challenge having identified an opportunity is gaining approval from the Group Board and shareholders to provide funding to the client, which requires being able to evidence robust processes that are fully complied with, thereby proving there is appropriate governance and risk management protecting their investment. In an organisation that has grown through regional acquisitions and has regional silos that have led to local ways of working, satisfying the Group Board that there is appropriate governance is challenging.

Summary of findings

The problems encountered touch many aspects of the organisation: people, rewards, accounting practices, organisational design/structure, resource planning, processes and systems. At present, these are primarily designed to support production activities and, as such, associated measures and targets continue to drive the product manufacturer/systems integrator agendas rather than the new strategy for solutions provision and its inherent focus on customer needs.

In addition, the imbalance in focus - in terms of resources, capability, targets - between the front end and back end teams needs to be evened so that there is a mutually supportive arrangement. Front end teams need to have the business consultancy and financing time and skills to negotiate and develop opportunities, receiving the same recognition and incentives as the back end teams who need to

continually develop their capabilities and improve the offering that the front end teams can sell.

A strong centre (Foote et al. 2001) that sets a clear strategy and mediates between teams across the business is therefore required in order to connect these aspects of solutions provision and ensure they are working towards the same goal. Similarly, feedback loops that prompt reflection and learning will also enable teams working in different phases of the project life cycle to connect their activities with the wider goal of developing and delivering solutions.

PRACTICAL MECHANISMS TO MAKE CHANGE

Despite the problems outlined in the previous section, the business has had some success in solutions provision, although there remains much more work to be done before it could be considered that it is able to do this repeatedly. As suggested by Brady et al (2005b), the learning gained from projects where the business has specifically focused on delivering solutions has been captured and is being used to develop company-wide processes and capabilities.

During the last three years, founded on lean philosophy, the business has involved its people in the development of standard processes that are aimed at ensuring consistency across all the business and repeatable systems integration. These standard processes, which include lean construction techniques such as Last Planner (Ballard & Howell 2003), have been implemented through in-house delivered training, compliance audits and management checks. Changing the business' operating routines has been shown to help overcome some of the path dependencies (Morrey et al. 2012) and has also helped develop new capabilities as well as improve performance. These now need to be developed further, paying attention to ensuring there is a flow of common understanding (Pasquire 2012) across all parties involved in the project thereby enabling the co-creation (Vargo et al. 2008) and delivery of value.

More recently, the business has restructured its professional support services - IS, business systems, finance, marketing and human resources - so there is one team for each function that works across all group businesses. It is anticipated that aligning the strategies of these service departments to the group strategy of service manufacture will support the transition. For example, part of the IS strategy is an enterprise content management system that will provide the platform for shared processes and shared information, all of which can ultimately be extended to third parties to ensure full collaboration. Also, the Building Information Modelling agenda, being led by the UK government and some clients, and therefore arguably an accepted reason for change, is being used as a mechanism to improve information collection, encourage innovation and manage knowledge. This will support the business consultancy and systems integration characteristics of service manufacture.

CONCLUSIONS

This paper contributes to the growing construction related products-service literature by providing an insight into the practical problems faced by a contracting organisation that has a vision to become a service manufacturer, providing solutions to its clients. With the majority of literature primarily based in the manufacturing and goods sectors, and also consisting largely of theoretical models and generalisations in terms of what needs to change, for example, 'develop capabilities' and 'restructure' that make the transition seem simple (Johnstone et al. 2008), by contrast this study describes the day to day complexities associated with making these changes.

Using the characteristics outlined in Brady et al. (2005) as a framework to examine where the problems lie offers a way of exploring readiness to provide integrated solutions, in addition to showing the relevance of these characteristics to the construction sector. What remains unclear are the relative importance of each of the characteristics to making the transition to service manufacturer, and the priority of addressing these in a business that is concurrently delivering a number of projects, not all of which demand an integrated solutions approach.

Having operated for over a century, for the majority of the time as a product manufacturer, the business is struggling to overcome its path dependencies, existing routines and organisational structure that have all hitherto been aligned to meeting internal performance targets. Realigning all these aspects of the organisation to attend to the new strategy of service manufacture, the purpose of which is adding value to the customer by "providing products and services that create unique benefits for each customer," (Brady et al. 2005a:362) has been shown here to be challenging.

Repeatable systems integration, arguably yet to be proven to be the core characteristic, remains problematic even in a well-established contracting business. The opportunity for deterioration in the understanding of customer value at specific "handover" points in the project jeopardises not only the customer relationship but also the chances of the team delivering the desired outcomes. Organisational structures, accounting practices and reward mechanisms, along with outdated processes, all serve to reinforce the old strategy.

Similarly, integration across the group of businesses is also problematic in practice. Historical decisions taken to ensure each business could operate independently now inhibit collaboration. The creation of Professional Services teams that serve all of the businesses is aimed at developing human resources, information systems, finance, marketing and business systems strategies that will reach across the divides.

The problems discussed here are actively being addressed by the business which is currently juggling the implementation of a new strategy whilst also having to continue to deliver product in a traditional way. In particular, practical mechanisms are being developed that will bring operating routines in line with the new strategy, actively encouraging people to work differently and thereby develop new capabilities.

Finally, the paradox of developing bespoke solutions for each client versus creating standardised offerings that can be picked to create a client specific package has yet to be solved. In the relatively new and immature marketplace for integrated solutions in the construction sector, the company is currently pursuing a variety of opportunities in which it can engage with clients, focusing on their individual needs, rather than creating standard services and/or products that it tries to fit to customer needs. Whether economies of scale and learning from delivering solutions will drive the business down a certain route is yet to be seen, but will undoubtedly be considered in future work.

REFERENCES

Alderman, N, Ivory, C J, Vaughan, R, Thwaites, A and McLoughlin, I P (2002) The project management implications of new serivce-led projects. British Academy of Management Conference, London, 9-11.

Baines, T S, Lighfoot, H W, Benedetti, O and Kay, J M (2009) The servitisation of manufacturing. "Journal of Manufacturing Technology Management", 20(5), 547-67.

Ballard, G and Howell, G (2003) Lean project management. "Building Research and Information", 31(2), 119-33.

Brady, T, Davies, A and Gann, D (2005a) Creating value by delivering integrated solutions. "International Journal of Project Management", 23(5), 360-5

Brady, T, Davies, A and Gann, D (2005b) Can integrated solutions business models work in construction? "Building Research and Information", 33(6), 571-79.

David, P A (2001) Path dependence, its critics and the quest for "historical economics". In P. Garrouste and S. Ionanides (eds.) "Evolution and Path Dependence in Economic Ideas: Past and Present." 15-40. Cheltenham: Edward Elgar.

Davies, A (2004) Moving base into high-value integrated solutions: a value stream approach. "Industrial and Corporate Change", 13(5), 727-56.

Easterby-Smith, M, Thorpe, R and Jackson, P R (2008) "Management Research". 3ed. London: Sage.

Fellows, R and Liu, A (2008) "Research Methods for Construction". 3ed. Oxford: Wiley-Blackwell.

Foote, N W, Galbraith, J, Hope, Q and Miller, D (2001) Making solutions the answer. "The McKinsey Quarterly", 3, 84-93.

Galbraith, J (2002) Organizing to deliver solutions. Prepared for Special Issue of Organizational Dynamics.

Gebauer, H and Friedli, T (2005) Behavioural implications of the transition process from products to services. "Journal of Business & Industrial Marketing", 20(2), 70-8.

Johnstone, S, Dainty, A R J and Wilkinson, A (2008) In search of "product-service": evidence from aerospace, construction, and engineering. "The Service Industries Journal", 28(6), 861-75.

Johnstone, S, Dainty, A R J and Wilkinson, A (2009) Integrating products and services through life: an aerospace experience. "International Journal of Operations and Production Management", 29(5), 520-38.

Koskela, L (2000) "An exploration towards a production theory and its application to construction." Espoo, VTT Building Technology. 296 p. VTT Publications; 408. www:http://inf.vtt.fi/pdf/publications/2000/P408.pdf.

Leiringer, R, Green, S D and Raja, J Z (2009) Living up to the value agenda: the empirical realities of through-life value creation in construction. "Construction Management and Economics", 27(3), 271-85.

Lind, H and Borg, L (2010) Service-led construction: is it really the future? "Construction Management and Economics", 28, 1145-53.

Livesey, F (2006) "Defining High Value Manufacturing." University of Cambridge Institute for Manufacturing.

Morrey, N, Pasquire, C.L, Dainty, A.R.J and Thompson, D.S (2012) Path dependency to path creation: enabling strategic lean implementation. In: Tommelein, I.D and Pasquire, C.L (Eds.) "20th Annual International Group for Lean Construction Conference", 17th-20th July 2012, San Diego State University, USA. Vol. 1, 241-50.

Oliva, R and Kallenberg, R (2003) Managing the transition from products to services. "International Journal of Service Industry Management", 14(2), 160-72.

Pasquire, C (2012) The 8th flow - common understanding. In: Tommelein, I.D and Pasquire, C.L (Eds.) "20th Annual International Group for Lean Construction Conference", 17th-20th July 2012, San Diego State University, USA. Vol.1, 21-9.

Vargo, S L, Maglio, P P and Akaka, M A (2008) On value and value co-creation: A service systems and service logic perspective. "European Management Journal", 26, 145-52.

IMPLEMENTING AN OFFSITE CONSTRUCTION STRATEGY: A UK CONTRACTING ORGANISATION CASE STUDY

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Many United Kingdom (UK) contractors only consider offering offsite solutions on a bespoke project-by-project basis, with very few having immediate plans for integrating fully offsite manufacturing as part of their core business strategy. Limited literature exists regarding how a major UK contractor could achieve such a strategic offsite capability, as this capability is usually referred to as an out-sourced, sub-contracted activity. The concept of a major contractor providing its own capability and completing large scale infrastructure projects using offsite construction (OSC) methods is not common in the UK, although the concept is less rare in certain other countries, such as Australia. The aim of this paper is to determine the benefits that OSC can offer for UK contractors and to investigate how an offsite strategy can be implemented in practice. Semi-structured interviews were conducted with a major UK contractor, transcribed, and thematically analysed to determine how effectively the offsite strategy and methods were being implemented at different levels within the contractor's operations. The potential attractiveness and future of offsite for major UK contractors is discussed. The paper concludes with three recommendations for contractors considering the development of offsite capability. First, commitment from senior leadership at a strategic level, second, clear communication to all level through the firm and third, investment in innovation.

Keywords: case study, contractor, infrastructure, offsite, prefabrication, strategy

INTRODUCTION

Significant research into the drivers and barriers to OSC has been undertaken (Nadim and Goulding, 2010; McKay, 2010; Blismas et al., 2005; Gibb, 2001; Goodier and Gibb, 2005a; Goodier and Gibb, 2007). Attempts to establish similarities in approach between construction and manufacturing companies have been made, and it has been commonly suggested that OSC should utilise manufacturing techniques similar to those used in automotive manufacturing (Egan, 1998; Crane et al., 2002; Constructing Excellence, 2009). Currently, the UK Government is looking into offsite as an option for cheaper, more affordable housing (Miles and Whitehouse, 2013). There is also significant knowledge regarding the principles behind manufacturing and offsite (Gann, 1996; Pan and Arif, 2011; Gann, 2010). There is little literature, however, on how a major construction contractor could begin to achieve its own in-house offsite capability, other than simply taking advantage of a project-specific opportunity. The process is usually referred to as an out-sourced, sub-contracted activity (Yorkon,

Vernikos VK, Nelson R, Goodier CI and Robery PC (2013) Implementing an offsite construction strategy: a UK contracting organisation case study *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 667-677.

2013). The idea of a major contractor providing its own capability while completing large scale infrastructure projects for clients using OSC is rarely discussed. “The question remains, what construction companies have to be mindful of, when going for manufactured construction?”(Pan and Arif, 2011). The aim of the research is to identify key measures that will enable a contractor to successfully obtain an offsite capability.

Manufacture and Construction

The performance of the UK construction industry has been frequently debated, with the industry's perceived poor performance commonly cited (Latham, 1994; Egan, 1998; Crane et al., 2002; Constructing Excellence, 2009). Specifically, the efficiency of construction activities is frequently questioned, particularly by Egan (1998), who thought that "within five years, the construction industry should deliver its products to its customers in the same way as the best consumer-led manufacturing and service industries. To achieve the dramatic increases in efficiency and quality that are both possible and necessary we must all rethink construction”. These reports have increased the profile of offsite and encouraged debate (Pan and Arif, 2011; Constructing Excellence, 2009).

OSC could be described as a manufacturing process used within construction by virtue of its production process, prior to transportation and installation. Business leaders in manufacturing are often cited as championing standardisation and mass production (Pan and Arif, 2011). Increased standardisation of components in buildings can result in fewer defects, higher quality and a more reliable rate of production depended on less fluctuation in construction programmes of projects (Egan, 1998; Gibb and Isack, 2003). As a result of Henry Ford’s vision, mass production became “almost synonymous to manufacture” (Crowley, 1998). Pan and Arif (2011) claim that customised production could not offer benefits, such as economies of scale, that mass production provided. However, it is recognised that mass production is not necessarily an aim for all OSC products, particularly with infrastructure projects which are often "prototype" projects - one-off construction of a particular size, span, skew or other trait.

Egan (1998) based his recommendations for improvement on the techniques of automotive manufacturers. This raised the question of whether the construction industry could adopt a similar approach. In the automotive industry, “products” cover a wide range of vehicle sizes and types. All production is undertaken in controlled environments and the basic "model" is standardised with only matters of detail being varied. Strategic plans for manufacture are made across cycles of several years. Planning considers the whole life-cycle of many of the lines launched within this period. Automotive manufacturers aim to predict the expected sales of prospective product releases before planning for production capability and resourcing (Fleischmann et al., 2006). Buildings however, have a longer life-cycle than cars and higher unit production costs. This makes sales planning over such lengthy periods challenging. In construction the "product" provided is significantly different with regards to output (Gann, 1996; Pan and Arif, 2011). When compared to many other manufactured "products", housing and buildings have complex components and are of a much larger scale, and with greater expected durability (Pan and Arif, 2011). Pan and Arif (2011) discuss “the logic of mutual learning between construction and manufacturing is perceived to, and should, be embedded in the many attempts to address their relations”.

BACKGROUND

The UK OSC market

Various attempts have been made to quantify the UK OSC market (Goodier and Gibb, 2005b; Goodier and Gibb, 2007). The size of the UK "offsite fabrication" market was estimated to be worth £800.9m in 2002 (Samuelsson et al., 2003), which is 1.7% of new construction (£47.137bn in 2002). Goodier and Gibb (2007) estimated the total value of the OSC market in the UK in 2004 to be £2.2bn, with the total value of the UK construction sector being £106.8bn. The proportion of the UK offsite market was therefore 2.1% and was predicted to reach approximately £4bn by 2009. BuildOffsite predicted a market of £6bn by 2009 (Goodier and Gibb, 2007). Taylor (2010) obtained financial accounts for 245 companies operating within the UK OSC sector. From the market's turnovers and profits, he estimated that the value of the OSC would contribute between 6% and 7% of construction output and the value predicted for 2013 was £4.8bn (Taylor, 2010). This 2013 prediction considered the recession of 2008-09 whereas Goodier and Gibb's (2007) did not. Nadim and Goulding (2010) explained that the majority of growth would be in new buildings rather than refurbishment work and that the UK was ready to “embrace offsite production”. At that time, two thirds of respondents felt the UK was ready for such an uptake.

Historically, in the UK profitability for contractors has been low, with large turnovers required to generate significant economic stability. The Government’s Department for Business and Innovation and Skills (2011) provided data on Key Performance Indicators (KPI’s) across the whole construction industry which demonstrated further evidence of this decline in profitability. These statistics supported by the Construction Excellence report (2009) emphasise that the construction industry getting by without much innovation before the recession. The industry’s productivity was clearly dropping, whilst profits were rising and staying high. Only once profits began dropping, productivity within the industry began to increase dramatically. This was an economically unstable practice and required "significant improvement" (Constructing Excellence, 2009).

Research and Development (R&D) in the UK construction industry

R&D in the construction industry has been frequently debated (Hampson and Brandon, 2004). The amount of money spent on R&D in the UK construction industry is insufficient to lead to performance improvements (Dulaimi et al., 2002). Sir John Fairclough’s 2002 report concluded that a “modern, efficient, high quality construction industry” would benefit society. In order to achieve this, he recommended innovation driven by R&D activities (Fairclough, 2002; Kulatunga et al., 2007 and 2009). Macmillan (2002) also argued that R&D activities were important in improving the performance of the UK construction industry. R&D has been credited with the ability to influence and encourage best practice within the industry (Barrett, 2007). As with any exploratory activity however, there are risks attached to undertaking R&D activities (Van Rooij, 2008; Mitchell and Hamilton, 2007). Kulatunga et al. (2009) discuss that R&D activities may not always deliver obvious benefits or generate large profits, but there is a possibility that construction organisations could benefit in the long run by considering less obvious innovations and changes. They argue that effective management to minimise the risks of R&D was required in industry, as opposed to “rejecting R&D altogether”.

The need for more R&D, innovation and OSC is discussed by the literature, however innovation is risky, and offsite requires investment in manufacturing. Hence, if a major contractor chooses to invest, aside of the technical difficulties, it is critical to methodically review the company's culture aiming to embrace OSC within its normal business processes.

RESEARCH METHOD

Qualitative case study analysis based predominantly on the Eisenhardt (1986) approach was employed, focusing on capturing the dynamic research potential of offsite innovation in an organisation by using multiple levels of analysis within a single study. A literature review was firstly undertaken, including content analysis of industry reports (i.e. annual reports, company websites and business strategies). After reviewing the innovation strategies of the six leading UK contractors one was chosen to be investigated due to its company strategy being strongly aligned towards offsite innovation. Nine members of staff were interviewed, representing a variety of seniority levels and roles within the firm, from site civil engineers, to construction managers, to senior commercial managers. This sample enabled comparisons between the opinions of technical and commercially orientated staff's views of the firm's innovation and offsite strategy.

Semi-structured interviews were employed to enable maximum input from the interviewees whilst allowing data to be collected uniformly (Glaser and Strauss, 1999). The first phase of the interview was structured using an interview pro-forma, followed by more in-depth discussions on key points identified by the interviewee. In order to identify the most appropriate people to interview a combination of purposive and "snowball sampling" (Dawson, 2009) was conducted. All interviews were recorded and transcribed. Thematic analysis was employed to compare the interviewees' responses amongst themselves and also against their firms' innovation strategy and the literature, in order to allow triangulation of the data (Glaser and Strauss, 1999).

ANALYSIS AND FINDINGS

Although OSC was mentioned by four of the six contractors in their annual reports as being a competitive advantage for the firm (Table 1), it was evident from their strategy that Firm C was making the most significant steps in achieving its own offsite capability. The six documents reviewed may not cover all aspects of the firms' commitment to construction innovation and OSC nevertheless the research considers them valid sources of qualitative data as they are the formal and official strategy. Other firms were more unclear as to how they were investing in and developing offsite, if it was mentioned at all. Most commonly it was through specialist suppliers on a project-by-project basis.

Table 1: Summary of the leading contractors' competitive advantage propositions according to their strategy or annual reports from 2011 and 2012

Competitive advantage stated in company literature	Contractors					
	A	B	C	D	E	F
Sustainability			X		X	X
Quality			X		X	X
BIM	X		X			
Culture	X	X			X	
More comprehensive capabilities than competition	X	X				
Asset Management	X					
While-life cycle services	X	X	X		X	X
OSC	X		X	X		X
Supply chain engagement	X	X				

Offsite strategy implementation in firm C

The analysis aimed to investigate whether the employees of firm C were aware of and actively implementing elements of the business strategy put in place to increase the usage of OSC throughout the organisation. Various benefits of offsite were presented in their company strategy; six aspects of the strategy were considered - 3 were strategic objectives (offsite as core process, commercial benefits and cost savings) and 3 were benefits on projects (quality, safety and sustainability improvements) and these were used for the interviews.

In terms of the benefits highlighted in the firm's annual review, business strategy and discussed with the interviewees, 7 of the 9 respondents felt that offsite was giving the company a slim "edge" over the competition. 6 respondents felt offsite provided quality improvements. With regards to safety, 6 respondents felt that safety improvements were provided by offsite. The greatest disagreement was when respondents were asked if they felt offsite created cost savings for their firm, with 4 positive, 2 negative and 3 with divided opinions. The more senior engineers explained that the upfront costs for projects could be offset by the reduction in site labour and programme duration. Some stated that they "knew" the firm was currently subsidising its offsite activities, but believed that in the long-term cost savings would materialise and hence increase profit margins. The current main saving cited was a reduction in material deliveries in comparison with in-situ construction, leading to far less deliveries, as well as a reduced carbon footprint, depending on the size of the item.

All 9 interviewees claimed that quality improvements were achieved through the usage of offsite. However, two did express their concern regarding the achievable quality improvements as they experienced quality issues and defects on some projects. The defects did not occur during the manufacturing phase but predominately during the delivery and installation process. This could be attributed to lack of experience in offsite and installation of some of the site staff. Two respondents (who had both operated in technical on-site roles) provided examples of effective offsite implementation. One explained that offsite usage provided "a different set of challenges", supporting Nadim and Goudling's (2010) findings on the difficulties in utilising offsite solutions. Sizing issues with the offsite deliveries from the manufacturing facility were mentioned and it was explained that it is very difficult to adjust to incorrectly provided or late changes in dimensions, which could be managed more easily with in-situ techniques. Effective management of the "organic" or "live"

environment of construction sites and contractor activities was also highlighted as very important. Drawing changes were also sometimes being made after offsite components had been manufactured and dispatched for the site, causing fabrication problems. This is supported by the literature as a lack of flexibility in offsite designs and as a barrier to greater uptake (Nadim and Goulding, 2010; Goodier and Gibb, 2007). A respondent also stated that "information management is very important for successful usage of offsite."

Sustainability benefits due to offsite were mentioned by only 4 interviewees. Most interviewees understood sustainability solely as having environmental impact and dismissed or didn't mention the economical and social aspects. Nevertheless, some raised the concern that the adaptation of offsite at a national scale may result in the reduction of labouring jobs and reduced income for many construction operatives. In addition, all of the respondents except one felt offsite usage provided savings in the construction programme. Customer satisfaction was only cited by two interviewees as a benefit for offsite, both of whom were from a commercial background. This could suggest engineering staff are more focused on the benefits to site operations and project delivery, whilst commercial staff are better able to appreciate client driven aspects.

Issues affecting successful Offsite

The most commonly mentioned barrier was the up-front cost to set up a manufacturing facility, particularly with the current UK economic circumstances. This was mentioned by all respondents to differing degrees. An additional barrier was the availability of good external specialist suppliers. By using only one source of manufacture, there was a high risk that problems at the source would affect all of the supplied projects. Strong management of information and quality within the manufacturing facility is needed to combat this. It was explained that in their experience, external suppliers cost the same as if the firm produced its own offsite components. The initial cost to develop offsite capabilities can be seen as unnecessary if the production costs are not cheaper in the long run, but it is worth noting, as stated by few of the interviewees that when components are self-produced, money is being kept within the contractor's business, which can have positive impacts on cash flow and company turnover. Additionally, offsite was sometimes seen as a potential barrier to winning work, with the firm's offsite strategy encouraging and promoting its use where appropriate. Care therefore had to be taken to ensure that offsite was not employed where an in-situ or bespoke solutions would be more appropriate. Further barriers also included geographical location, as some projects may be too far for delivering components. The time delay for successful training of a manufacturing workforce must also be considered, and was cited by two respondents. The case study contractor is a privately owned construction company, whilst the contractors with similar levels of turnover and delivering similar projects were publicly owned by shareholders. The requirement to satisfy shareholders was seen to be a barrier to significantly changing a companies' business model and strategy in order to adopt a more offsite capability. It was felt that the nature of the construction industry, with companies currently taking work at very low profit margins, was leading to more short-sighted planning and business decisions rather than forward thinking innovations, supporting the Nadim and Goulding (2010) survey of construction companies. Many felt that smaller companies did not have the necessary volume of work to make offsite use economically viable.

Implementing the Offsite

It is evident via the interviews and the company strategy that the firm is committed to supporting the implementation of offsite via various methods. These include a company intranet, which provides basic information and raises awareness of best proactive examples through an online catalogue of the offsite components available to site teams, and a graduate development programme that focuses on educating the inexperienced engineers with regards to the importance of offsite and its application. The company holds two "road shows" per year, where business leaders and directors communicate with all employees, with the aim of motivating the staff and keeping them focused on the firm's offsite targets. This provides a structured way for project leaders to communicate to site teams particular offsite solutions that may be best for individual projects.

When asked if the aim of the firm's strategy was achievable, the general response was positive, but with conditions. One third of the respondents were entirely sure that the aim could be achieved. Many issues with over-expectation were provided by the other 6 respondents. The suitability of all project types was mentioned; not all projects can use offsite solutions, such as refurbishment contracts. Examples were provided where the site team found the utilisation of offsite solutions on refurbishment projects to be challenging, particularly where assembling prefabricated components indoors was not possible. This supports Blismas et al.'s conclusions (2005) that projects should be considered individually before offsite is recommended, to ensure suitability. Nadim and Goulding (2010) also predicted that there would be a rise in offsite usage for construction projects, but not refurbishment projects. Three respondents felt that achieving the strategic offsite implementation aim by 2020 was unrealistic, with one respondent remarking, "it could be achieved perhaps, but perhaps the business is pushing a little too hard for it."

DISCUSSION

The research showed that the innovation strategy employed by the case study firm was targeting many of the offsite benefits cited in literature and the strategy claimed that the vast majority were being realised on projects. Although all the companies in Table 1 mentioned "innovation" multiple times in their annual reports and strategies, investing in R&D was not mentioned in any, which is crucial for increasing productivity (Latham, 1994; Egan, 1998; Fairclough, 2002).

The UK government has been prompting improvements in the industry's performance and profitability for many years, suggesting OSC as a possible solution (Latham, 1994; Egan, 1998; Crane et al., 2002; Constructing Excellence, 2009). According to the interviewees, the costs of providing manufactured solutions are very similar to using in-situ solutions. Nevertheless, the firm's strategy is hoping to have savings due to reductions in wasted materials, labour requirements on site and shorter programmes. A major contractor providing its own offsite manufacturing capability is an innovation to the traditional contractor business model. However, the techniques utilised are not all completely new and there are many established companies who have been providing offsite solutions for many years. A risk-averse culture is resistant to change (Kulatunga et al., 2009), but effective management can minimise the risks of R&D and will provide far greater benefits for industry than simply rejecting R&D altogether.

Although is the firm has a precise strategy with targets for offsite, the respondents indicated that offsite is used on a project-by-project basis and wherever it is seen as appropriate. It was made clear that there are no formal measures in place to force offsite upon project teams, supporting Blismas et al.'s (2005) advice on considering projects individually for OSC suitability. Only two of the respondents could quote the firm's set targets for offsite on projects. All respondents felt that having a robust offsite strategy will provide the firm with a future commercial advantage in the UK construction market place. However, there was some scepticism with regards to the return on investment as the cost for providing such capability will take "a long time to pay off". The firm's annual review explained that the offsite agenda is currently being subsidised within the business, and that on-going R&D was required, with £7m being spent in 2011-12. In the short-term, offsite capability may not be providing the firm with a financial advantage. But when work-winning for future projects and leading the market place in the future, the respondents believed that there may be significant benefits from differentiating their operating model from the more traditional one (and from others). Most believed that this speciality of the firm allows them to undertake projects that other competitors may not have the capacity or reputation to undertake. However, concerns were expressed as to how clients and local people would react to decreased employment opportunities as a result of reducing labour on site.

With regards to employee buy-in, the respondents were aware of the firm's dedication to an offsite agenda and agreed it would be the future for the business. The aim to achieve offsite capability was introduced in the firm's 2007 annual review, suggesting that on-going planning was taking place. Technologically, a company taking on the entire responsibility for manufacture and installation without specialists is seen as a great innovation (Teece, 2010). All interviewees were confident that the firm had the resources in place to achieve its offsite goals, but not by 2020 (as per the firm's aim). It was also made clear that there were two sides to the issue, as there may be an advantage to some projects but on the contrary, the firm may alienate itself from other potential projects where offsite is not suitable. There was a general belief amongst all the respondents that competitor firms were waiting to see whether this offsite initiative would be successful. Indeed, successful business models are usually copied, ultimately giving rise to many competitors within single industries (Teece, 2010).

Bessant and Tidd (2007) claim that, "the survival and growth question poses a problem for established players but a huge opportunity for newcomers to rewrite the rules of the game". OSC may offer a construction contractor significant commercial success if they are able to implement it and provide it for clients in an attractive way. Innovation is also credited to larger organisations in most cases due to their ability to invest in R&D and create new ideas and concepts to bring it to the marketplace (Mann and Chan, 2011).

CONCLUSIONS

Three main strategic measures appear to be required in order for a major contractor to successfully obtain an offsite capability. Firstly, a leadership team who are committed to achieving innovation through OSC, exhibited in this case through the development of an in-house consultancy cross-cutting the organisation, with an emphasis on innovation. Secondly, clear communication is needed to employees at all levels regarding the intention to use OSC e.g. communication best practice examples from project leaders to site teams on individual projects and training of graduates who may go on to become future site managers or business leaders. This commitment to

communicate the importance of offsite was also exhibited here through the firm's online intranet and in-house catalogue of available offsite components. Thirdly, it must show commitment through investment in R&D and a clear business strategy.

FURTHER RESEARCH

A similar interview based case study research should be undertaken with employees of other major contractors to gauge their thoughts on OSC and compare perceptions. A detailed cost-benefit analysis should take place on the construction and operation of an Offsite manufacturing facility to provide quantitative data for future business cases for Offsite manufacturing capabilities. Contractual agreements should also be investigated as they may act as a hidden barrier to OSC. Finally, an undated investigation into client perceptions of OSC will provide clarity on whether the UK construction is increasing the usage of OSC as dated literature claims.

REFERENCES

Barrett, P., (2007) Revaluing Construction: a holistic model, Building Research and Information, 35(3), 268-286

Blismas, N., Pendlebury, M., Gibb, A., and Pasquire, C., (2005) Constraints to the Use of Off-site Production on Construction Projects, Architectural Engineering and Design Management, 1(3), 153-162

Bryman, A., (2008) Social Research Methods, 3ed. Oxford: Oxford University Press

Crane, A., (2002) Rethinking construction [Online] Available at: http://www.constructingexcellence.org.uk/pdf/rethinking%20construction/Rethinking_Construction_2002.pdf [Accessed: 26/04/2013]

Crowley, A., (1998) Construction as a manufacturing process: Lessons from the automotive industry, Computers and Structures, 67, 389-400

Dawson, C. (2009) Introduction to Research Methods: A practical guide for anyone undertaking a research project. 4ed. Oxford: Howtobooks, UK

Dulaimi, M.F., Ling, F.Y.Y., Ofori, G., and De Silva, N., (2002) Enhancing integration and innovation in construction, Building Research and Information, Vol. 30 (4), 237-47

Egan, J., (1998) Rethinking construction : the report of the Construction Task Force to the Deputy Prime Minister, John Prescott, on the scope for improving the quality and efficiency of UK construction, Department of the Environment, Transport and the Regions, Great Britain: London

Eisenhardt, K.M. (1989) Building Theories from Case Study Research, Academy of Management Review, 1989, 14(4), 532-550

Fairclough, J., (2002) Rethinking Construction Innovation and Research: A Review of Government R&D Policies and Practices, Department of Trade and Industry, London.

Gann, D.E., (1996) Construction as a manufacturing process? Similarities and differences between industrialized housing and car production in Japan, Construction Management and Economics, 14, 437-450

Gibb, A.G.F., (2001) Standardization and pre-assembly: distinguishing myth from reality using case study research, Construction Management and Economics, 19 (3), 307–15

Gibb, A., and Isack, F., (2003) Re-engineering through pre-assembly: client expectations and drivers, Building Research & Information, 31(2), 146-160

Glaser, B. and Strauss, A., (1999) Discovery of Grounded Theory: Strategies for Qualitative Research Chicago: Aldine Transaction, USA

Goodier, C.I. and Gibb, A.G.F. (2005a) Offsite in the UK - Barriers & Opportunities, Systematic Innovation in the Management of Projects and Processes, Abdul Samad Kazi (ed), cib Helsinki international joint symposium, pp. 148-158Goodier, C.I. and Gibb, A.G.F. (2005b), The Value of the UK Market for Offsite, downloadable from www.Buildoffsite.org, March 2005, pp.13.

Goodier, C.I., and Gibb, A.G.F., (2007) Future Opportunities for Offsite in the UK, Construction Management and Economics, 25, 585–95, DOI:10.1080/01446190601071821, http://hdl.handle.net/2134/3100.

Hampson, K., and Brandon, P., (2004) Construction 2020: A Vision for Australia's Property and Construction Industry, CRC Construction Innovation, Brisbane, Australia

Kulatunga, U., Amaratunga, D., Haigh, R., (2007) Performance measurement in the construction research and development, International Journal of Productivity and Performance Management, 56(8), 673-688

Kulatunga, U., Amaratunga, D., Haigh, R., (2009) Critical success factors of construction research and development, Construction Management and Economics, 27 (9), 891-900

Latham, M., (1994) Constructing the Team: Joint Review of Procurement and Contractual Agreements in the UK Construction Industry, Department of the Environment, HMSO, London

Macmillan, S. (2002) The right vision for construction R&D? Responding to the Fairclough Review, Building Research and Information, 30(5), 328-33

Mann, L., and Chan, J., (2011) Creativity and innovation in business and beyond: social science perspectives and policy implications, New York: Routledge

McKay, L., (2010) The Effect Of Offsite Construction On Occupational Health And Safety, Department of Civil and Building Engineering, Loughborough University, UK

Mitchell, G.R., and Hamilton, W.F., (2007) Managing R&D as a strategic option, Research Technology Management, 50(2), 41-50

Miles, J., and Whitehouse, N., (2013) Offsite Housing Review, Department of Business, Innovation & Skills and the Construction Industry Council, London.

Nadim, W., and Goulding, J., (2010) Offsite production in the UK: the way forward? A UK construction industry perspective, Construction Innovation: Information, Process, Management, 10(2), 181 – 202

Pan, W., and Arif, M., (2011) Manufactured construction: revisiting the construction-manufacturing relations In: Egbu, C. and Lou, E.C.W. (Eds.) Procs 27th Annual ARCOM Conference, 5-7 September 2011, Bristol, UK, Association of Researchers in Construction Management, 105-114

Samuelsson, G., Parry, T., and Howlett, C., (2003) Offsite Fabrication: UK Attitudes and Potential, BSRIA, Bracknell, UK

Taylor, M., (2010) A definition and valuation of the UK offsite construction sector, Construction Management and Economics, 28:8, 885-896

Teece, D., (2010) Business Models, Business Strategy and Innovation, Long Range Planning, 4 (2), 172-194

Van Rooij, A., (2008) How R&D helped transform DSM, Research Technology Management, 51(1), 43-48

Constructing Excellence, (2009) Never Waste a Good Crisis: A Review of Progress since Rethinking Construction and Thoughts for Our Future, London: Constructing Excellence

Yorkon, (2013) Yorkon Awarded Contract for the Biggest Health Project to be Built Off Site in the UK [Online], Available at: http://www.yorkon.co.uk/news-releases.html/207 [Accessed: 26/04/2013]

A CRITICAL REVIEW OF RESPONSE STRATEGIES ADOPTED BY CONSTRUCTION COMPANIES DURING AN ECONOMIC RECESSION

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During a recession, companies are forced to restructure and to move quickly to reduce employment, costs, and debt, in order to ensure their survival. In the construction industry, recessions have the effect of reducing resources available to companies as clients procure less, financiers reduce lending and competition increases. Despite an increase of research in the area of strategic management in the last decade, little has been documented on what response strategies construction companies adopt as a result of an economic recession. From a thorough review of previous studies, two key issues became apparent: (1) very few offered a comprehensive and systematic overview and (2) limited connections were made to theoretical typologies such as Porter's generic strategies, which are a widely accepted typology of strategic options for companies. The objective of the paper is to fill this knowledge gap by: (1) critically reviewing the literature on response strategies in the construction industry; (2) developing a taxonomy of response strategies relative to Porter's generic strategies of cost leadership, differentiation and focus; and (3) using the taxonomy framework to critically evaluate the response strategies of Irish and UK construction contractors by drawing on qualitative data from the pilot case studies of an on-going PhD study. The results from the critical review show that the majority of construction companies adopt differentiation strategies in order to survive an economic recession.

Keywords: business strategy, corporate strategy, strategic management, recession, response strategy

INTRODUCTION

In a volatile market it is by definition difficult to secure a steady flow of work (Boon 1996), resulting in companies being forced to restructure and to move quickly to reduce employment, costs, and debt. Lim et al (2010) demonstrated that construction contractors need to adopt various response strategies in order to stay afloat in a recession. According to Jannadi (1997), the most important factors contributing to business failure as a result of a recession are; difficulty with cash flow, low profit margins, difficulty in acquiring work, lack of experience in the firms line of work, and

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Tansey P, Meng X and Cleland D (2013) A critical review of response strategies adopted by construction companies during an economic recession *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 679-689.

lack of managerial experience. Along with threats, recessions can also bring opportunities and as Lansely and Quince (1981) proposed, the most able firms can exploit opportunities in their markets even during an economic downturn.

During the recent 2007 global economic recession many construction companies failed to adopt appropriate response strategies and as a result led to bankruptcy or liquidation. In Ireland, four of the top ten construction companies ranked in 2007 failed to survive the recession, with construction company failures increasing from 120 in 2007 to 740 in 2011 (Scully, 2012). In the UK, there were 2,785 construction company failures in 2008 and this increased to 3,784 in 2009 (Department for Business, Innovation & Skills, UK Government).

In the field of strategic management little has been documented on what response strategies construction companies adopt as a result of an economic recession. From a critical review of previous studies, two key issues became apparent: (1) very few offered a comprehensive and systematic overview and (2) limited connections were made to theoretical typologies such as Porter's (1980) generic strategies which are a widely accepted typology of strategic options for companies.

This paper will critically review and synthesise existing research on response strategies and practices adopted in the construction industry. It aims to develop a taxonomy of response strategies relative to Porter's (1980) generic strategies of cost leadership, differentiation and focus, and to establish which generic strategy is most common during times of recession. Using the taxonomy framework two pilot case studies, one from Ireland, and the other from the UK, are presented to critically evaluate the response strategies adopted during the 2007 economic recession.

RESEARCH METHODOLOGY

The research methods adopted in this study consist of a critical review and pilot case studies. The critical review involves a thorough review of well known academic journals in the area of construction and project management, which include: Construction Management and Economics (CME), ASCE Journal of Construction Engineering and Management (JCEM), Engineering Construction and Architectural Management (ECAM), Journal of Management in Engineering (JME), International Journal of Project Management (IJPM), and Building Research and Information (BRI). The pilot case studies involve the extraction of qualitative data from a medium-sized Irish contractor and a medium-sized UK contractor using thematic coding based on the framework of Saldana (2011).

A critical review strategy similar to those proposed by Bemelmans et al (2012), Tang et al (2010), and Sun and Meng (2009) was adopted in this study. Some important changes were made as it was felt that an initial keyword search alone did not suffice and ran the risk of missing some important research papers. As a result, the search procedure for papers related to the research involved the following steps:

1. The title and abstract of every paper published within each journal mentioned above was scanned, with some journals going back to the year 1983, e.g CME.
2. A keyword search was also carried out on several online databases, including ScienceDirect, Business Sources Premier, Emerald Database and Taylor & Francis, and resulted in other leading journals being identified.
3. A further review of the abstract of the papers was conducted in order to filter out the less relevant papers.

4. The final method was through the reference lists of the papers selected from step 3.

As a result of the search, 79 journal papers have been found. From these, 11 studies were identified which specifically studied 'response' or 'survival' strategies of construction companies during an economic recession. Each of the 11 studies was critically reviewed in order to identify the most frequently adopted response strategies. 88 responses strategies were initially identified with the list being reduced to 36 response strategies that were common in at least two or more of the 11 studies. On this basis, an appropriate classification system, or taxonomy, is proposed (Table 1) whereby the 36 common response strategies are classified according to country of study, and Porter's (1980) generic strategies of cost leadership, differentiation and focus. Under each generic strategy, each response strategy is further grouped according to a specific theme. These eight themes emerged from the critical review and consist of; marketing, financial, human resources (HR)/personnel, technology/innovation, operational/project management (PM), procurement, restructuring, and tendering/contracts.

For the pilot case studies the same taxonomy framework was adopted, whereby the semi-structured interviews conducted with company directors used the taxonomy themes to lead the interviews. From the resulting interview transcripts, process coding was used to identify specific response strategies adopted as a result of the recent economic recession. According to Corbin and Strauss (2008), process coding is used for those that search for 'ongoing action' in response to situations or problems. A total of 38 response strategies (codes) were identified. Using the taxonomy framework each response strategy (code) is classified under a relevant theme and then further classified according to Porter's (1980) generic categories (Table 2).

RESPONSE STRATEGIES

According to Ye et al (2010), a response strategy has become an important instrument for dealing with the challenges of environmental changes, while in business terms, Waddock and Isabella (1989) describe it as the organisational capability of making due response to variations in external environmental factors. Lansley (1987) described them as rapid and creative responses which necessitate the development of new linkages with the environment.

Given the importance associated with response strategies, only a limited number of studies have been conducted on the response strategies adopted by construction companies in responding to an economic recession. These 11 studies are classified under the country of study (see Table 1) and are as follows;

In the US, research carried out by Wong and Logcher (1986) highlighted the strategies that construction contractors adopt in a cyclical environment, while also examining their associated performance. Mills (1996) examined how construction companies were managing to stay afloat as a result of the early 1990's recession.

In China, research conducted by Li and Ling (2012) assessed the critical strategies adopted by architectural, engineering, and construction firms in turbulent economic times and explored their effect on the firms profitability.

In Japan, Hasegawa (1988) examined competitive strategies in the Japanese construction industry following the 'Ice Age' construction slump that continued for a decade from the mid 1970's to 1986.

In the UK, research conducted by Lansley and Quince (1981) examined the strategic responses of a cross-section of UK building companies during the mid 1970's recession and its affect on the company performance. Studies carried out by Hillebrandt et al (1995) involved the examination of the behaviour and strategies of 20 large UK construction contractors during late 1993 and early 1994.

In Singapore, research conducted by Lim et al (2010), found that a total of 33 response actions were taken by contractors to ride out the eight-year recession (1997-2005). Research by Low and Lim (2000) also examined the survival strategies of Singapore contractors, but this was restricted to the period 1997-1998. Another study by the Singapore Contractors Association Ltd (SCAL) in The Contractor (1998), conducted a survey of its members to gauge their business sentiments as well as the measures that they may take over the financial crisis.

In Hong Kong, research carried out by Tan et al (2012) assessed the competitive strategies adopted by construction contractors during turbulent times and outlined their effects on performance and its relation to the competition environment.

In New Zealand, research conducted by Boon (1996) examined the survival strategies of small professional firms in a volatile construction market (1987-1992) in Auckland.

TAXONOMY OF RESPONSE STRATEGIES

The proposed taxonomy (Table 1) utilises the well known theoretical typology of Porter's (1980) generic strategies for the classification of the response strategies. Tan et al (2012), and Li and Ling (2012) also proposed Porter's (1980) generic strategies for the classification of strategies during economic turbulence.

Porter's model (1980, 1985) is a well known theoretical framework among business strategists and industrial economists. According to Ormanidhi and Stringa (2008), Porter's model is considered as an insightful and convenient approach to analysing the firm's competitive behaviour due to its popularity, well defined structure, clarity, feasibility, generality and simplicity. Porter's work has also come under criticism by authors such as Fellows (1993), but given the level of importance placed on Porter's work by others in the construction management field (Ramsay (1989), Langford and Male (1991), Betts and Ofori (1992) & (1993), Tan et al (2012), and Li and Ling (2012)) it felt justified to apply its principles to construction.

The proposed taxonomy (Table 1) can be used as a knowledge-based framework for construction companies to use to survive economic turbulence. Of the three generic strategies, differentiation strategies were found to be the most frequently used across the studies, and according to Porter (1980), differentiation is concerned with differentiating the product or service offering of the company, by creating something that is unique. This finding agrees with Li and Ling (2012) who found that differentiation is the one that helps firms survive economic turbulence. In times of excessive competition, Cheah et al. (2007) demonstrated that differentiation has a stronger relationship with performance. The top four differentiation strategies adopted are:

1. investing in R&D/new technologies (Technology/Innovation);
2. increase/improve marketing and advertising (Marketing);
3. improving relationships with stakeholders (Marketing);
4. improve/increase services/products offered (Technology/Innovation).

In relation to cost leadership strategies, it contained the highest number of response strategies, accounting for 14 of the 36 response strategies listed. The most common ones adopted relate to HR/personnel strategies, and consist of: upskilling/retraining staff, freezing/cutting salaries, and laying off employees. The most common focus strategies were found to be related to operational/PM strategies (focus on core skills/capabilities), marketing strategies (entry into new construction markets), and tendering/contract strategies (joint venture on contracts).

Table 1: Taxonomy of response strategies adopted as a result of economic recessions

Strategies	U1	U2	C	J	UK1	UK2	S1	S2	S3	H	N
Cost Leadership											
Financial:											
Implement stricter financial management						X	X				X
Renegotiating loan arrangements						X	X				
Setting aside cash reserves			X				X				
HR/Personnel:											
Upskill/retrain staff		X	X		X				X	X	
Freezing/cutting salaries of employees		X				X	X	X			
Laying off employees		X		X		X	X				
Freezing/cutting bonuses						X	X	X			
Employ staff on a project by project basis						X		X			
Freezing staff recruitment						X	X				
Operational/Project Management:											
Cutting operational/administrative costs			X			X					X
Revert to simple efficiency planning					X	X					
Procurement:											
Cuttings supplier costs/Direct sourcing			X					X			
Restructuring:											
Retrench/downsize business		X							X		X
Tendering/Contracts:											
Lowering project tendering prices						X			X		
Differentiation:											
Marketing:											
Increase/improve marketing & advertising	X		X	X	X	X			X		
Improving relationships with stakeholders		X	X		X				X		X
Forming partnerships with clients/suppliers					X			X			
Specialising in a particular expertise					X			X			
Technology/Innovation:											
Investing in R&D/new technologies	X	X	X		X			X		X	X
Improve/increase services/products offered			X	X		X			X	X	
Innovative project financing methods				X		X				X	
Innovative project management methods						X				X	
Operational/Project Management:											
Speed up project delivery			X					X		X	
Ensure high quality of inputs			X	X						X	
Provide high quality outputs			X	X						X	

(continued)

Table 1: Taxonomy of response strategies adopted as a result of economic recessions (continued)

Strategies	U1	U2	C	J	UK1	UK2	S1	S2	S3	H	N
Restructuring:											
Changing/adapting organisational structure			X			X					
Focus:											
Marketing:											
Entry into new construction markets	X	X	X	X		X				X	
Venturing into overseas markets		X		X		X	X		X		
Diversify into other construction businesses	X			X			X			X	
Entry into more specific regions, nationally			X	X						X	
Service only a specific group of clients			X							X	
Set up a network of partners			X								X
Operational/Project Management											
Focus on core skills/capabilities		X			X	X	X	X	X		X
Restructuring:											
Expand by merger or acquisition				X						X	
Tendering/Contracts:											
Joint venture on contracts		X	X	X		X	X		X		
Undertake smaller contracts				X		X	X				

Notes: U1 & U2 = United States studies by Wong & Logcher (1986) and Mills (1996). C = a Chinese study by Li and Ling (2012). J = a Japanese study by Hasegawa (1988). UK1 & UK2 = United Kingdom studies by Lansley and Quince (1981) and Hillebrandt et al.(1995). S1, S2, & S3 = Singapore studies by Lim et al.(2010), Low and Lim (2000), and The Contractor (1998). H = a Hong Kong study by Tan et al.(2012). N = a New Zealand study by Boon (1996).

PILOT CASE STUDY RESULTS

From the two pilot interviews, a total of 38 response strategies taken to survive the 2007 economic recession were identified and classified in Table 2 using the taxonomy framework developed in Table 1. The Irish company adopted 31 strategies while the UK company adopted 24 strategies out of the 38 listed response strategies. The majority of the response strategies adopted by both companies were found to relate to cost leadership, which according to Porter (1980) involves the pursuit of cost reductions and cost minimisation. The Irish company adopted 17 cost leadership strategies while the UK company adopted 13, which demonstrates the significantly harsher economic climate encountered in Ireland during this time. The most common strategies for both companies within this generic category relate to HR/personnel strategies, consisting of; upskilling/retraining of staff, cutting bonuses, employ staff on a project by project basis, and train staff for ways to reduce costs.

Table 2: Response strategies adopted during the 2007-2012 recession

Strategies	UK	Ireland
Cost Leadership		
Financial:		
Implementing stricter financial management	X	X
Renegotiating loan arrangements	X	
New Financing arrangements with clients	X	
Acquire overdraft facilities	X	
HR/Personnel:		
Upskill/retrain staff	X	X
Freezing salaries of employees	X	
Cutting salaries of employees		X
Cutting bonuses	X	X
Cutting overtime		X
Employ staff on a project by project basis	X	X
Reduce staff perks		X
Train staff for ways to reduce costs	X	X
Increase staff working hours		X
Employ cost claim consultants		X
Technology/Innovation:		
Reduce R&D budget		X
Operational/Project Management:		
Use resources more efficiently	X	X
Increase in the use of subcontractors		X
Procurement:		
Cuttings supplier costs/Direct sourcing	X	X
Adopt Just-In-Time purchasing	X	X
Restructuring:		
Close regional offices	X	
Tendering/Contracts:		
Lowering project tendering prices		X
Increase revenue through project claims		X
Differentiation:		
Marketing:		
Increase in advertising		X
Improve relationships with clients	X	X
Improve public relations	X	X
Change company brand image	X	X

(continued)

Table 2: Response strategies adopted during the 2007-2012 recession (continued)

Strategies	UK	Ireland
Financial:		
Offering of financial packages for clients		X
Technology/Innovation:		
Investing in innovation -R&D/new technologies	X	
Improve/increase services/products offered	X	X
Innovative project management methods	X	
Operational/Project Management:		
Speed up project delivery		X
Focus:		
Marketing:		
Entry into new construction markets	X	X
Increase market share in existing market	X	X
Target less vulnerable clients	X	X
Restructuring:		
Increase the company's asset base	X	X
Tendering/Contracts:		
Joint venture on contracts	X	X
Undertake smaller contracts		X
Front loading tenders		X

In relation to differentiation strategies, the Irish company adopted 7 while the UK company adopted 6. The most common strategies for both companies within this generic category relate to marketing strategies, consisting of; improve relationships with clients, improve public relations, and changing company brand image. In relation to focus strategies, the Irish company adopted 7 while the UK company adopted 5. The most common strategies for both companies within this generic category relate also to marketing strategies, and consist of; entry into new construction markets, increase market share in existing market, and target less vulnerable clients.

The results of the pilot case studies found that cost leadership strategies were the most commonly used during the 2007 recession. These findings differ from the critical review findings of the 11 studies, which found that differentiation strategies were the most commonly adopted during economic recessions. This can be explained by the fact that most of the companies in the critical review studies were large companies, while the pilot case studies were medium-sized companies. These findings agree with Cheah et al (2007) who found that large companies have more resources and competencies to differentiate themselves from their competitors, and therefore adopt differentiation strategies, while small and medium-sized companies adopt cost leadership strategies.

CONCLUSIONS

This study critically reviewed and synthesised 11 studies on response strategies adopted in the construction industry as a result of economic recessions. This resulted in the development of a taxonomy of response strategies to economic recessions relative to Porter's (1980) generic strategies. The taxonomy framework was also used to critically evaluate the response strategies of Irish and UK construction contractors to the 2007 economic recession.

The results from the critical review show that the majority of construction companies adopt differentiation strategies in order to survive an economic recession, while the pilot case study results show that cost leadership strategies were mostly used in the 2007 recession. Within the limits that are possible with a pilot study, it is acknowledged that the conclusions must be regarded as tentative, however it is felt that they provide an indication of the severity of the current recession experienced, more so by Irish construction companies, than by UK construction companies. The pilot case studies will form part of an on-going PhD study which aims to investigate the response strategies of Irish and UK construction contractors to the economic downturn 2007 – 2012. The study will be extended to examine large, medium and small construction contractors in Ireland and the UK.

This study contributes to knowledge and practice in the strategic construction management field by proposing a comprehensive taxonomy of response strategies that construction companies can use to survive economic turbulence. It also provides a platform for academic researchers in their future studies in this field. Researchers could examine trends in organisational restructuring and in the strategic management processes of construction firms during economic recessions. It could also extend to areas such as investigating the response strategies adopted by failed companies during economic recessions.

REFERENCES

Bemelmans, J, Voordijk, H and Vos, B (2012) Supplier-contractor collaboration in the construction industry: A taxonomic approach to the literature of the 2000-2009 decade. "Engineering, Construction and Architectural Management", **19**(4), 342-368.

Betts, M and Ofori, G (1992) Strategic planning for competitive advantage in construction. "Construction Management and Economics", **10**(6), 511-532.

Betts, M and Ofori, G (1993) Competitive advantage in construction: Reply. "Construction Management and Economics", **11**(1), 73-74.

Boon, J (1996) Survival strategies for small professional firms in a volatile market. In: Langford, D.A and Retik, A. (eds) "The Organisation and Management of Construction: Shaping Theory and Practices". Vol 1, London:E & FN Spon.

Cheah, C Y J, Kang, J and Chew, D A S (2007) Strategic analysis of large local construction firms in China."Construction Management and Economics",**25**(1), 25-38.

Corbin, J and Strauss, A (2008) "Basics of qualitative research:Techniques and procedures for developing grounded theory".3ed. Los Angeles, CA: SAGE.

(The) Contractor (1998) SCAL members respond to economic changes. "The Contractor", **15**(5), 1-3.

Fellows, R F (1993) Competitive advantage in construction: comment. "Construction Management and Economics", **11**(1), 71-72.

Hasegawa, F (1988) "Built by Japan: Competitive strategies of the Japanese construction industry". New York: John Wiley & Sons.

Hillebrandt, P M, Cannon, J and Lansley, P (1995) "The construction company in and out of recession". London: Macmillan.

Jannadi, M O (1997) Reasons for contractor failure in Saudi Arabia. "Project Management Journal", **28**(2), 32-36.

Langford, D and Male, S (1991) "Strategic management in construction", Aldershot: Gower.

Lansley, P R (1987) Corporate strategy and survival in the UK construction industry. "Construction Management and Economics", **5**(2), 141-155.

Lansley, P and Quince, T (1981) Organizational responses to a major recession "Construction Papers", **1**(2), 5-16.

Li, S and Ling, F Y Y (2012) Critical strategies for Chinese architectural, engineering and construction firms to achieve profitability "Engineering, Construction and Architectural Management", **19(**5), 495 - 511.

Lim, B T H, Oo, B L and Ling, F (2010) The survival strategies of Singapore contractors in prolonged recession "Engineering, Construction and Architectural Management", **17**(4), 387-403.

Low, S P and Lim, N H (2000) The strategic responses of construction firms to the Asian financial crisis in 1997-1998. "International Journal of Construction Marketing", **1(**2), 1-12.

Mills, Q (1996) "Staying afloat in the Construction Industry: Economic and political trends for the 1990's that you need to know". Los Angeles, CA: BNI Publications.

Ormanidhi, O and Stringa, O (2008) Porter's Model of Generic Competitive Strategies: an insightful and convenient approach to firms' analysis. "Business Economics", **43**(3), 55-64.

Porter, M E (1980) "Competitive Strategy: Techniques for analysing industries and competitors". New York: Free Press.

Porter, M E (1985) "Competitive Advantage: Creating and sustaining superior performance". New York: Free Press.

Ramsay, W (1989) Business objectives and strategy. In: Hillebrandt, P M and Cannon J (eds.) "The management of construction firms: Aspects of theory". London: Macmillan.

Saldana, J (2011) "The coding manual for qualitative researchers". London: SAGE Publications.

Scully, P (2012) Below cost tendering, "CIF annual conference 2012", 12th September 2012, Dublin.

Sun, M and Meng, X (2009) Taxonomy for change causes and effects in construction projects. "International Journal of Project Management", **27**(6), 560-572.

Tang, L, Shen, Q and Cheng, E W L (2010) A review of studies on public-private partnership projects in the construction industry. "International Journal of Project Management", **28**(7), 683-694.

Tan, Y, Shen, L and Langston, C (2012) Competition Environment, Strategy, and Performance in the Hong Kong Construction Industry. "Journal of Construction Engineering and Management", **138**(3), 352-360.

Waddock, S A and Isabella, L A (1989) Strategy, beliefs about the environment, and performance in a banking simulation. "Journal of Management", **15**(4), 617-632.

Wong, T K and Logcher, D R (1986) Contractors in Cyclical Economic Environments. "Journal of Construction Engineering", **112**(3), 310-325.

Ye, K, Shen, L and Tan, Y (2010) Response strategies to the competition in the Chinese construction market. "Construction Management and Economics", **28**(2), 115-124.

THE EFFECTS OF BUSINESS ENVIRONMENTS ON CORPORATE STRATEGIES AND PERFORMANCE OF CONSTRUCTION ORGANISATIONS

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The study examines the moderating effects of business environment in the relationship between strategies used by construction organisations and examines how these can be used in attaining competitive advantage, and improved corporate performance. The grounds for the examination stems from arguments by researchers that efficient and effective business strategy is an essential tool employed by organisations to direct their business endeavours to the ever changing business environment and record continuous improved performance. The study involves a meta-study of extant literature on construction business environments and business strategies in-use. From this approach, a conceptual framework is proposed for relating business environment and corporate strategies used by construction organisations to their corporate performance that could serve as the basis for further studies in construction organisation strategic planning. Preliminary results of a pilot survey to examine the moderating effects of environmental dimensions on strategies and organisational performance are provided in support of the concept developed. The results reveal that organisations adopt differentiation strategies to ensure survival in a complex business environment. It thus concluded that dimensions of business environment have moderating effects on organisational strategies and performance.

Keywords: business strategy, competitiveness, corporate planning, organisation.

INTRODUCTION

Today's construction business is universal, extremely obsessed and technologically driven most especially with the advancement in information technology (Parnell, 2013). According to Parnell (2013) the resulting business tasks for strategist in organisations is vast, unstructured and woolly, and would demand effective and efficient strategies that could provide sustained competitive advantage and the achievement of superior performance. Conversely, Thompson and Strickland (2003) argue that no matter how good formulated strategies are, superior performance can only be attained and sustained if the strategies are rightly matched with the organisation's external environment and internal circumstances. Dess and Keats (1987) contend that existing literature on strategic management allude to the fact that successful organisations' strategy and structure must be auspiciously aligned with the

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Oyewobi LO, Windapo A and Rotimi JOB (2013) The effects of business environments on corporate strategies and performance of construction organisations *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference*, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 691-701.

external environment to guarantee optimal performance needed for their survival. Construction organisations operate in environments that are so active and quick changing, making it very difficult for any modern business enterprise to function. The construction environment is often regarded as uncertain and generally assumed to be more risk prone than any other (Balatbat, Lin and Carmichael, 2011). Owing to these difficulties, threats and restraints, construction business organisations are under intense pressure to find ways and means for their healthy survival. Balatbat et al. (2011) for example, conclude that abysmal business performance and failure of construction businesses are the result of poor business strategies. Under these circumstances, the only fall-back is to make the most and effective use of strategic management tools that could help construction organisations' business management to explore their potential opportunities. They very often would simultaneously work around the threats either to avoid them or turn them into organisational advantages to achieve an optimum level of efficiency.

The objective of this study is to examine the effects of the business environment and strategies on the corporate performance of construction organisations with a view to having a better understanding of the nature of relationships that exist between these concepts. Several studies determine the impact of strategies on performance, strategy process or formulation, while others examine the relationship between business environment and organisational performance within the construction industry (Junnonen, 1998; Tan, Shen and Langston, 2012). However, not many of these studies investigate the effects of the business environment and strategies on corporate performance in a single study. Hence, in this paper a review of literature on construction business environments, business strategies and corporate performance is provided. The approach would give theoretical basis for further studies that would incorporate this triad of knowledge into better construction organisation performance. The concluding parts of the paper present a developed conceptual framework for relating business environment and corporate strategies used by construction organisations to their corporate performance.

LITERATURE REVIEW

Rue and Holland (cited in Nandakumar, Ghobadian and O'Regan, 2010) assert that organisational strategy describes the approach a firm will pursue in achieving its strategic objectives and mission. Such organisational strategies would consider the threats and opportunities within the operating environment, resources at its disposal and capabilities. Organisations cope with significant restraints and exigencies from their external environments and their competitiveness depends on their ability to monitor the environment and adjust their strategies accordingly (Boyd and Fulk, 1996). According to Audia, Locke and Smith (2000), failure of an organisation to address changes in the environment can negatively affect performance. Present day economies appear to be more challenging than before to effectual and effective management of any organisation. The nature of the present day environment is regarded as hyper-competitive or in other words of high-velocity (Bourgeois & Eisenhardt, 1988; D'Aveni, 1994). Thus eenvironments' are likely to be associated with an increasing occurrence of major, discrete environmental shifts in competition, technology, social, and regulatory domains.

The conceptual model proposed in this study, which depicts the linkages among the constructs discussed in this paper is shown in Figure 1. This framework illustrates business environment factors as a moderator of the relationship between business

strategies and performance. Increase in competitiveness and internationalisation of construction markets has made many organisations to differentiate themselves from their industry rivals by continually reviewing their business strategies. As organisations grow and operate in hyper-competitive environments, it is essential that the moderating effects of the business environment be investigated to examine the nature of relationship between strategies and performance.

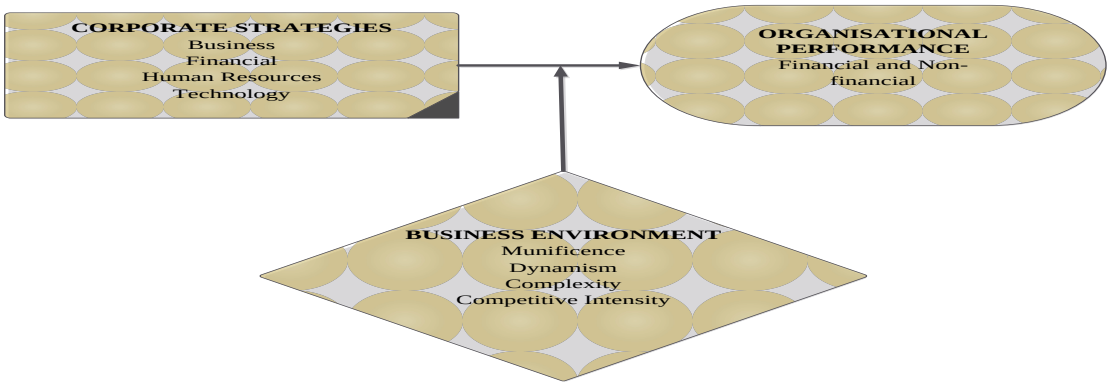

Figure 1: Conceptual framework for moderating effects of business environment in the relationship between strategies and corporate performance

Business environment

Duncan (1972) views business environments as the interaction between organisations' internal and external factors consisting of pertinent physical and social factors within and outside the organisation boundaries that exhibits direct influence on decision making actions of individuals and groups. Khandwalla (1985) views the environment as the main cause of exigencies, constraints, problems, threats and opportunities that influences the terms on which organisations base their business transactions. Chi, Kilduff and Gargeya (2009), support the Khandwalla's view that innumerable forces are present in the environment where organisation functions. These forces are most often beyond the control of managers and constitute threats or opportunities to organisations. Therefore considerable attention needs to be paid to environmental elements in almost every business strategy and operations design/management (Ward, Duray, Leong & Sum, 1995). Inattention (poor corporate strategies) could result in abysmal business performance and failure (Balatbat et al., 2011).

In strategic management literature, several authors have classified environmental latent variable that jointly whittle the business environment in variety of ways. For example, Lenz and Engledow (1986) analyse and classify business environments using five models namely: industry structure, cognitive, organisation field, ecological and resources dependence, and era model. In the current paper, four environmental variables identified from Mintzberg, (1979), Dess and Beard (1984), Ward et al. (1995) and Sougata (2004) are considered which include: munificence, dynamism, complexity and competitive intensity.

Munificence explains the existence of a myriad of resources and opportunities that abound in the environment where organisations operate, and the competition among them for those limited opportunities and resources. This environmental influence was further classified by Sougata(2004) into intensity of market forces and regulatory intensity. Dynamism refers to uncertainties and it is viewed as the rate or speed of change in an industry as well as predictability or uncertainty in the business environment. Dynamism stems from the actions of industry rivals or customers

including advancements in technology and shifts in aggregate demand (Chi et al., 2009; Nandakumar et al., 2010). The fourth environmental variable, complexity refers to the heterogeneity and the degree to which organisations are required to have a great deal of marketing techniques or leading-edge knowledge about their products, needs of their customers, or multiplicity in production. Finally competitive intensity refers to the degree to which threats of environmental influences such as regulatory and market forces (hostility as a result of competition), is experienced by firms while operating within the construction industry.

The underlying assumption here is that environments influence organisations resource availability required for survival. Hence, turbulent environmental circumstances can cause external changes that may increase diversity in the business environment, and the more diverse the interface set, the higher the complexity. Externally induced changes in a diverse environment can create low munificence, which depicts scarce resources and vice versa. The later part of this paper examines the effects of business environmental latent variables on the relationship between strategies and performance.

Corporate strategy

Corporate strategy is described in the context of organisations' mission objectives and vision by considering the markets and the businesses in which organisations choose to operate, the reason for their existence, where they intend to be in future and organisations' overall direction towards growth. Porter (1980: 6) emphasises that "the essence of formulating strategy is relating company to its environment". Porter contends that corporate level strategy entails a purposeful search for a new domain in which an organisation can tap or protect its ability to develop value from the utilisation of its low-cost or differentiation core competences. Corporate strategy is the responsibility of top management and it involves value creation skills that will enhance the competitive position of organisation business units. Strategy enables organisations to capitalise on their strengths to recognise and improve on their weaknesses by ascertaining the level of seriousness of business threat and differentiate between worthy and marginal opportunities open to companies (Orcullo, 2008). Organisational strategy is dependent on the moderating effects of the environment where construction organisations operate and provides clearer understanding of business environment (Prescott, 1986; Kotha and Nair, 1995). Thus, as organisations increase in size and branches, the need to choreograph and harmonise business activities becomes difficult. Hence there is a need to develop a comprehensive organisational roadmap outlining how an organisation will achieve its overall mission and corporate objectives in a turbulent business environment.

Within the construction industry, Cheah and Garvin (2004) designed an open framework for corporate strategy in construction and argue that corporate strategy encompasses: business, financial, human resources, technology, marketing, information technology and operational strategies. In line with this submission, this study considers business, financial, human resources and technology strategies for inclusion in the conceptual framework presented as figure 1. Nandakumar et al.(2010: 907) reports that business strategy "is a powerful predictor of other organisational phenomena and perhaps the most useful stream of research for practitioners is the empirical examination of its relationship with organisational performance". Human resources strategy refers to the provision of an effective organisational system that will lead to recruiting, training, mobilizing and managing the human assets of an organisation to systematically carry out business operations and new business

enterprises (Cheah and Garvin, 2004). Finance strategies consist of how organisation financial activities will be managed effectively to assist in the realisation of the overall business strategy to achieve the strategic mission and objective of the finance unit of the organisation. Cheah and Garvin (2004) argue that it is difficult for any business enterprise to operate without due attention to financial issues. Technology strategy is viewed as one of the most strategic postures an organisation can adopt, particularly in dynamic business environments, to create competitive advantage by introducing novel procedure or technological process that can attract customers or change the pattern of competition within the industry (Zahara, 1996).

Organisational performance

Though, performance measurement is an essential ingredient in decision making and judgement by organisations, the definition of the term remains inconclusive, in spite of research on performance concepts focusing mostly on performance measurement. Keats and Hitts (1988) suggest that the concept is a difficult one both in terms of definition and measurement. According to Wu (2009) performance is a measure of how effective and efficient the mechanism/process put in place by an organisation attains its desired results. Effectiveness and efficiency are the two basic components of strategic control and performance, which were highlighted by Neely (2005) and Capon (2008). Effectiveness as an element of performance connotes the degree to which the requirements of stakeholders are achieved. Efficiency on the other hand measures how well the organisation utilises its resources and capabilities economically in meeting requirements or desired level of satisfaction of stakeholders. This definition suggests that performance must align to effectiveness of actions stemming from the strategic thinking of organisations (O'Regan, Sims & Gallear, 2008).

Traditionally, measures of organisations' performance have been based on financial terms or accounting-based such as return on investment, return on assets, turnover etc. Kagioglou, Cooper and Aouad (2001) argue that reliance on financial measures by organisations can only assist them identify their past performance but not what contributed to achieving that performance. Therefore, there is a need to encompass non-financial with financial measures of performance in an all-inclusive performance measurement system (Bourne, Mills, Wilcox, Neely & Platts, 2000).

Furthermore, construction organisations today require viable information across a wider scope of activities more than what the traditional measures of performance can provide. For this reason, Laitinen (2002) surmise that inclusion of both hard and soft measures of performance in a framework will provide managers with opportunities to survey performance in many areas at the same time, to assist in making effective strategic judgement or decisions. Many organisations' failures result from the inadequacy of measures of performance, which hinders their ability to convert strategy to effectual course of actions to attain their set objectives (McAdam & Bailie, 2002). However, a complete range of non-financial measures of performance rarely exists in reality, despite the volume of researches focusing on the concept of performance within the construction industry. Therefore, it is essential to have a comprehensive portfolio of measures of performance that can serve as an early warning of the health conditions of construction businesses by aligning it organisations' strategy. Price (2003) identifies Balance Scorecards (BSC) and Business Excellence Model (European Foundation for Quality Management, EFQM) as tools that are capable of aligning performance measures and strategy to achieve superior performance.

Moderating effects of the business environment on corporate strategy and organisation performance

Ward and Duray (2000) contend that both in conceptual and empirical studies involving business strategy, the impact of the business environment has been recognised for long as an important contingency factor. Mintzberg (1979) for example submits that performance of any organisation is solely hinged on the fit between its strategy and environment. Also one of the major concerns in strategic management literature has been the occurrence of strategic adaptation of organisations to their environment, which depicts how organisations achieve a proper 'fit' with the environment where they operate through changes in corporate strategy (Zajac, Kraatz & Bresser, 2000). This section explains how the identified latent environmental variable serves as a moderator in the relationship between corporate strategies and organisational performance. Munificence environment reportedly has three different dimensions, which include: growth/decline, capability and opportunity or threat (O'Regan et al., 2008) and these allows it to create opportunities, profit and growth through growth strategy. Munificence in industry environments allows an organisation to be more competitive, identify opportunities and strive for growth.

This environmental condition enables organisations to diversify because entry barriers to new markets are removed and as such an organisation enjoys balance or reduced risk that will increase its profitability through improved performance. Sougata (2004) posits that an organisational environment with higher munificence is motivated to increase business scope, scale of its operation and geographical scope to attain superior performance. In an environment where competition is intense and stiff, organisations require lowering-cost business strategy with little emphasis on product differentiation. Sougata (2004) asserts that increase in bargaining power of customers and competitive intensity reduces profitability and compels organisations to seek opportunities in another market or probably divest some part of its business, if it is a corporation, and re-strategise to remain relevant. Environments with less complexity and dynamism require organisations to adopt differentiation strategy and be more innovative in its production process to wade off imitation by rivals in the industry, and enjoy premium price because the main competitors may consider change of strategies unnecessary (Kabadayi, Eyuboglu & Thomas, 2007).

RESEARCH METHODS

This study is part of an on-going PhD research, which is at the data collection stage. Based on the conceptual framework for the research, the study designed structured questionnaires using a survey approach amongst construction organisations listed on the Construction Industry Development Board (cidb) contractor register in the South African construction industry to elicit information and collect quantitative data. Saunders, Lewis and Thornhill (2009) assert that using questionnaires in explanatory research will enable the researcher investigate and describe the nature of relationship between variables and particularly the cause-and-effect relationships. Therefore, internet mediated approach to administration of the well-structured questionnaire to construction organisations in the South African construction industry was used because it involves many provincial regions with large geographical dispersion. The items used in measuring business strategy were adopted from Kale and Arditi (2003) and Nandakumar et al. (2010). Also, business environmental dimension items were adapted from Dess and Beard (1984), Kabadayi et al. (2007), Chi et al. (2009) and Nandakumar et al. (2010). Performance of construction organisations were measured

using Return on Capital Employed (ROCE), which is a measure of both profitability, growth and how effective and efficient organisation manage its business with respect to the use of its funds in growing the size of the business. This was collected for the period of five years. The responses for the adopted constructs were elicited on 5-point Likert scale. No open questions were asked to encourage participation. The estimates of the internal consistency reliability of the constructs ranged from 0.663 to 0.944. The questionnaires were piloted to 30 large (Grade 7-9) construction organisations listed on the cidb register of contractors in the South African construction industry. The participants sampled consisted of chief executive officers and senior management employees of the organisations who have more than ten years' of work experience in their respective organisations. A total of 16 valid questionnaires were completed, returned and analysed using regression analysis at the end of the pilot study.

RESULTS AND DISCUSSION OF PRELIMINARY FINDINGS

The results of the regression analysis in Table 1 for ROCE indicates that an organisations' ROCE improves as it maintains differentiation strategy in complex business environment and the results are significant at 5% level. The presence of other factors that have the possibility of raising hyper-competition may be responsible for differentiation strategy instead of cost leadership or focus strategy (Cheah, Kang and Chew, 2007). Although, focus strategy is also significant at 5% level of confidence, it exhibits a negative relationship with ROCE. This suggests that a unit increase in spending on a focused market will lead to decrease in organisations ROCE; it implies also that construction organisations should not pursue both differentiation and focus strategy at the same time. If this done, the company may experience the situation Porter refers to as stuck in the middle. In addition, technology strategy indicates negative but significant relationship this suggests that pressure on technology by organisations to pursue both differentiation and focus strategy may be a threat to the organisation and result in inefficient utilization of resources. Furthermore, positive and significant relationship of financial strategy emphasises the ability of organisations to secure loans or financial assistance from banks to enhance business operations. None of the variables in model 2 is significant, but the R-square value indicates that the variables are capable of explaining 90% of the variations in the overall performance.

Table 1: Results of regression analysis of competitive strategies and organisation performance

Corporate strategies and environmental dimensions	ROCE model 1	Overall performance model 2
Differentiation	1.10**	-0.029
Cost leadership	0.401	0.497
Focus	-1.694**	0.326
Dynamism	-0.207	0.058
Complexity	0.915**	-0.183
Competitiveness	-0.958	0.408
Munificence	-1.078*	1.252
Technology	-0.593*	-0.253
Financial	1.068*	-1.057
Multiple R	0.989	0.889
R2	0.979	0.791
F-Change	10.35*	1.262

Note: *p<0.1; **p<0.05

Table 2 provides the summary of the moderated regression analysis conducted to investigate the nature of the relationship between business strategies and dimensions of the organisation environment indicates insignificant relationship. However, the results in model 1 suggest that environmental dimensions (Munificence and complexity) have significant moderating effects on performance. Detailed explanation of the analysis and discussions of results will be provided in another research paper.

Table 2: Results of regression analysis of business strategies and organisation environmental dimensions

Environmental dimensions	Differentiation model 3	cost leadership model 4	Focus model 5
Dynamism	0.271	-0.023	-0.238
Competitiveness	-0.1	0.008	0.181
Complexity	0.302	-0.177	-0.147
Munificence	0.496	0.022	-0.206
Multiple R	0.579	0.373	0.247
R2	0.335	0.139	0.061
F-change	1.009	0.322	0.13

CONCLUSIONS

Investigating the moderating effects of the business environment on the relationship between corporate strategy and organisational performance confers significant benefits to construction organisations. Considering the turbulent and hyper-competitive environment in which construction organisations operate, it is essential that they become adaptable, creatively crafting strategies that will ensure their survival

whilst also meeting performance expectations of their clientele. The preliminary results of the pilot study undertaken show that construction organisations adopt differentiation strategy to survive in the complex business environment. It also indicates that environmental dimensions have moderating effects on construction organisation performance. Further research work will not only test the developed framework but operationalise the construct in a manner that provides useful piece of research that could assist businesses to achieve their performance objectives.

REFERENCES

Audia, P G, Locke, E A, and Smith, K G (2000) The paradox of success: An archival and a laboratory study of strategic persistence following radical environmental change. “Academy of Management Journal”, 43, 837-853.

Balatbat, M C A, Lin C and Carmichael, D G (2011) Management efficiency performance of construction businesses: Australian data, “Engineering, Construction and Architectural Management”, 18(2), 140-158

Bourgeois, L J and Eisenhardt, K M (1988) Strategic decision processes in high velocity environments: Four cases in the microcomputer industry. “Management Science”, 34, 816-835.

Bourne, M, Mills, J, Wilcox, M, Neely, A and Platts, K (2000) Designing, implementing and updating performance measurement systems. “International Journal of Operations & Production Management”, 20(7), 754-771.

Capon, C (2008) "Understanding Strategic Management". Pearson Education. Hallow Essex.

Cheah, C Y J and Garvin, M J (2004) An open framework for corporate strategy in construction. “Engineering, Construction and Architectural Management”, 11(3), 176-188

Cheah, C Y J, Kang, J and Chew, D A S (2007), Strategic analysis of large local construction firms in China, Journal of Construction Management and Economics, 25, 25-38.

Chi, T, Kilduff, P P D and Gargeya, V B (2009) Alignment between business environment characteristics, competitive priorities, supply chain structures, and firm business performance. “International Journal of Productivity and Performance Management”, 58(7), 645 - 669

D’Aveni, R A (1994) “Hypercompetition: Managing the Dynamics of Strategic Maneuvering”. New Press, New York, NY.

Dess, G and Beard, D (1984) Dimensions of organizational task environments. “Administrative Science Quarterly”, 29, 2-73.

Dess, G G and Keats, B W (1987) Environmental boundary-spanning and information-processing effects on organisational performance. “Academy of Management Proceedings”, 21-25.

Duncan R B (1972) Characteristics of organizational environments and perceived environmental uncertainty. “Administrative Science Quarterly”, 17(3), 313-327.

Junnonen, J M (1998) Strategy formation in construction firms. “Engineering, Construction and Architectural Management”, 5(2), 107-114

Kabadayi, S, Eyuboglu, N and Thomas, G P (2007) The performance implications of designing multiple channels to fit with strategy and environment. “Journal of Marketing”, 71(4), 195-211

Kagioglou, M, Cooper, R and Aouad, G (2001) Performance management in construction: A conceptual framework. "Construction Management and Economics”, 19, 85–95

Keats, B W and Hitt, M A (1988) A causal model of linkages among environmental dimensions, macro organizational characteristics and performance. " Academy of Management Journal", 31(3), 570-78.

Khandwalla, P N (1985). "Pioneering Innovative Management: An Indian Excellence," Organization Studies, 6(2), 161-83.

Kotha, S and Nair, A (1995) Strategy and environment as determinants of performance: Evidence from the Japanese machine tool industry. "Strategic Management Journal", 16, 497-518.

Laitinen, E K (2002) A dynamic performance measurement system: Evidence from small Finnish technology companies. "Scandinavian Journal of Management", 18, 65-99.

Lenz, R T and Engledow, J L (1986) Environmental analysis: The applicability of current theory "Strategic Management Journal", 7(4), 329-346

McAdam, R and Bailie, B (2002) Business performance measures and alignment impact on strategy. "International Journal of Operations & Production Management", 22(9), 972-96.

Mintzberg, H (1979) "The Structuring of Organizations". Prentice-Hall, Englewood Cliffs, NJ

Nandakumar, M K, Ghobadian, A and O'Regan, N (2010) Business-level strategy and performance: The moderating effects of environment and structure. "Management Decision", 48(6), 907-939

Neely, A (2005) The evolution of performance measurement research developments in the last decade and a research agenda for the next. "International Journal of Operations & Production Management", 25(12), 1264-1277

Orcullo, N A (2008) "Fundamentals of Strategic Management". (1st ed.), Mannila, Rex Book Store, Philippine

O'Regan, N, Sim, M A and Gallear, D (2008) Leaders, loungers, laggards: the strategic-planning-environment performance relationship re-visited in manufacturing SMEs

Parnell, J A (2013) "Strategic Management: Theory and Practice". 4th ed, Sage Publications

Porter, M E (1980) "Competitive Advantage: Creating and Sustaining Superior Performance". New York: Free Press.

Prescott, J E (1986) Environments as moderators of the relationship between strategy and performance. "Academy of Management Journal", 29, 329-49.

Price, A D F (2003), The strategy process within large construction organisations. "Engineering, Construction and Architectural Management", 10(4), 283- 296

Saunders, M, Lewis, P and Thornhill, A (2006) "Research Methods for Business Students". 5th Ed. Hallow: Prentice Hall

Sougata, R. (2004). Environment-strategy-performance linkages: A study of Indian firms during economic liberalization. Vikalpa, 29(2), 9-23

Tan, Y, Shen, L and Langston, C (2012) Competition environment, strategy, and performance in the Hong Kong construction industry. "Journal of Construction and Engineering Management", 138(3), 352-360.

Thompson, A A and Strickland, A J (2003) "Strategic Management: Concepts and Cases". Tata McGraw Hill: New Delhi

Ward, P T and Duray, R (2000) Manufacturing strategy in context: environment, competitive strategy and manufacturing strategy. "Journal of Operations Management", 18(2), 123-38.

Ward, P T, Duray, R, Leong, G K and Sum, C (1995) Business environment, operations strategy, and performance: An empirical study of Singapore manufacturers, "Journal of Operations Management", 13, 99-115.

Wu, D (2009) "Measuring Performance in Small and Medium Enterprises in the Information & Communication Technology Industries", Unpublished PhD thesis submitted to School of Management College of Business, RMIT University, Australia

Zahra, S A (1996) Technology strategy and financial performance: Examining the moderating role of the firms' competitive environment. "Journal of Business Venturing", 11, 189-219

Zajac, E, Kraatz, M S and Bresser, R K F (2000) Modelling the dynamics of strategic fit: A normative approach to strategic change. "Strategic Management Journal", 21(4), 429-53

UNDERSTANDING THE POLARIZED PERSPECTIVES IN BIM ENABLED PROJECTS

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Successful implementation and use of Building Information Modelling (BIM) require consideration of people issues. Two polarised views of BIM are shown from the literature based on technology-centred or human-centred perspectives each of which acknowledges the other but subsumes this into their view. Indeed it is the way that each adopts the other that is problematic. This paper demonstrates that acknowledging these differences and working with them better addresses the management of the implementation of BIM. Empirical findings, from in-depth interviews in a multi-disciplinary engineering company, show that individuals use BIM but are confused by its role depending on their job and perspective. Given this, collaboration and development are held back by the un-expressed differences. It is argued that recognising these differences and using them in a balanced way is essential for the successful adoption of BIM.

Keywords: BIM, human-centred, technology-centred, implementation, development

INTRODUCTION

Building Information Modelling (BIM) has become a significant topic for the UK construction industry due to the UK government's decree (UK Cabinet Office 2012), promotion of its potential benefits (e.g. Azhar 2011) and expectations of consequent business improvement (e.g. Gu et al. 2008). However, despite these push factors, it has been argued internationally, that the BIM adoption rate is slower than anticipated (Azhar 2011; Gu et al. 2008; Gu & London 2010) and its full potential has not been realized where it is implemented (Brewer & Gajendran 2012).

It is stated that in addition to technology implementation, BIM implementation should include process and organizational changes in order to realize its potential benefits and these changes should consider people issues (Gu & London 2010; Arayici et al. 2011; Olatunji 2011). Furthermore, it has been argued that the inability to realize the full potential of BIM is connected to people issues (Neff et al. 2010; Brewer & Gajendran 2012). In a similar way, Hartmann et al. (2012) criticize the top-down, technology-push approach that dominates the BIM implementation literature. Here, the top-down, technology-push approach suggests that business processes need to be aligned to a new way of working that BIM requires to realize its benefits. Their argument does not mean that the majority of existing work does not pay attention to people issues but

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Cidik MS, Boyd D and Thurairajah N (2013) Understanding the polarized perspectives in BIM enabled projects *In:* Smith, S.D and Ahiaga-Dagbui, D.D (Eds) *Procs 29th Annual ARCOM Conference,* 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management, 703-713.

rather suggests that their starting position for problem statement and problem resolution is more technology-centred.

This paper picks up this last point and uses it to consider the different views of BIM between objectivist/technology-centred perspectives and constructivist/human-centred perspectives. The paper adopts a human-centred perspective to counter the dominance of the technology-centred view (Hartmann et al. 2012) and argues for a more balanced view of BIM for positive change. Literature is presented which demonstrates extremes of views to clearly show their fundamental differences. It is argued that the polarization is set by the problem formulator's view of the connections between technology, organizations and people. According to the view they adopt, authors can see technological issues from human-centred perspective, or people issues with a technology-centred perspective. Thus, it is the way that each addresses the other that is problematic. Empirical evidence from interviews in a multi-disciplinary engineering practice shows that individuals are confused by their use of BIM because of the dominant technology-centred perspective overlooks some important issues that can be addressed with a human-centred perspective. It is argued that this makes collaboration difficult and successful development of BIM impossible. It is concluded that recognising these differences in perspective is essential so that a better understanding of the management issues can be achieved which would lead to effective solutions for the advancement of BIM.

The paper takes a critical realist position (Ackroyd & Fleetwood 2000; Mingers 2008) as being the most suitable for the practical task of researching how to use BIM better. This sees the physical world and technology as factually real but accepts that human views and actions of this are socially constructed. Key to a robust enquiry is to adopt a wide critical perspective on both ideas and practice.

LITERATURE

Information Technology (IT) perspectives

By its nature, the IT world is dominated by a technology view of problems. UK Government's BIM Industry Working Group (2011) also uses this view to identify “exploitable information” as the key driver to produce improvement. Objectification of the word 'information' assumes that the same information has the same meaning for different actors using it (BSI 2007; Mutis & Issa 2012). This view of information directly affects how problems in the world are viewed by reducing them to structured and objective information problems (Gleick 2011). Although definitions of information have been well discussed; the way these definitions are used depends on the view adopted for its conceptualization. Thus, the engineering system centred view sees technology as the driver of change and that people are subsumed into the technology.

The shortcoming was realized in 1980s and continues to be discussed (e.g. Wilson 2000; Theng & Sin 2012). Dervin and Nilan (1986) called for a paradigm shift in information needs and uses area away from a system centred view (that they call traditional view) to a user centred view (that they call alternative view). According to Dervin and Nilan (1986), the traditional view sees information as objective and as something to be transmitted in quantified packages from the system to users, where users are seen as input-output processors of information. This perspective focuses on externally observable dimensions of behaviour and events to search for propositions that are valid for different situations so emphasising the 'what' of systems.

In contrast, Dervin and Nilan's (1986) alternative view, posits information as something constructed by its users, human beings. Human beings are constantly freely constructing information (within system constraints) in relation to the system and the situational context; and therefore search for universal dimensions of sense-making thus emphasising the 'how' of systems.

Organizational perspectives

In a similar way to information, organizations can be viewed as machines or as social enterprises. BIM related studies (e.g. Gu & London 2010; Arayici et al. 2011) tend to see organizations as process systems which respond to the changing external environment (Lindsay et al. 2003). These systems can be seen as technology or human driven and this determines the approach to how business processes are modelled.

The technology-centred perspective of business process modelling adopts a simplistic view consisting of general input-process-output streams with clear start and end points. It has been argued that this approach is most suitable for production-line like, standardizable and automatable business processes (Lindsay et al. 2003). Many authors emphasize the difference of nature between production processes and goal-oriented processes in terms of process modelling (e.g. Lindsay et al. 2003; Kueng 2005). They claim that the analysis of activities which is done to model production processes is not appropriate to model office workflow, coordination processes and decision-making processes or, in other words, goal-oriented processes. Thus, the deterministic view is criticised for overlooking many hard-to-model important aspects of real life business practices (Melao & Pidd 2000; Lindsay et al. 2003). The human-centred perspective of process modelling some of which are listed in Table 1 accommodates these aspects.

Table 1: Different Techniques of Human-Centred Process Modelling

Author (Year)	Brief Explanation
Yu (1995)	i star Framework: A process modelling framework considering strategic dependencies of agents and issues and the concerns that agents have about existing processes and proposed alternatives.
Van Der Aalst (2012)	Process Mining: Analysis of collected event logs of activities in the processes for process discovery, monitoring and improvement. This technique has also been used for organizational perspectives and decision points analyses.
Dustdar et al. (2005)	Ad-hoc Process Mining: In this study authors aimed to explore ad-hoc processes which are described as “completely unstructured processes” using process mining.
Xia & Wei (2008)	A context driven business process adaptation approach in which business process context can be gathered and reasoned to modify business process structure.
Stoitsev et al. (2007)	A conceptual framework for unobtrusive support of unstructured, knowledge-intensive business processes.
Koschmider et al. (2010)	Social Software for Process Modelling: Use of social networks to help users to behave as modellers. Users are guided within the context of an existing Recommendation-Based BPM Support System to which social features are added.
Chan & Choi (1997)	Soft systems Methodology (SSM) is applied in Business Process Reengineering.

Melao and Pidd (2000) overview process modelling and relate different approaches to the philosophical stand points shown in Figure 1; for example, most of the techniques listed in Table 1 fall to the right half. The human-centred process modelling shows

that deterministic modelling limits business practices and fails to assist innovation and creative improvisation (Brown & Duguid 2000). Lee (2005) argues for achieving a balance between business process optimization through modelling and the use of human-centred and human-driven business practices.

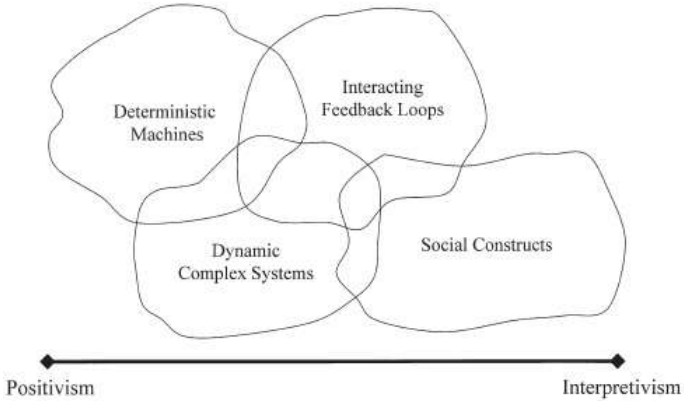

Figure 1: Business Process Views against Paradigms (Melao & Pidd 2000)

People perspectives

Although people perspectives tend to adopt a human-centred view, many authors writing about IT see people as machines (Brown & Duguid 2000, Brewer & Gajendran 2012). People live and work within organizational social settings and this leads to an explanation of behaviour set by organizational cultures. This is a disputed concept (Wright 1994) but can be taken as an explanation of how people within organizations create, shape and are affected by shared cognitive, affective and behavioural patterns. The centrality of organizational culture to organizational life is emphasised by several authors (e.g. Smircich 1983; Alvesson 2002).

Smircich's (1983) work focuses on two extreme views of organizational culture: functional and non-functional, which provides the argument for the differences adopted in this paper. The functional view emphasises prediction, generalizability, causality and control. This view sees culture as a variable among many others and as something an organization "has". Such a view considers that culture can be consciously managed to improve organizational performance due to its casual nature. Consequently, the functional view reduces culture to limited aspects that are perceived from an organizational performance point of view (Smircich 1983; Gajendran et al. 2012).

In contrast, a non-functional view explains culture as part of observable human behaviour, thus, is seen as something an organization "is". Informal aspects of organizations are seen as important and need to be explored to develop organizations (Smircich 1983; Gajendran et al. 2012).

BIM IN PRACTICE

Semi-structured interviews were conducted with professionals from the Birmingham, UK office of a multidisciplinary engineering company which has been established for forty years in the UK and now operates in twenty locations around the world with over four hundred staff. The interviews were conducted with an associate partner, two mechanical engineers, two energy modelling engineers, one structural engineer and one acoustic engineer. The interviews aimed to gain insight into the changes that occurred with the implementation of BIM and about their perceptions of BIM.

Although these people were engineers and so inclined to have a technological perspective and be supportive of technology such as BIM, this did not dominate their practice. For example, the acoustic and energy modelling engineers did not interact with any collaborative BIM software. Both disciplines believed that the inputs and outputs of their discipline are different in nature than other disciplines and that there is no need to be integrated in a merged building model. However, energy modelling engineers stated that if there was a plug-in which ensures the seamless interoperability between the model and their proprietary software they would use it. Nevertheless, they added that even in this situation they would doubt the accuracy of data entered by other parties and probably be cautious about using it.

Although the majority of interviewees were aware of the capabilities of BIM as a total project delivery approach, all the interviewees saw and used BIM merely as a design coordination platform. This means that i) even the disciplines interacting with BIM software (i.e. mechanical and structural engineers) create their design solutions the way they used to do in 2D form and then transfer it to BIM platform for clash detection and drawing generation; ii) BIM software capabilities are not being fully exploited and no object information other than geometrical information is entered in 3D models (i.e. schedules and specifications are created as separate text documents to be printed out and not linked to models). While the software that the structural engineer uses for structural analysis has an export feature to the collaborative BIM tool, this is not the case for mechanical engineers because they create their preliminary solutions through sketches and 2D drawings.

The reasons identified by the interviewees to explain their approach to BIM merely as a design coordination platform are listed below:

- The only perceived advantages of 3D modelling are early clash detection and better design coordination.
- The amount of the detail required in 3D modelling is non-supportive for the preliminary design phase of mechanical engineering discipline.
- Drafting work cannot be delegated to CAD technicians anymore because 3D modelling requires decision making during modelling, thus, increasing the workload of mechanical engineers. The time needed to embed all design information (visual and non-visual) into the model is not perceived as adding enough value in return.
- Structural and mechanical engineers considered the necessity to fully detail 3D models which then generated 2D drawings as a negative effect.
- The amount and type of information that contractors use has not changed. They don’t use 3D models and ask for 2D drawings.
- There is a belief that the control and tracing of the non-visual design information (e.g. specifications) is more difficult in the model than when it is in spread sheet tables and/or text documents.
- Senior engineers sign off design documents but do not have BIM knowledge.
- Software interoperability problems are not currently resolved.

On the other hand all the interviewees agreed that implementation of BIM improved coordination within the team and between the teams of different companies. They stated that the nature of 3D modelling which is transparent and which requires design decisions to be made earlier increased communication. Increased communication, clash detection meetings and better visualization made people to better understand

others' work. However it was also stated by the interviewees that unlike communication, the collaboration between the parties hasn't improved. All the interviewees see BIM as an important part of the future of the construction industry but it needs to be supported by training and go through significant rationalization.

DISCUSSION

The interviews were analyzed to understand BIM practices in: i) adopting BIM tools ii) shaping business processes, and iii) addressing collaboration which revealed the significance of the added complexity introduced by BIM.

Making sense of use of IT in BIM

The interviews revealed that the only pure technological problem for the use of BIM merely as a design coordination platform is interoperability. All other reasons show the importance of making sense of the use of IT for people to make them use a particular IT, just like human-centred perspective of IT would suggest. A technology-centred perspective would assume that the functionalities embedded in IT would be used by its users. However, despite better visualisation and more sophisticated tools provided by BIM software, all the disciplines interviewed have created their design solutions as they used to do in the 2D tradition. The major reason for this is that all the interviewed disciplines believe that the creative design processes they used previously are good enough and they do not need to be changed. For example, mechanical engineers keep using sketches and 2D drawings for their preliminary design and they find this method to be faster and more efficient. They claim that 3D modelling requires too much detail to be entered into the model from the beginning and that this much detail is unnecessary when multiple design solutions are being evaluated to choose the best one. Furthermore, pen and paper are not just old fashioned tools that they use to communicate their design but are part of their creative process.

A similar situation is reported by Harty (2008) for the case he studied where a planned project based shift from pen and paper sketches and 2D CAD drawings to 3D modelling faced strong resistance from the design team. He claimed that people resisted because the implemented vision and artefacts did not account for the other material objects that were an integral part of designing and drafting. Consequently new processes were seen as discontinuous with existing ways of working. Gustavsson et al. (2012) explain that design is a proactive and iterative process where the designer uses a unique combination of practical, theoretical and tacit knowledge which cannot be achieved by any technology. This particular nature of the design process is currently not being supported by IT solutions. Therefore, designers use a combination of different methods (i.e. both manual and technology based) and only use IT when they make sense of its use.

Practice is Business Process (BP)

The company's BIM strategy stated by the associate partner and most of the engineers emphasised BIM as a "selling point" and "catch phrase" for the company. Thus, there was a necessity to use BIM but not a need for extended use. This situation, to some extent, gives more power to people using BIM tools in determining the scope of the BIM related change in BPs. Although BIM tools have capabilities beyond design coordination and interviewees are knowledgeable about them; BIM practices played a critical role in determining the scope of the BP change and led the company to use BIM merely as a design coordination tool.

Automatic clash detection capability and 3D visualization are the obvious, immediate benefits of BIM even in cases where any non-geometric object information is not entered into the model. Therefore, it can be argued that under a vague and non-leading organizational strategy, it is only the immediate benefits that are adopted. In practice then, BIM tools are only used for the tasks where users made sense of the BIM way of working, in this case design coordination. Thus, BPs are not evolved in the direction of BIM's capabilities but had minor changes with implementation of BIM because of the way it is used in practice. In this case, people's use of BIM was the limiting factor however as this didn't disturb current strategy and technological capabilities, a pragmatic congruence is achieved. Moreover, the positive current and future perceptions of the interviewees about BIM, despite their limited use of BIM technology, can also be related to this congruence. This example demonstrates the power of practice in shaping BPs in organizations.

This is in line with Linderoth and Pellegrino (2005) as they showed the way IT is used in practice is an important factor in determining the scope of realized change in IT implementation projects. They identified that strategy, the perceived nature of technology and the use of technology are inter-related and inter-dependent with varying emphasis on the different relations between these three elements according to the stage of implementation and use. In accordance with our findings, they claim that congruence should be established between the strategy, the nature of technology and the use of technology for the change to occur.

BIM Tools, Interoperability and Collaborative Culture

All interviewees agreed that implementation of BIM improved coordination within and between the project teams. Engineers interacting with BIM software stated that 3D modelling made the design more transparent and this pushed team members to think more about their solutions and its consequences earlier. In the 2D tradition, different service headings could work separately and meet less frequently for coordination. However, in 3D environment there is a need for people to contact each other more to understand others' solutions before proceeding with theirs. Interestingly, when the definition of collaboration was made explicit to the interviewees as “creation of collaborative and innovative solutions with shared goals”, they stated that the level of collaboration hasn’t changed. Furthermore, one of the mechanical engineers stated that “sharing (of the model) doesn’t make a better team”. Interviewees stated that design meetings focus on problem identification and discussion rather than the creation of collaborative and innovative solutions. Interviewees saw the 3D model as a facilitator in design meetings with the common, understandable and visual information it provides. However, they also stated that this enhanced understanding of other parties’ work doesn’t necessarily encourage them to collaborate.

Similar findings were presented by Neff et al. (2010) who argued that while there are instances where BIM tools may improve collaboration and communication within the teams, it is not due to its ability to close the informational gaps between disciplines. Furthermore, they argue that the lack of flexibility of the information created and stored with BIM tools hinders inter-organizational collaboration and group working. They argue that BIM tools reflect and amplify the disciplinary representations instead of supporting collaboration. Moreover, Homayouni et al.’s (2010) findings suggest that the theoretical categories of successful collaboration are the same for BIM enabled projects as projects without BIM. Similarly, Dossick and Neff (2011) present transparent and reliable technology and communication as the key factors for effective

inter-organizational team work with a strong emphasis on the importance of informal, active and flexible visual communication. Therefore, it can be argued that the belief that improved information sharing capabilities (i.e. better interoperability) leads to improved collaboration is not correct. Thus there is not a direct causal relationship between the technological tools alone and change in collaboration culture.

Over Simplification of a Complex Realm?

Construction projects are characterised by their technical and organizational complexity (Dubois & Gadde 2002). Therefore, the construction industry should be ready to face the added complexity when implementing BIM. However, complex systems require the whole to work beyond the capacity of the details (Bertelsen 2004). The adoption of technology-centred perspective of BIM leads to an abstraction of real life practices inducing a limited understanding of their effects, thus severely curtailing sense-making. Koskela and Vrijhoef (2001) make a similar argument stating that one of the main deficiencies of the current construction theory, in terms of innovation activity, is its abstraction of uncertainty and interdependence. Consequently, business improvement attempts made from such an abstract perspective would have limited effects.

Managers and problem solvers should acknowledge the added complexity in the adoption of BIM and avoid having too many expectations from technology-centred approaches (Brown & Duguid 2000). It is argued that a balanced view of BIM should be adopted to understand the challenges of BIM and to create solutions. Moreover, the complex nature of this area should be embraced as an important input for problem statement, problem resolution and management (Brown & Duguid 2000; Bertelsen 2004; Gajendran et al. 2012).

CONCLUSIONS

This paper has demonstrated how the currently dominant technology-centred perspective of BIM requires a human-centred perspective to enhance our understanding about BIM developments. The extremes of views in terms of IT, organizational and people issues were presented from the literature which provided an understanding of the differences between the perspectives and a robust enquiry frame for researchers and practitioners. It was argued that due to the complex nature of construction projects, a delicate balance between the technology-centred perspective (i.e. which is characterized as simplistic, structured, deterministic, mechanistic and casual) and human-centred perspective (i.e. which shows a world of practice characterized as complex, unstructured, unpredictable, dynamic, and non-generalizable) is required to better understand the problems of BIM and thus to create positive change.

REFERENCES

Ackroyd, S and Fleetwood, S (2000) "Realist perspectives on management and organisations". London: Routledge.

Alvesson, M (2002) "Understanding organisational culture". London: Sage.

Arayici, Y, Coates, P, Koskela, L, Kagioglou, M, Usher, C, and O'Reilly, K (2011) Technology adoption in the BIM implementation for lean architectural practice. "Automation in Construction", 20(2), 189–95.

Azhar, S (2011) Building information modelling (BIM): Trends, benefits, risks, and challenges for the AEC Industry. "Leadership and Management in Engineering", 11(3), 241–52.

Bertelsen, S (2004) Lean construction: Where are we and how to proceed? "Lean Construction Journal", 1(1), 46-69.

BIM Industry Working Group (2011) Strategy paper for the government construction client group. [online] Swindon, UK: The Technology Strategy Board. Available at: <https://connect.innovateuk.org/c/document_library/get_file?uuid=6842e020-20df-4449-8817-08ce2ba9ef7c&groupId=68909>. [Accessed 08 April 2013].

Brewer, G and Gajendran, T (2012) Attitudes, behaviours and the transmission of cultural traits - Impacts on ICT/BIM use in a project team. "Construction Innovation", 12(2), 198-215.

British Standards Institution (2007) BS ISO 12006-3:2007. Building construction. Organization of information about construction works. Framework for object-oriented information.

Brown, J S and Duguid, P (2000) "Social life of information". Boston, MA: Harvard Business School Press.

Chan, L D and Choi, C F (1997) A conceptual and analytical framework for business process reengineering. "International Journal of Production Economics", 50(2-3), 211-23.

Dervin, B and Nilan, M (1986) Information needs and uses. In: M.E. Williams, (ed.) "Annual review of information science and technology", Vol. 21, 3-33. White Plains, NY: Knowledge Industry Publications.

Dossick, C S and Neff, G (2011) Messy talk and clean technology: communication, problem solving and collaboration using Building Information Modelling. "Engineering Project Organization Journal", 1(2), 83-93.

Dubois, A and Gadde, L (2002) The construction industry as a loosely coupled system – Implications for productivity and innovation. "Construction Management and Economics", 20(7), 621-31.

Dustdar, S, Hoffmann, T, and Van der Aalst, W (2005) Mining of ad-hoc business processes with TeamLog. "Data Knowledge and Engineering", 55(2), 129-58.

Gajendran, T, Brewer, G, Dainty, A and Runeson, G (2012) A conceptual approach to studying the organisational culture of construction projects. "Australasian Journal of Construction Economics and Building", 12(2), 1-26.

Gleick, J (2011) "The information : A history, a theory, a flood" London:Fourth Estate.

Gu, N, Singh, V, London, K, Brankovic, L and Taylor, C (2008) BIM : expectations and a reality check. In: Ren, A, Ma, Z and Lu, X (Eds.), "ICCCBE-XII & INCITE 2008", 16-18 October 2008, Tsinghua University. Tsinghua University Press, 1-6.

Gu, N and London, K (2010) Understanding and facilitating BIM adoption in the AEC industry. "Automation in Construction", 19(8), 988–99.

Gustavsson, T K, Samuelson, O and Wikforss, Ö (2012) Organizing it in construction: present state and future challenges in Sweden. "Journal of Information Technology in Construction", 17, 520-34.

Hartmann, T, Meerveld, H V, Vossebeld, N and Adriaanse, A (2012) Aligning building information model tools and construction management methods. "Automation in Construction", 22, 605–13.

Harty, C (2008) Implementing innovation in construction: contexts, relative boundedness and actor-network theory. "Construction Management and Economics", 26(10), 1029-41.

Homayouni, H, Neff, G, and Dossick, C (2010) Theoretical categories of successful collaboration and BIM implementation within the AEC industry. In: Buwanpura, J, Mehamed, Y, and Lee, S. (Eds.) "CRC 2010", 8-10 May 2010, Banff, Alberta, Canada. American Society of Civil Engineers, 778-88.

Koschmider, A, Song, M and Reijers, H A (2010) Social software for business process modeling. "Journal of Information Technology", 25(3), 308-22.

Koskela, L and Vrijhoef, R (2001) Is the current theory of construction a hindrance to innovation? "Building Research & Information", 29(3), 197–207.

Kueng, P (2005) Expert view. "Business Process Management Journal", 11(6), 624-27.

Lee, L L (2005) Balancing business process with business practice for organizational advantage. "Journal of Knowledge Management", 9(1), 29 – 41.

Linderoth, H C J and Pellegrino, G (2005) Frames and inscriptions: tracing a way to understand IT-dependent change projects. "International Journal of Project Management", 23, 415–20.

Lindsay, A, Downs, D and Lunn, K (2003) Business processes—attempts to find a definition. "Information and Software Technology", 45, 1015–19.

Melao, N and Pidd, M (2000) A conceptual framework for understanding business processes and business process modelling. "Information Systems Journal", 10, 105–29.

Mingers, J (2008) Management Knowledge and knowledge management: realism and forms of truth. "Knowledge Management Research and Practice", 6(1), 62-76.

Mutis, I, and Issa, R R A (2012) Framework for semantic reconciliation of construction project information. "Journal of Information Technology in Construction", 17, 1-24.

Neff, G, Fiore-Silfvast, B, and Dossick, C S (2010) A case study of the failure of digital communication to cross knowledge boundaries in virtual construction. "Information, Communication & Society", 0(0), 1–18.

Olatunji, O A (2011) Modelling organizations' structural adjustment to BIM adoption: a pilot study on estimating organizations. "Journal of Information Technology in Construction", 16, 653-68.

Smircich, L (1983) Concepts of culture and organizational analysis. "Administrative Science Quarterly", 28(3), 339-58.

Stoitsev, T, Scheidl, S and Spahn, M (2007) A framework for light-weight composition and management of ad-hoc business processes. In: Winckler, M, Johnson, H and Palanque, P (Eds.): "TAMODIA 2007", 7-9 November 2007, Toulouse, France. Springer-Verlag France, 213–26.

Theng, Y L and Sin, S C J (2012) Analysing the effects of individual characteristics and self-efficacy on users' preferences of system features for relevance judgment. "Information Research", 17(4), paper 536. Available at: <http://InformationR.net/ir/17-4/paper536.html>. [Accessed 08 April 2013].

UK Cabinet Office (2012) Government Construction Strategy. London, UK: Cabinet Office.

Van Der Aalst, W (2012) Process mining: Overview and opportunities. "ACM Transactions on Management Information Systems", 3(2), 1-17.

Wilson, T D (2000) Human Information Behavior. "Informing Science", 3(2), 49-55.

Wright, S (1994) Culture in anthropology and organisational studies. In: S. Wright (ed.) "Anthropology of organizations". New York, NY: Routledge.

Xia, Y and Wei, J (2008) Context-driven business process adaptation for ad-hoc changes. In: "ICEBE 2008", 22-24 October 2008, Xi'an, China. IEEE Computer Society, 53-60.

Yu, E (1995) "Modelling Strategic Relationships for Process Reengineering", Unpublished PhD Thesis, Graduate Department of Computer Science, University of Toronto

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