A R C O M

ASSOCIATION OF RESEARCHERS IN **CONSTRUCTION MANAGEMENT**

TWENTY-EIGHTH ANNUAL CONFERENCE **2012** September 3-5

Edinburgh

Volume 1

Association of Researchers in Construction Management (ARCOM)

Proceedings of the 26th Annual Conference

Edited by Simon Smith

First published 2012

ISBN: 978-0-9552390-6-9 (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
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ARCOM Declaration:
The papers in these proceedings were double refereed by members of the scientific committee in a process that involved detailed reading of the papers, reporting of comments to authors, modifications of papers by authors and re-evaluation of re-submitted papers to ensure quality of content.

FOREWORD

Welcome to Edinburgh for the 28th edition of the Association of Researchers in Construction Management's annual conference. This year's conference promises to be one of the biggest yet, and returns to Scotland's capital for the second time, having first been hosted by Heriot-Watt University in 2004; and to Scotland for the third time after Glasgow in 2000.

This year's conference call attracted a huge amount of interest. 329 abstracts were submitted in February, which resulted in 181 full papers. This has been further reduced to 134 final accepted papers, all of which appear in full in these proceedings. This is one of the highest number of papers that an ARCOM conference has seen and is testament to the popularity, quality and importance of this annual showcase of the best research in international construction management research, particularly at a time of financial difficulty for so many delegates. It is possibly also a reflection of the popularity of our host city for 2012. The Scottish capital needs little to persuade us to visit its mix of Georgian and Medieval streets and our location for the conference itself, at the foot of the Salisbury Crags and Arthur's Seat; opposite the Holyrood Parliament and next to the Queen's Park and Holyrood Palace will hopefully inspire enlightened debate!

In recent years ARCOM, and the ARCOM conference, have grown to become an internationally significant institution. The committee has recognised this yet has steadfastly refused to attempt to cash in on this popularity; rather we have tried to increase the quality of the papers presented. Thus we maintain quite strict standards of academic quality and rigour in our review process. This is impossible without the efforts of its Scientific Committee and I must pause to hopefully ensure all delegates are aware of the key role that these 67 people have played in the development and passage of their papers through the review process. It is worth pointing out that a total of 1333 separate reviews were conducted in order that the proceedings appear as they do.

The industry we research is, as ever, facing a great deal of challenges. It has been very hard hit in Europe by the worldwide financial situation with negative growth in the last year in some countries. It is not just construction that has been hit of course, and this downturn is seen in the academic and higher education sectors also. Frustratingly, many academics are unable to fund and thus fully develop the knowledge and understanding in the way they wish to in order to prepare for better times to come. Yet we continue to see progression and changes in the make up of the research presented at our conference. In particular we continue to see a development of understanding of people: the way they behave, the differences in cultures, how they might be treated and protected better and how the diversity of a workforce can be recognised and treated correctly. This must give us hope for the future, that when the world is able to develop its infrastructure and countries that have lain idle for so long can be allowed to grow that its workforce will be better able to deliver. The papers in these proceedings on equality and diversity; on respect for people; on behavioural and cultural differences are a reflection of this and one only needs to look at the table of contents of proceedings from the early '00s to see how trends have changed. These themes have become more prominent.

In recent years the sustainability agenda has rightly affected the way we approach our work and has resulted in a huge increase in research on sustainability theory, low carbon construction, environmental assessment and of energy reduction. The number of papers on sustainability in this year's proceedings is the largest by some margin in comparison to the other themes. 23 papers have been separated out in to two themes: sustainability theory and design issues as well as research on the operation and practice of sustainability implementation. Many works reflect the policy and strategic governmental changes to produce low carbon dwellings and public buildings.

This year we see a new theme on Building Information Modelling and while the large number of abstracts submitted in this area did not, unfortunately, translate to a similar number of accepted final papers, it is clear that there is much work to be done to appreciate the benefits – and uses – of this new technology; and to educate the breadth of the industry on how to exploit and utilise it. I suspect this will be a growing theme for the next few years.

Papers come from a wide variety of sources. This year, over twenty countries are represented with a vast number of papers coming out of PhD and postgraduate research. ARCOM is proud to nurture this talent and it is also very gratifying to see that a large number of experienced academics number among the registered delegates. I am hoping that the long ARCOM tradition of support and encouragement of early career researchers continues in the debate and discussion, in both lecture room and social arenas of this conference.

There are eight paper prizes to be awarded this year. Three are ARCOM's own awards, commemorating past chairs and committee members Rod Howes, Paul Townsend and David Langford. Five awards are funded by our sponsors: CIOB, RICS and publishers Wiley-Blackwell and Taylor & Francis. The late Prof. Dave Langford is also remembered by the Second Annual Langford Lecture, this year delivered by Aletha Holborough from University of Westminster.

It goes without saying that a conference of this nature needs a lot of support and work behind the scenes and a note of thanks must as always go to the main ARCOM committee in addition to the scientific committee mentioned above. Particularly thanks to Paul Chan, Ani Raiden and Stephen Gruneberg for managing our debate and keynote speaker sessions. I'd like to offer thanks and appreciation to Will Hughes for his support and advice on academic, editorial and many other issues. And last but not least a sincere nod to our new Conference Secretary, Dominic Ahiaga-Dagbui whom most of you will already know from his numerous email communications.

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, University of Edinburgh, UK
ARCOM 2012 Conference Editor

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BUILDING INFORMATION MODELLING

AWARENESS, USAGE AND BENEFITS OF BUILDING INFORMATION MODELLING (BIM) ADOPTION – THE CASE OF THE SOUTH AUSTRALIAN CONSTRUCTION ORGANISATIONS

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Research has shown that while Building information modelling (BIM) is not a new concept, and that its uptake is becoming an increasingly important factor in the efficiency and international competitiveness of the Australian construction industry (ACI), when compared with other industries, the ACI is often regarded as being slow to implement new ideas and technologies. Furthermore, they are limited studies conducted which seek to assess the current levels of awareness, usage and advocated benefits of BIM among construction organisations, within the context of South Australia. The study is aimed at filling that knowledge gap. The objectives of this study were to: (1) ascertain the current awareness and determine usage rates of BIM adoption; and (2) establish the advocated benefits relating to the adoption of BIM relative to its impact on project outcomes among the stakeholders of the South Australian construction industry. A field study was conducted with a randomly selected sample of twenty-nine construction organisations. Ten BIM benefits were used, and survey response data were collected using structured questionnaires and analysed using mean and ranking analysis. Relative to the awareness and usage, the findings indicates that a significant proportion of respondents have little or no understanding on the concept of BIM and the usage was found to be very low. The results indicated that 'improved constructability', 'improved visualisation', 'improved productivity', and 'reduced clashes' as the highly ranked benefits associated with BIM adoption. The highly ranked major issues surrounding the adopting or use of BIM were 'lack of understanding about BIM', 'education & training costs' 'start-up costs' and 'changing the way firms do business'. The practical implication for Senior Managers within the construction organisations are that; awareness of BIM processes through education and training; both formal and informal process including more information, and provision of expertise within BIM could enhance the levels of adoption.

Keywords: modelling, awareness, construction industry, South Australia

INTRODUCTION

Despite the importance of the construction industry as a key player in Australia's economic development as evidenced by its contribution (in excess of 6%) to Gross Domestic Product (GDP) and employing nearly 1 million people (Australian Bureau of Statistics 2010), compared with other industries, it is often regarded as being slow

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Newton K and Chileshe N (2012) Awareness, usage and benefits of Building Information Modelling (BIM) adoption – the case of the South Australian construction organisations *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 3-12.

to implement new ideas and technologies, which have the potential to make it a much more competitive and productive industry.
Furthermore the construction industry is inherently fragmented, partly due to the once-off nature of most construction projects, often meaning project teams, processes and ideas learned previously are not relevant for the next project and also because of the competitive environment that often exists between disciplines. This fragmentation can result in poor information flow and poor collaboration between disciplines ultimately leading to inefficiencies in productivity. The need for the industry to embrace change is highlighted in a report by the Department of Innovation, Industry, Science and Research (2010) which indicates the uptake of technologies such as Building Information Modelling (BIM) are 'becoming an increasingly important factor in the efficiency and international competitiveness of the Australian construction industry.' The report explains that 'international activity indicates global markets view BIM as an important tool for the future growth and competitiveness of the built environment.' The above observation calls for the further exploration into the possible adoption of BIM among the construction organisations in South Australia.

OBJECTIVE

The objectives of the study were as follows:

- To ascertain the current awareness of BIM by members of the SA construction industry.
- Determine the current usage rates of BIM by stakeholders of the SA construction industry
- Explore the SA construction industry member's perception on the problems and benefits surrounding the adoption and usage of BIM and identify solutions to address key issues.

Due to non-availability of documented and structured data on BIM awareness, usage and benefits with the Department of Planning, Transport and Infrastructure (DPTI) prequalified Category 1, 2 and 3 builders and trade contractors for the study, questionnaire survey was used for the data collection. The responses received were statistically analysed.

LITERATURE SURVEY

Adoption, awareness and usage issues

A number of studies have reported on the reluctance of the construction industry to adopt new technologies (Yang, 2007; Lawrence and Scanlan, 2007; Gambatese and Hallowell, 2011; and Sargent *et al.* 2002). For example, a study by Yang (2007) which explored the links between technology usage and project outcomes, found that, when compared to other industries, the construction industry was less reluctant in the application of new technologies. Similarly, Gambatese and Hallowell (2011) study aimed at investigating the varying differences in the rate of technical innovation throughout the construction industry, found 'fear of change' among the inhibitors to this diffusion. Similarly, within the context of small and medium enterprises (SMEs), Hardie and Newell (2011) conducted a study aimed at determining whether any common lesson could be drawn from the experience of individuals, who had managed to successfully implement or deploy the technical innovation. The study identified a number of factors that enabled construction innovation. These were as follows: (1) company resources; (2) client and end user influence; (3) project-based conditions; (4)

Industry networks; and (5) regulatory climate. These enablers were further classified into fifteen sub-factors using analytic hierarchy process methodology.

Other studies conducted within the Australian context such as Kymmell (2008), Gerrard *et al.* (2010), BIM in Australia (2010) have attributed the following barriers as contributing to the low level of awareness and poor uptake of BIM: 'Poor collaboration and trust between stakeholders in the construction industry' 'lack of trained staff', 'lack of understanding', and 'implementation costs of BIM'. A study by Arayici *et al.* (2011) aimed at presenting a systematic approach for BIM implementation found the people, process and technology as crucial for its success.

Challenges and Benefits

A number of studies such as CRC for Construction Innovation, (2007); Jordani (2008); Allen Consulting Group (2010; BIM in Australia (2010); Underwood and Isikdag (2011) have highlighted the potential benefits to be gained from the adoption of BIM. For example, a study by Allen Consulting Group (2010) established a number of benefits resulting from the implementation of BIM technology. These included the following: improved information sharing enhanced productivity, improved quality, and increased sustainability and labour market improvements. Each of these benefits has significant flow on effects which ultimately result in a much more competitive industry along with the more efficient use of resources and also a higher quality building. Other notable benefits arising from BIM as indentified by the same study (Allen Consulting Group, 2010) included the following: 1) 'Better design', 2) 'Controlled whole-life costs and environmental data', 3) 'Enhanced processes', 4) 'Higher production quality', 5)' Improved customer service', and 6) Life-cycle data. Similarly, a study by BIM in Australia (2010) highlighted increased efficiencies, improved productivity and enhanced communication between and within teams as major benefits that can arise from the introduction of BIM.

According to Underwood and Isikdag (2011), there is scope for BIM in future directions such as improving the way facilities are managed through applications of data sensors, known as WSN's (Wireless Sensor Networks). Accordingly, these WSN's can be achieved through their installation into building elements. However, Underwood and Isikdag (2011), explains that 'in order to get the greatest benefit from BIM technology it must be used as a facilities management tool.' This was also earlier identified by Jordani (2008) who pointed out that, the many benefits possible with BIM are rendered practically useless unless the information is further utilized in Facilities Management (FM). 'Simply delivering project BIM's to an owner has marginal value. To be effective, the data captured in BIM's must be channelled into a variety of FM software systems'. It is assumed Jordani's opinion is based on the fact that the major cost involved in a facility is not its construction but the operation and running costs during its life-cycle where the use of BIM technology will prove to be most beneficial. Other benefits identified in literature have ranged from 'enhanced visualisation' (Kymmell, 2008), 'improved productivity' to 'enhanced sustainability of construction industry' (CRC for Construction Innovation, 2007).

RESEARCH METHODS

As the main objectives of this study were to ascertain the current awareness and determine usage rates of BIM adoption, with a view to establishing the advocated benefits relating to the adoption of BIM to the impact on project outcomes, the following research methodology was employed in the study.

Instrument

The questionnaire was divided into four sections as follows: 1) general demographics of the respondents and awareness / usage issues; (2) BIM enabler's; (3) barriers and challenges to BIM adoption; and (4) benefits of adoption BIM. Each item in the BIM enabler instrument was measured from a range of (1) representing not important to (5) representing highly important. Thus, (3) represented indifference, i.e. neither not important or highly important. The last section sought to measure the benefits of BIM adoption, and comprised ten items (see Table 1). Each item (barriers) was measured on a 5-point Likert format where 1 = not important and 5 = highly important. Thus (3) represented indifference, i.e. neither important nor not important.

Selection of Key Respondents

As the study sought to reveal the understanding and usage rates of BIM by stakeholders of the South Australian (SA) construction industry, the primary source of information was identified as being firms involved in the SA construction industry. In order to be able to infer research findings back to a population, and produce accurate and meaningful results, indicative of SA construction industry in general, an approach of random sampling from the Government of South Australia's Department of Planning, Transport and Infrastructure (DPTI) prequalified Category 1, 2 and 3 builders and trade contractors were selected (DPTI, 2011). These stakeholders were selected as they represent a broad cross-section of the SA construction industry (from $2M to $50M Australian dollars projects), allowing for accurate data relating to the awareness and usage rates of BIM in the SA construction industry to be collected. Another reason for the selection of stakeholder's from the SA Government's prequalification list, was that these firms would be more likely to be involved in a broad range of projects and potentially use more current technology, in order to remain competitive and ultimately sustainable

Reminder phone calls were also made approximately two weeks after the surveys were sent, resulting in four additional responses. In a related study, by Gerrard *et al.* (2010), a comparable approach to reduce the sample population was adopted for data collection purposes. These stakeholders were also chosen as they are more likely to be leaders in the industry, adopting change more readily than other smaller, less recognised firms. It is therefore, assumed that members from these companies may have a greater understanding of BIM and provides the researcher with more meaningful results.

Survey Administration

Because the purpose of the study were descriptive, and the research question involved establishing the opinions of respondents on BIM awareness , usage, benefits and challenges, according to Forza (2002), the recommended strategy is that of an analytical survey. To this end, survey questionnaires were used as the data collection technique.

A total of 75 questionnaires were sent out using a random sampling technique, which ensures bias is not introduced. Although 35 were returned, 4 were rejected because they were not completely filled out. The reasons provided by the returnees were that the study was not relevant to their business. A further 2 respondents indicated that some of the information required was 'confidential to their business; thus only 29 were included in the analysis for a response rate of 39%. This response rate is similar to previous studies within the construction (Shash 1993; and Kometa & Olomolaiye

1997) which obtained response rates of 28% and 23% respectively. The response rate was therefore deemed adequate for the purpose of data analysis. Akintoye and Fitzgerald (2000 cited in Odeyinka *et al.* 2008) argued that this is well above the norm of 20-30 % for postal questionnaire of the construction industry.

However, the high non-response rate (53.33%) also suggests that BIM wasn't relevant to their organisations, given that the targeted respondents were selected from the Department of Transportation, Energy and Infrastructure (DTEI) top three tiers of preferred building and trade contractors. This also, indicates a significant lack of interest and understanding of BIM and its potential benefits to their business and the SA construction industry

Statistical methods

As the purpose of the study was descriptive, frequency and ranking analysis were used (Forza, 2002). The *Statistical Package for Social Sciences* computer program was used to analyses the data thus collected. Furthermore, in order to transfer the responses obtained from the questionnaire surveys into accurate and meaningful data, the adoption of a relative importance index (RII) has been utilised where appropriate. The use of a RII, as a data analysis tool, has been used in other construction industry studies involving questionnaire surveys, such as Park (2009) and Tarawneh (2004).

SURVEY RESULTS

Sample profile

A total of professionals completed the questionnaire with the majority (20.69%; n = 6) drawn from Project Managers, followed by an equal number of Managing Directors (13.78%, n = 4). The rest were an equal number of marketing manager, design manager, estimator, administrator and project coordinator (3.45%; n = 1). Although the responses were not spread evenly throughout the roles, the results show that the sample population held significant positions in their organisations, and would therefore, be expected to have a good understanding of current practices and processes within their organisations and the wider construction industry.

BIM Usage Rates

This section reports on the use of BIM within South Australian construction organisations. The following question was posed to the respondents: *Is your firm currently using any form of BIM technology*? Only a minority (17.24%, n = 5) of the firms were currently using some level of BIM. Conversely, the majority, 24 (82.76%) reported as not using BIM. Given the low reported usage (17.24%, n = 5, of all the SA construction stakeholder respondents) of any form of BIM technology, the percentage responses reported here represent minority views. This finding contradicts the recent study by Allen Consulting Group (2010, pg 28), which found that from a total of 56 Australian engineering and construction contractors, 75% were currently using BIM. However, the results in our study are consistent with the earlier studies by Gerrard *et al.* (2010) and Kymmell (2008), which pointed out 'that there was currently a relatively low adoption rate of BIM in the Australian construction industry', but according to Kymmell (2008), it was 'approaching the tipping point'. Furthermore, a survey conducted by Gerrard *et al.* (2010, p 531) of Australian architecture, engineering and construction firms, revealed a usage rate of 7%. This appears to be more in-line with the questionnaire survey results, especially when the time laspes between surveys are taken into account.

Usage rates and Organisation Size
The data gathered also shows a link between the use of BIM and the size of the firm. The findings established that none of the firms with an annual turnover of less than $10 Million were currently using BIM. These results are consistent with literature which suggests that 'implementation costs of BIM were perceived by contractors, as potentially prohibitive in the short term' (BIM in Australia 2010, pg, 3).

Time since implementation of BIM
This section reports on the time elapsed since implementation use of BIM within South Australian construction organisations and whether the usage had increased or decreased. The results revealed that only a minority, (20.0%; n = 1) of the five firms had adopted BIM over four years ago, whilst the remainder have implemented it within the last two years. Furthermore, the results indicate that two (40.0%; n = 2) out of the five firms currently using BIM stated that, its usage had neither increased nor decreased since implementation. The remainder, (60.0%; n = 3) of BIM users however, indicated that its use on projects had increased since adoption within two respondents revealing that its use had increased significantly. Studies have shown that construction firms throughout Australia are only starting to become aware of the potential benefits of BIM and therefore, its use by most firms is only fairly recently. Furthermore, as previously highlighted by the Department of Innovation, Industry Science and Research (2010, p.2), 'the uptake of new technologies are becoming an increasingly important factor in the efficiency and international competitiveness of the Australian built environment industry'. Therefore firms are now more than ever turning to technology to remain competitive.

Industry understanding of the terminology 'BIM'
In order to achieve the first objective, namely that of 'ascertaining the current awareness of BIM by members of the SA construction industry', the respondents were asked the following question: How would you rate your understanding of the term BIM (Building Information Modelling)?' The respondents were asked to rate this understanding on a five-point Likert scale (where 1 = Never hear of, 2 = some knowledge; 3 = Fair (or moderate) knowledge; 4 = competent; and 5 = highly competent). The results showed that, a significant proportion (51.72%, n = 15) currently have either never heard of, or only have some knowledge of BIM. Whilst, only a combined total of (24.14%; n = 7) comprising BIM users (n = 3) and non-BIM users (n = 4) believed they had a moderate (or fair) knowledge of understanding. Significantly, only a minority, (3.45%; n = 1) of the respondents had a highly competent understanding of BIM. This respondent was drawn from the non-BIM utilisation organisation.

'Lack of understanding and awareness' was highlighted by Gerrard *et al.* (2010) and also by BIM in Australia (2010) as key barriers preventing more wide-spread adoption of BIM. Kymmell (2008) also reveal that there is a lack of understanding of what BIM is. These results therefore agree with literature that there is currently a genuine lack of understanding of BIM in the broader SA construction industry. A key point to note from the results, in terms of industry and awareness of BIM, was that, apart from one respondent, none of the remaining respondents whose firms were using BIM indicated they had more than a moderate knowledge of it.

Benefits associated with BIM Usage
Table 1 lists the ten benefits surrounding the adoption of BIM. The top four benefits (mean score > 4.0) were: 1) 'Improved constructability' (mean = 4.33, RII = 0.87), 2)

'Improved visualisation' (mean = 4.22, RII = 0.84), 3) 'Improved productivity' (mean = 4.07, RII = 0.82), and 4) 'Reduced clashes' (mean = 4.04, RII = 0.81).

Table 1: Means, Relative Importance Indices and Importance levels of the Benefits surrounding the adoption of BIM

Benefits	Mean[1]	RII (MS/5)	Importance level	Rank
Improved constructability	4.33	0.87	High	1
Improved visualisation	4.22	0.84	High	2
Improved productivity	4.07	0.82	High	3
Reduced clashes	4.04	0.81	High	4
Improved quality and accuracy	3.85	0.77	Medium	5
Improved client satisfaction	3.81	0.76	Medium	6
Increased competiveness	3.59	0.72	Medium	7
Improved information sharing	3.33	0.67	Medium	8
Improved sustainability	2.96	0.59	Low	9
Other reasons	1.00	0.20	Low	10

Notes: [1]: Likert scale values where 1 = Not important; 2 = low importance; 3= neutral; 4 = important; and 5 = highly important

The least important benefits, ranked eighth, ninth and tenth respectively were: 8) 'Improved information sharing' (mean = 3.33, RII = 0.67); 9) 'Improved sustainability' (mean = 2.96, RII = 0.59); and 10) 'Other reasons' (mean = 1.00, RII = 0.20).

DISCUSSION

Improved constructability

'Improved consructability' resulting in time, cost and quality benefit was the most highly ranked (mean = 4.33, RII= 0.87). This finding is consistent with other studies from CRC for Construction Innovation (2007); Jordani (2008) and Underwood & Isikdag (2010), which indicated th biggest benefit of BIM was the ability to have a complete and accurate set of documents for easy retrieval for the life of a facility, providing benefits not only during construction, but also throughout its life (such as facilities management tool). Similarily, improved constructability through lowered construction costs can be achieved through BIM adoption (CRC for Construction Innovation, 2007). Accordingly, the study (CRC for Construction Innovation, 2007) pointed to 'improved project efficiency' and also has the ability to 'prevent reworking', due to early pickup of issues such as clashes and other problems which may arise during construction.

Improved visualization

The second highly ranked benefit of BIM adoption was that of 'Improved visualization' (mean = 4.22, RII = 0.84). This finding is consistent with other studies from Kymmell, (2008) to CRC for Construction in Innovation (2007). For example, according to Kymmell (2008), the largest problem in the planning and construction process is incorrect visualization of the project. Kymmell (2008) further explains that, if a project is not fully visualized, understood and communicated, it cannot be

represented correctly in the contract documents which may cause problems later in the construction process that will be much more costly to rectify. Similarly, a study by CRC for Construction Innovation (2007) acknowledges that one of the key benefits of BIM is its accurate geometrical representation of the parts of a building in an integrated data environment. Accordingly, this allows contractors to be much more accurate when ordering materials, helping prevent wastage and over-ordering. This not only provides significant cost savings on a project but also aids with the sustainability of construction industry by making the most of the world's precious resources.

Improved productivity

'Improved productivity' emerging as a result of improving collaboration between all parties involved in a project, including the client, designers and other professionals such as architects, engineers and contractors was the third ranked benefit (mean = 4.07, RII = 0.82). This finding is consistent with other studies such as CRC for Construction Innovation (2007), which indentified this aspect of 'improved productivity' as an important one in improving productivity of specific projects and industry in general. The study (CRC for Construction Innovation (2007), revealed that the use of BIM allowed for designers to work on a single model rather than having each member recreating and producing information. It also found clients gained a better understanding of the project via a 3D model containing information; this allows them to make more informed decisions on different options available to them by changing the project parameters and reviewing the resultant outcomes.

Reduced clashes

'Reduced clashes' resulting in reduce costly variations during construction and the ensuing delays which could result in liquidated damages being claimed resulting in time, cost and quality benefit was the fourth ranked benefit (mean = 4.04, RII = 0.81). According to a study conducted by BIM in Australia (2010), the application of BIM allows potential clashes between different trades or disciplines to be picked up early in the design phase. The resolution of clashes or inconsistencies between the works of different disciplines can also occur in the virtual environment, significantly shifting the time commitment for consultants from the construction phase back into the design phases, with resultant impacts on project team management and fee structures.

Improved productivity

Although this benefit of 'enhanced sustainability' was among the least ranked ones (mean = 2.96, RII = 0.59), its importance cannot be overlooked. As noted by CRC for Construction Innovation, (2007), 'enhanced sustainability, of the construction industry' has the potential of making the most of the world's precious resources.

IMPLICATIONS & LIMITATIONS

Implications

Based on the findings, the Senior Managers within the construction organisations are that; awareness of BIM processes through education and training; both formal and informal process including more information, and provision of expertise within BIM could enhance the levels of adoption. Based on the findings, one of the solutions aimed at to addressing the key issues surrounding the adoption and use of BIM by SA construction firms, is that there needs to be a concerted effort, though government and industry organisations, such as the Construction Industry Training Board in providing

subsidised courses aimed at clients and industry leaders, educating them on the role BIM can play in the industry. Furthermore, as suggested by Hardie and Newell (2011), the regulatory climate under which the specific construction industry operates can act as a deterrent or agent of change (motivator). This study proposes that the South Australian construction industry makes it mandatory for construction organisations to have some form of BIM adoption as a requirement for bidding. Anecdotal evidence suggests that there is already a shift toward this requirement within the U.K

Limitations

Interpretation of these findings must consider the following study limitations. This study cannot be generalised statistically for the whole of the South Australian construction industry members as respondents were only drawn although from a random sample of the Government of South Australia's Department of Planning, Transport and Infrastructure (DPTI) prequalified Category 1, 2 and 3 builders and trade contractors.

CONCLUSIONS

This paper has presented the perceptions of the stakeholders representing the construction organisations in South Australia regarding the awareness, usage, challenges, and advocated benefits of adopting Building Information Modelling (BIM). The benefits identified from an extensive literature review have been analysed using descriptive statistics such as mean scores and standard deviation in order to rank their importance. Issues surrounding the adoption, usage and awareness levels were analysed using method of frequencies to measure the central tendency.

It can be concluded 'constructability' is viewed by the stakeholders as the highly ranked benefit that emanates from usage of BIM. The other highly ranked benefits were found to be 'improved visualisation', 'increased productivity' and 'a reduction in clashes'. The results indicate the least important benefit as that of 'the ability of BIM to increase sustainability. The most significant implication arising from this study is that the benefits surrounding BIM significantly outweigh its negative aspects. While there was a lack of adoption of BIM among the respondents, it was established that increased education and awareness of BIM needs to occur through the industry, in order for more wide-spread adoption to take place in South Australia. The study has provided some new insights into some of the reasons for the low awareness levels, slow uptake and the perceptions of the benefits of BIM related to the South Australian context

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EXPLORING CAVE: USING IMMERSIVE ENVIRONMENTS FOR DESIGN WORK

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Providing complex health and care infrastructure brings with it demanding design requirements. Information Modelling (BIM) is increasingly used as a solution to managing the complexity of the design process, and coupled with collaborative virtual environments, offers the potential to mediate design activities in ways not possible with traditional CAD models and drawings. This paper describes early analysis of the use of virtual environments for performing design. The project being studied is the design of a new hospital in the UK with all patient accommodation in single rooms. There are particular client requirements around the size of the rooms, and the visibility of patients from nursing stations. Models of the single rooms were imported from CAD models into a CAVE – a 1:1 scale 3D immersive environment set up in a UK University lab. The design teams then used the CAVE to review the design against the client requirements. The methodology for the research consists of both direct observation of these review meetings and analysis of video and audio data captured during them. Early analysis is revealing three emerging themes around the practicalities and utility of this immersive technology. The first is around the work done by users to initially orient and familiarise themselves with the technology and virtual space. The second is the way the environment allows things to be noticed about the design which have previously not been identified. The third is the way users shift between their role as designers, and imagined roles as client viewing the model.

Keywords: CAVE, client engagement, design practice, immersive environments.

INTRODUCTION

Providing complex health and care infrastructure brings with it demanding design requirements. Information Modelling (BIM) is increasingly used as a solution to managing the complexity of the design process, and coupled with collaborative virtual environments, offers the potential to mediate design activities in ways not possible with traditional CAD models and drawings. The study is based on the design of a new hospital in the UK with all patient accommodation in single rooms. There are particular client requirements around the size of the rooms, and the visibility of patients from nursing stations. The study focuses on understanding how the design

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Maftei L and Harty C (2012) Exploring CAVE: Using immersive environments for design work *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 13-22.

process is being performed in an immersive environment and on distinguishing particularities of this experience.

LITERATURE REVIEW

Existing research around understanding new technologies in building design work point out the complexity of implementation and highlight how unpredictable ways of interacting with new technologies may generate 'hybrid practices'; where new tools and technologies are incorporated into, rather than replace, existing ways of working (e.g. Harty 2005; Harty and Whyte 2010). It is also noted that the effects of implementation may "spill beyond a single sphere of influence" (Harty 2005: 515) and function at an inter- organizational level. This presents a challenge in anticipating and predicting the outcomes of utilising new technology which may, as Harty states, bring about "not only transformation of practices, processes and systems, but also the potential transformation of technologies themselves" (Harty 2005: 512).

Taking into account this idea of tracing the dynamics of innovation in design practice and the various patterns that are established through interaction, this paper sets out to understand how immersive virtual reality environments (IVRE) as non -traditional technologies might impact on both design work and on the way design is communicated to stakeholders. The capabilities of virtual reality (VR) technologies for supporting design processes have been discussed. For instance Whyte describes the potential of this "interactive, spatial, real-time medium" (Whyte 2002: 4) to "augment and extend" (Whyte 2002: 54) the use of CAD packages. Similarly, studies around hybrid design environments examine circumstances of immersive and non-immersive architectural design (e.g. Okeil 2010), building on VR's features of providing "the feeling of presence in a three dimensional computer generated world" (Okeil 2010: 204) and emphasizing on "the user's ability to interact directly and in real time with the virtual environment" (Okeil 2010: 204).

Other research around developing technologies for design and construction looks for new methods to support the end-user's involvement and to set up an intuitive way of collaboration and sharing information in all stages of design process (Christiansson 2011). This context is complementary to studies exploring the interdisciplinary use of 3D object models to improve interactions inside and outside design teams (Moum 2010), or developing platforms for spatial interaction management (Lertlakkhanakul 2008). Potential uses of VR within specific construction design process have also been studied, such as supporting the collaborative design review (e.g. Wang and Dunston 2008) or for other stages of architectural design, like conceptual design (e.g. Anderson, Esser and Interrante 2003).

The potential and use of VR technology for mediating work on health and care projects has also been explored. Both the HospiTool project developed by VTT in Finland (Nykanen, Porkka, and Kotilainen 2009), and the CAVE-CAD software created at the University of California (Palmer 2011) developed an interactive user – orientated and performance based design process, and looked at how testing the virtual spaces experientially enabled monitoring and measuring psychological feedback from users.

METHODOLOGY

The aim of this research is to investigate the potential of CAVE technologies to mediate design activities in ways not possible with conventional CAD models.

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 (an immersive virtual reality environment) at the University of Reading. This was to be used to demonstrate to the client that the rooms were of an appropriate size.

The CAVE (Cave Automatic Virtual Environment), is a multi-person, room- sized, 3D multi-display medium that provides an immersive environment for simulating and viewing at full 1:1 scale virtual models (e.g. CAD). It offers the user (equipped with 3D glasses and a head mounted tracking device with location sensor) an active and real-time interaction with the model. 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).

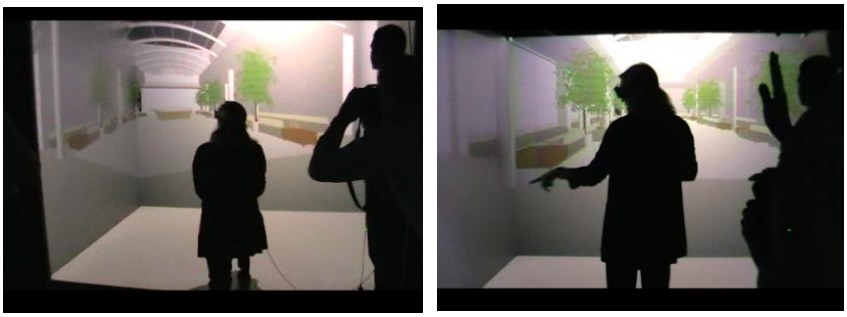

Figure 1: the CAVE

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, culminating in a session with representatives of the client. These sessions produced 11 hours 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.

For this paper we were most interested in the processes of design reviewing occurring in the CAVE, the activity around presenting the models to the NHS client and their use in demonstrating particular design requirements, such as the size of the single rooms and the visibility of patients from nursing stations, and more generally how design teams and contractors are exploring a new work setting. The data was sifted to select particular episodes which are examined in detail below. 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).

EMERGING THEMES

Theme 1: Orienting to the technology and virtual space

The first theme examines how the immersion in the CAVE requires certain ways of movement in the setting and navigation of the model. Although the virtual space is

large, the physical dimensions and technical aspects of the CAVE are always present. To explore the model, participants shape their behaviour by adjusting their body positions (they put on 3D glasses, hold joysticks or connection wires in their hands), and by changing their shoes (to protect the sensitive floor projection screen), and through limiting the motion within the physical space of the CAVE (to avoid collision with the rear projection screens).

Evaluating the model (dimensional geometry, perceived volumes) requires aligning the review process to the particular physical capacities of the setting and of the technology. Prior to the design meeting session, participants familiarise themselves with the spatial perception (perspective angles, dimensions, geometry) allowed by the technology and with features of lighting, colours and textures, in the CAVE as compared to the CAD models geometry, and computer screen representation. The technician introduces them to the limitations of imagery in the CAVE (inaccurate representation of light and textures), as well as to capacities such as objects' motion and animation. The participants evaluate the geometry perception, while testing various viewing angles allowed by the stereoscopic glasses and the head trackers. To make sense of the immersive virtual environment across several sessions in the CAVE, the teams' members learn particular ways of directing the patterns of the design review process and a certain way of communicating between themselves.

Episode 1 (E1)

Designer 1 (14:14):	It's totally out of perspective for me, I can't tell anything.
CAVE technician 1(14:16):	Do you want to swap head trackers over there?

During an episode of discussing textures in the patient room, one designer expresses her difficulty in evaluating the space because of the distorted perspective (E1, 14:14). The CAVE technician invites them to swap glasses, so that each team member can see the model whilst wearing the head tracker, to get the most accurate perspective (E1, 14:16).

Designer 2 (14:23):	It's odd (.) It's something to do with the point you sit.
Designer 3 (14:25):	It's got to do with me ((laughs)) yeah:
Designer 1 (14:27):	'Cause you have the head trackers on.

The designer wearing the head trackers moves through the CAVE to swap the glasses, but hesitates and stops to explore the model, displayed on the surrounding projection screens, as she notices that by her movement, the model is offering a different perspective. Such a reaction suggests the impact of the reality-like effect of moving within the CAVE space, provoked by perceiving different perspective images as viewing angles change continuously to correspond with the observer's position and orientation (E1, 14:25). Another observer points out the correlation between the glasses and the visualised projections (E1, 14:27). This episode suggests how participants learn the rules of navigating the 3D virtual model in the CAVE, acknowledging that navigation is led by one person at a time and the other participants have to follow his movements and within the containing space and the generated projections.

Episode 2 (E2)

Designer 4 (23:13):	That's good. This is very successful.
Designer 4 (23:29):	But I think they seem a bit smaller spaces.
Designer 5 (23:32):	Do they seem obviously smaller?

Designer 4 (23:33): No.
Designer 5 (23:33): So that's good!

One member of the designer's team expresses his appreciation of the model as presented in the CAVE. The examination entails a positive impression (E2, 23:13) and even though the appearance of the space as 'small' is noted the overall impact is a satisfactory one. The above fragment reflects how the design meeting participants establish through discussion a shared way of understanding and interpreting the perception of the 3D model's representation, based on the specificity of the technology.

Episode 3 (E3)

Designer 1 (14:52): It seems like you see a corridor when you put head trackers on. It looks like the window is far away. 'Cause the window really is far away.
Designer 5 (15:05): Yeah: It does actually.
Designer 5 (15:06): It's quite interesting:, isn't it? 'Cause this space is so tiny(..)
Designer 5 (15:15): Well: that is part of the problem with our rooms.

When one designer takes the head tracker, another designer who knows the geometrical features of the room, utters her impression of how the spatial perception is about to become different. The user is forewarned about how the depth of the patient's room will appear augmented from the previous perspective that she could perceive just with 3D glasses. It is pointed out that even though the room has a small area, which conflicts with the client's requirement, the 1:1 scale perception in the CAVE presents a satisfactory spatial sensation.

Summary theme 1

The episodes above address issues of perception experienced by the participants when exploring the model of the hospital and navigating within the real space of the immersive environment. Examining their perception of perspective, size, volume, geometry and dimensions, the observers remark differences between representations of the model as visualised with the head trackers and as observed with 3Dglasses. The observers point out the distortion effect of the viewing perspective, depending on the angle and on the type of glasses they are wearing. They notice that not all of them are able to see the same image at one time (they have to change glasses), and particularly the person who is leading the discussion at each time is being offered the head tracker to have a clear judgement of the undistorted perspective. It is suggested that the interior space of the patient room is perceived to be slightly smaller as projected in the CAVE than the dimensions of the precise geometry of CAD layouts. Building on these observations, the group members establish a particular way of performing the design review in the environment and establish a contextual code of using the technology for their objectives.

Theme 2: Drawing attention to detail

The second emergent theme looks on how the representation of the design in the CAVE affects the design review process. The focus is on distinguishing specificities of the design's representation in the CAVE versus its representations in other traditional media and looking for particularities of the review process, which these differences might bring about. It is examined how the designers teams are using the CAVE technology to verify how the design is complying with the functional flow and

with the aesthetical and technical requirements of the hospital programme and, particularly, with the client's expectations.

The distinctiveness of an immersive and navigable simulation of the 3D model, at more real scale, and experienced as an extension of designers' more familiar and perhaps mundane setting and tools, serves to explore the work they had previously created in their offices. Expectations and assumptions on spatial effects, intended through their design solutions, were either confirmed by the visual perception enabled by the CAVE, or in some cases there were not as noticeable as wished for. The fragments selected address issues of comparing the perception of the 3D model visualised (with 2D-3DCAD) on desk computer screens and its visualisation allowed by the CAVE technology in the immersive, 1:1 scale environment.

Episode 4 (E4)

Designer 2 (25.27):	You don't get the perception of the curve, as you do on the plan:.
Designer 5 (25.35):	No.
Designer 2 (25.39):	'Cause we do [get it] with the bird's eye view all the time.
CAVE technician 1 (25.39):	Yeah, I believe that. 'Cause when you zoom out-in you have different perception.

Performing the review process, team members examine how spatial effects at a real scale and the perception allowed by the CAVE match the assumptions of the conceptual design and the expected associated visual representation. The design session illustrates how these can be either confirmed (e.g. "One (), two (.), three! We can see three beds", (20:40), in verifying the client's requirement for visibility of the patient rooms) or, can be not confirmed ("You don't get the perception of the curve", (E4, 25:27), in the sequence of discussing the visual perception of the hall).

The episode of checking the curved shape of the hallway, the designers are disappointed to observe the lack of the curved effect, as previously noticed in the 3D CAD model on the desk computer screen. Even though they would have had the possibility to observe the same effect on the desk computers, the context of evaluating geometry of a large area within a screen space (set up at a desk's height) is more likely to prefer an aerial perspective (bird's eye view), rather than using the human eye line of sight. The differences noticed between perceiving the spatial geometry using the CAD simulation on computer screens, and the perception of the 3D model simulated in the CAVE, might suggest differences of performing the design process in traditional work settings and in the CAVE.

Episode 5 (E5)

CAVE technician 1 (24:20):	So how does it compare from when you look at it in Revit?
Designer 1 (24:25):	Oh: (1) Hum:: (.) It's not really comparison: I mean the views in Revit are always stretched, because of perspective cameras (.) You do walkthrough in Revit, you have the path, but you don't have that feeling of space.
CAVE technician 1 (24:57):	So do you find it useful?
Designer 5 (24:59):	Yeah:. Specially people that don't understand the scale of spaces that we're showing them (…). So they might

	think we're completely lying when we're showing them perspectives.

It is pointed out the usefulness of the CAVE (E5, 24:57 and 24:59), as allowing a better understanding of the design compared to conventional design presentation interfaces. The design session participants indicated the 1:1 scale and the feeling of space (E5, 24:25 and 24:59) as elements specific to the CAVE, that might better communicate the design, especially to a client who may lack the knowledge of spatially interpreting conventional visual representation.

Summary theme 2

Possible differences between the design (review and visualisation) process in the alternative technological settings can be seen. Participants pointed out three issues. Firstly, the reported differences between perceiving the spatial geometry in the CAVE and in traditional design settings (such as CAD packages used on desk computer screens), by means of possibly revealing things that have not been previously noticed. Secondly, it has been highlighted the sense of presence (enabled by the interactive immersion, at a human scale perception) as distinctive feature provided by the CAVE's technology. Thirdly, it has been indicated the usefulness of the technology, particularly as instrument for presenting to the client, through providing more intuitively the sense of scale and enriching the non-specialists' understanding of the design.

Theme 3: Shifting roles as designers, and imagined roles as client

The third theme focuses on how participants simulate the experience of occupying the designed space. In addition to a "sense of being there" (as highlighted above) participants simulated different roles. In a game-like performance they were verifying spatial dimensions and viewing angles as though they were the non-expert client viewing the model, 'acting' as nurses, patients or clients by testing the lines of sight from the nursing station, adjusting their position, simulating sitting down on the patient's bed, or on the toilet). As a function of the immersion in the setting, body movements are perceived realistically, and gestures towards representations of the hospital's interior spaces (rooms, halls, atrium) such as pointing out with hands or fingers, are regularly engaged throughout the reviewing process, as well as navigating with the controller. Multiple changes of gazes (towards different sides of the rooms or corners of the CAVE), reorienting heads' directions, or physically moving around inside virtual rooms attempts to perceive the spaces in the way end users of the not yet built hospital might.

Episode 6 (E6)

Designer 5 (07:28):	This is totally blocking what is suppose to be there: ((pointing with the hand)), towards the atrium.
Cave Technician 1 (07:36):	But this is partly unknown yet. They just want to see what's happening.
Designer 4 (07:38):	But we don't want them to see that!
Designer 5 (07:39):	Yes, we don't want them ((the client)) to see that.
Designer 4 (07:41):	We don't want them to see, no, ((that)) you can't see that. ((the atrium))
Designer 2 (07:45):	Ok. 'Cause this is ((just)) a phase, no? ((of the design proposal))
Designer 1 (07:58):	((Speaking about the model)) It's good, though!

On examining the issue of visibility towards the atrium area, team members are observed as playing the role of the client. Imagining the client's feedback regarding the spatial perception of the model entails filtering the visual information through estimating the model's compliance with presumed expectations. Even though it has not been mentioned as a design requirement, and although this phase of the project is strictly meant to illustrate the spatial outcomes of the layouts discussed on previous stages (E6, 07:36, 07:45), the visibility towards the atrium area is assumed to be, preferably, accomplished.

Drawing on the previous theme of the analysis, which discusses how the technology allows things to be noticed, the episode illustrates how the model in the CAVE reveals a lack of visibility (E6, 07:28). In discovering this, they decide not to show this visual effect to the client, even though at this point the design is not fixed (E6, 07:38, 07:39, 07:41). The use of the CAVE as a 'marketing tool' is to be noticed in this episode, as only particular viewing angles will be selected for presenting to the client, those considered to be potentially advantageous for the bid, in terms of complying with the maximum possible requirements and presumed expectations.

Episode 7 (E7)

Designer 2 (08:56):	This is huge. ((pointing with the finger))
Designer 5 (08:58):	No, no. They have to. (be in here). Because they are all the imaging screens. ((showing with hands)) No, they're showing: (.) whatever imaging they're doing, to the patient that's on the table ((pointing with hands towards the on the left side of the operating theatre)). Will show up and then can look at different views on those screens. ((pointing towards the screens on the right side of the room))
Designer 2 (09:14):	But this room, is huge, but it doesn't look big.
Designer 2 (09:18):	It is a big room.
Designer 1 (09:20):	This is 80sqm.

The episode of reviewing the operating theatre again illustrates simulating roles of end users. Several issues are to be noticed in this sequence: firstly, the impact of the spatial perception in the CAVE, secondly the analysis of technical equipment from the end user's point of view, and thirdly the frequency of physical gestures and body movements as part of the discussion. Despite certainty over the theatre's size, (E7, 09:14, 09:18, 09:20), the model in the CAVE reveals a perception of the operating theatre as small, and a disharmony between the "huge" volume of the equipment (E7, 08:56) and its placement in the room. The issue of perceiving spaces differently in the CAVE has been previously acknowledged (as presented on the first theme's discussion). The situation provokes questioning the dimensions of the imaging equipment (through considering that furnishing a room with too big or too many objects might create a crowded effect and an undersized look).

To explain, a member of the group proceeds to describe the equipment based on its subsequent use by the medical staff (E7, 08:58). The succession of actions related to particular parts of the equipment is presented with the support of visually illustrating each step of the medical procedure. The 3D model's examination is dynamically accompanied by observers' physical motion inside the space, while constantly reorienting their gazes and the direction of heads, and/or indicating different zones by making gestures with hands or fingers. This kind of dynamic exploration of spaces

accompanied by a set of physical reactions of the participants while reviewing the design and experiencing occupying the space, may be distinguished as a particularity of the design process within the CAVE.

Summary theme 3

Simulating scenarios is a part of the design process, which is often testing the outcome of the spatiality inferred from the existing CAD models. Such scenarios are regularly being imagined, through associations between dimensions in the model and in the real life. Yet in this instance, arising from the immersion in the CAVE, enables a more physical experience of this simulation. Despite certain limitations (such as the lack of tactile feedback, or a restricted accuracy of detail), the CAVE provides the "sense of being there". This is a transition from conventional, static examination of the 3D model (which solely allows visualising it's representation on computer screens), to a more dynamic and physical investigation, through engaging the participants' bodies in exploring the designed spaces. In the CAVE, physical motion inside the space is enabling a distinct way of tracing the flow of activities meant to be performed in the spaces especially created to accommodate them. It also demonstrates a different way of exploring the compatibility between form and function, and the ergonomics of the spaces created.

DISCUSSION

The discussion around the three emergent themes reveals several observations concerning design meetings performed in the CAVE. As depicted in the first theme, aligning the CAVE within the design process requires learning or developing specific procedures for navigating the physical space of the CAVE and navigating the virtual space of the 3D model. The last implies understanding the spatial perception of the representation projected, as allowed by the technology. The second theme outlines two issues. The first addresses the particular spatial perception mediated by the CAVE and looks at how this allows design features to be noticed, not noticed, or juxtaposed with visual outcomes unexpected from perspectives based on CAD models. This relates to how the immersive translation of the layout's geometry is either confirming or not confirming design expectations. The second points out the usefulness of the technology, in terms of allowing an enriched spatial understanding of the design, by providing the "feeling of space" generated by immersion in the model. The third theme reveals how the immersion at the 1:1 scale of the CAVE enables a more dynamic exploration of the model, allows the physical motion of participants in the space, and provides a different way of making sense of the space. This entails a different experience of simulating roles of end users or clients.

CONCLUSIONS

Drawing on such observations, several conclusions might be outlined. Although conventional design simulations have the capacity to allow the perception of spatial geometry and dimensions, using such technologies seems to not reveal certain aspects as obviously and intuitively as the CAVE allows. The freedom of engaging in natural behaviour (moving; looking around) inside the virtual space suggests a different sort of review process, shaped towards a way similar to examining an existing building. It is a means of enabling a fluid and experiential simulation of the actions and activities meant to be performed within these spaces. The technology allows an enriched way of understanding the geometry of the layout as translated to realistic dimensions. The level of detailing the model and the chosen perspective angle might entail limitations

or distorted visual effects but nevertheless such immersive, dynamic interaction provides a different sort of flexibility in understanding the space.

This study is built on data based on direct observation and audio- video recordings. Augmenting this data set with more reflective interviews with the various participants involved might enrich the understanding of the phenomenon. Tracing back (individually) the groups of designers, visualizers, contractors and clients, and allowing them to reflect on how they had perceived the impact and value of experiencing the CAVE, would be an interesting addition to the data.

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CONTROL, SURVEILLANCE AND THE 'DARK SIDE' OF BIM

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Various BIM (building information modelling) technologies are increasingly being positioned as a way to improve coordination horizontally across construction disciplines and vertically between design, construction, manufacture and, increasingly, facility management. The arguments for implementing BIM are persuasive, with potentially significant savings in terms of reducing the re-working of information across the supply chain, and reducing the high levels of physical waste generated. They are also now supported by the recent UK government mandate to use BIM on public projects by 2016. But there are other more problematic considerations with the mobilisation of integrated information management systems, especially around issues of control, surveillance and power. Primarily drawing on Foucault inspired studies of information systems use and surveillance in this paper we look at some of these implications for the division of labour and for control during the construction process. We use empirical material from two longitudinal case studies of BIM implementation; a new airport terminal and two large PFI hospitals, both in the UK. We draw out the issues around the potential and limitations of this technology as a method of imposing control across disciplines and down the supply chain. Whether these technological change initiatives are initially intended to be an instrument of leveraging control over other actors is difficult to ascertain, but our empirical evidence shows that negotiations over who has the power to enforce or resist the technology and processes supporting it are fundamental in shaping how implementation plays out.

Keywords: BIM, control, ICT, labour, power, resistance, surveillance.

INTRODUCTION

BIM (Building Information Modelling) is the process of integrating and coordinating the information required to design, construct and operate a building or facility. Commonly associated with 3D CAD modelling, a Building Information Model is a digital representation of the physical and functional attributes of a building, which can be used throughout its life cycle. Computer-aided design and 3D representation along with various forms of electronic communication and document management are well established, even ubiquitous, technologies, especially within large construction projects (Whyte, 2002). But BIM represents something other than just the use of these technologies; it implies a seamless integration and sharing of data across projects,

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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.

organisations and disciplines, a reconfiguration of when and what information is provided for the model, and a commitment to reproducing the digital model on-site. Numerous case studies have demonstrated the benefits of BIM modelling in areas such as reducing the re-working of information across the supply chain, and reducing the high levels of physical waste generated (Olofsson *et al.* 2008). Proponents have high expectations for BIM's potential in overcoming many of the problems faced by the industry – even assigning it the power to transform construction, the construction industry, the economy and society at large (Rezgui *et al.* 2009; Crotty, 2011). This optimism is reflected in recent UK government policy decisions to encourage BIM and to mandate its use BIM on public projects by 2016.

Much BIM research, and that into ICT on construction in general, treats implementation of new technologies and tools as unproblematic technical activities. It is positioned as politically neutral and generally beneficial if implemented 'correctly' taking care of the human and social issues 'arising from' the technology. However, such a technologically deterministic approach is only one of a number of theoretical paradigms that can and have been applied to the study of technology. Alternative approaches include: market determinism; labour process accounts; process approaches that emphasises political shaping; and numerous forms of social constructivism (McLoughlin, 1999). The differences between these approaches are about the relationship between technology and organisation (Orlikowski, 1992). The extent to which these approaches should be seen as competing or complementary is subject to some debate (Lewis & Grimes, 1999). However, drawing on Morgan's (1986) advocacy of the use of metaphor in organisational research, both McLoughlin and Lewis & Grimes have argued for a multi-paradigm approach to research on technological change. This paper seeks to apply this approach to the study of BIM in construction. Given the already extensive coverage of the managerially necessary and beneficial aspects of control in the construction management literature (see Tuuli *et al.* 2010a, 2012b) we present a thoroughgoing application of a political paradigm to analyse issues of surveillance and control in two case studies of BIM implementation and use on two major construction projects in the United Kingdom.

ICT, SURVEILLANCE AND CONTROL

In order to think about the issue of control in managerial implementations of BIM, it is useful to look at the work of Foucault. Foucault's work, along with other social studies of technology, has a methodological commitment to revealing the specific conditions under which certain types of knowledge become powerful and persuasive (Kendall & Wickham, 1999). Foucault's work has been extensively applied in research into information systems and the ways they configure working practices. In 'Discipline and Punish', Foucault traces the historical evolution of control from being based in direct, physical, individual punishment to a new "general recipe for the exercise of power over men" (Foucault, 1991: 102). New modes of control moved away from acting on the physical body, towards a more general level of pervasive observation, located deep within society. More generally, society is effectively controlled by the imposition of ideas and norms of behaviour onto individuals which define whether their actions are normal and acceptable, or not.

Foucault describes Bentham's 1791 design for a prison, the Panopticon, to illustrate how these contemporary modes of control function. Bentham's design consisted of prison cells arranged in a circle, with walls between each cell but which were open (except for bars) to the front and back, with a watchtower in the middle. Someone in

this tower could see into every backlit cell, but all that the occupants of each cell could see was the watchtower. Prisoners knew that they could be being watched at any time and this threat of surveillance was supposed to be enough to deter any abnormal behaviour. The prison is described by Foucault as embodying a pure form of panoptic surveillance, but he translates it to other institutions throughout society such as schools, hospitals, military institutions and, importantly in this case, the workplace. Panoptic modes of surveillance make the surveyed visible in specific ways, and permit knowledge to be collected about them (the term Panopticon suggests total visibility; pan-optic). Just as in the prison, this gives the surveyor power, where individuals impose self-control because there is always a chance that they are being observed. Their behaviour is conditioned by their being rendered visible.

Foucault describes four main conditions of panoptic surveillance and control. The first of these is the spatial distribution of individuals, the segregation of groups with supervisors maintaining watch over them. The second condition is the control of activities where regularity of action and scheduling impose a framework of routine, normal behaviour. The third condition, exercise, is related to the control of the surveyed populations body through the imposition of physical techniques. The final condition Foucault calls tactics: the ordering of individuals as groups or collectivities which facilitates the subordination of individual behaviour to being one holistic unity. Foucault argues that such techniques create 'docile bodies', subjects who conform to behavioural patterns defined by those in control of the setting of these conditions. The connections between Foucault's analysis of disciplinary regimes and the design of work in bureaucratic organisations in general, and construction and design management in particular, is immediately obvious.

The significance of this line of argument for considering the role of BIM is that ICT itself can be regarded as a medium of or tool for surveillance and control. Poster (1990) and Lyon (1994) have described the encroachment of ICT into work practices (as well as into more private areas of life) and they write about how the capacity to monitor, store and manipulate large amounts of information allows a level of surveillance beyond that possible with human actors alone. Zuboff's (1988) ethnography of computer use in the workplace argues that panopticism is becoming a basis of contemporary management techniques, and that the potential for surveillance inherent in IT makes the activities of workers highly visible and leads to 'anticipatory conformity'. Like the prisoners in Bentham's Panopticon, the threat (rather than the reality) of being watched generates self discipline and hence conformity. There is also a growing body of work using Foucault to understand management practices more generally as part of an attempt to increase control of workers, through electronic and other means of surveillance (for instance the discourse of team-working, or the use of psychometric testing to make individuals comparable and calculable) and through the internalisation of norms associated with being an efficient worker (e.g. Brewis, 1996; Dean,1999; Townley, 1993).

CONTROL IN CONSTRUCTION MANAGEMENT

Construction management is largely concerned with achieving control over the design and build processes. Tuuli *et al.* (2010a) describe the "pervasive" nature of control in project environments, "encompassing all the devices and systems employed to ensure that acts, behaviours, outcomes and decisions of individuals, teams, and organizations in a project are consistent with meeting organizational or project goals, objectives and strategies" (p190). At the same time, the site-based nature of projects, lack of

integration, uncertainty and change also suggest the merits of organising construction based on principles of delegation, autonomy and empowerment, or at least the difficulties in imposing and realising systems and devices of control. Tuuli etal's case studies of modes of control (2010a, 2010b) identified a 'portfolio' of control mechanisms including (after Nieminen & Lehtonen, 2008): formal/bureaucratic control (both outcome-based and behaviour-based) and informal control (in the form of clan- and self-based regulation).

If, as Tuuli argues, construction projects need to find a balance between empowering teams and maintaining control of the process, then forms of unobtrusive and pervasive control offered by ICT-enabled surveillance will be attractive. In fact part of the control 'portfolio' identified by Tuuli *et al.* included use of an electronic document management system that "provid[ed] a full document history that can be traced and monitored". Other construction research has found international firms "developing more subtle and informal systems that are less hierarchical" to control their overseas subsidiaries and that they "recognized the importance of IS for the management and control of their international operations" (Neves & Bugalho, 2008; 11, 10). Whyte & Lobo's (2010) case study of coordination and control on a large infrastructure project found a document management repository "used to structure distributed forms of communication and control ... dictated a set of working practices [and] made visible knowledge about the audit trail of design deliverables" (563). It is clear that such systems can, intentionally or otherwise, impact on working practices through the imposition of standard processes and the collection of data (for instance to establish accountability and provide audit trails). What is less clear is how those systems are developed and embedded, what their precise effects might be, and who benefits from their introduction.

METHODS AND CASE DESCRIPTIONS

The empirical data analysed in this paper was gathered in the course of two independent, longitudinal case-studies of major construction projects in the United Kingdom: a new airport terminal ("Terminal") and two new acute hospitals ("Hospital"). Data collection on the Terminal project was through contemporaneous, ethnographic observation and semi-structured interviews (n=23). Data collection on the Hospital project was through semi-structured interviews (n=27). In both cases, additional data was collection in the forms of documents and notes from informal meetings.

In both cases the implementation of BIM consisted of use of spatially coordinated 3D CAD models in the design phase supported by electronic document management systems (EDMS) and processes. On the Terminal project, further organisational arrangements were put in place including collocation of all design team members at project offices and project-wide formal processes and procedures for CAD and information management. The Terminal BIM implementation was mandated and driven by a powerful client and required designers to work in a shared model environment. In contrast, on the Hospital project BIM was a project team initiative implemented through the mechanism of separate model files brought together in a read-only for the purposes of coordination. The Hospital project research also studied the development of 'Site BIM' implementation in the form of tablet PCs to read design information and capture progress data on site.

ANALYSIS

Terminal Project

It was widely acknowledged in the Terminal project that the benefits of single model coordination using BIM relied upon the production and sharing of transparent, compatible and accurate information. This would often be in the form of complex and highly specified documents, reflecting the level of detail required to ensure inter-compatible practices of, for example, CAD or EDMS use. This required working to standardised, documented practices and producing and entering 'metadata' that allows others to use the document management system. This rigour required both changes in established working practices and extra work for users to maintain these standards, on top of their 'usual' duties. The benefit and the need for control inherent in such coordinated working is reflected in the following from the head of engineering:

"when I go into this EDMS thing I'm looking at the latest version of that document [...] That [assuring everyone has the most up-to-date information] is of great benefit, but it needs discipline in how you actually use the system."

In order to achieve consistent ways of using across the project other methods of ensuring adherence were required. In the words of one application manager involved with supporting document management, "the process is very managed, but it needs to be… you need to make sure that they [the users] are adhering to the process definitely".

This managing was largely undertaken by the project's IT support services. As specified in project documents their role was to, "verify compliance with Document Management policies & practices, including verifying compliance of document control procedures operated within the various teams, using surveillance and audit techniques." These 'techniques' did include ICT-enabled surveillance; for instance IT support staff could "see how many people are logging on at any one time". This lends itself to a Foucauldian description of being under continuous monitoring although examples of resistance, conflict and negotiation identified (see Harty, 2005 and later this section) suggest that a regime of totalising panoptical surveillance was not in place. Instead (or in combination) a variety of human / organisational methods of direct surveillance and control were deployed. IT workers would seek to persuade rather than enforce usage. As one IT manager described it, "I used to walk around and see what was happening. Sometimes I hear a team aren't using it and I try to cajole them into using it…"

More formal and strategic methods for getting compliance than 'walking around' included training of new project workers. Training is often framed as support rather than control but on the Terminal project it was clear that "when a member of staff comes in they need to be running through what is expected and one of the things is how they should use EDMS, where they should be putting information and also following the project procedures"

The project required users to learn a number of new technologies, some of which, such as document management, were totally unfamiliar for many. But they also had to quickly begin actual work, producing design information, drawings and models. This drive to quickly get on with 'real work' is at odds with learning and applying new project-wide compliance behaviours. As such the impact of training is often limited:

"you get put through a EDMS course… but people go back to their desk, and they're not given any direction, from what I can see, as to how the task team leader expects them to use it."

Here is a problem related to the distribution of work, and influence, across the project. Training is obligatory, but when the newly trained worker is 'released' onto the project they might not be under immediate pressure to follow the strictures imparted during the training. The electronic, remote surveillance continues, but the influence of team leaders and other users closer to the new worker can dissipate its effectiveness as a control tool.

Another of strategy employed sought to overcome the distance between IT support and design teams by installing designated 'document controllers' within each separate team on the project. This can be seen as an attempt to extend the surveillance capabilities of the IT network and those 'in charge' of it away from the particular centre of the IT support department, and to supplement electronic surveillance with face to face monitoring. It can also be seen as an encroachment of the capabilities of the IT department into each local team:

"you need to make sure that they [the users] are adhering to the process definitely. Most of the delivery teams do now have a document controller to keep an eye on things."

The role of 'document controllers' within each team was significant and formally established in project procedures to "ensure that the project's key principle of effective Document Management is adhered to [... and to] actively engage with the project on a day-to-day basis to promote and progress best practice in Document Management…"

The presence of the document controllers produced an increase in the use of EDMS but not just through surveillance and control. Instead, through mediation, and through negotiation, document controllers reconciled team activities and the requirements of using EDMS. This weakened the case for uncompromising resistance. Document controllers were able to solve problems encountered by users as they did their work, or find ways of integrating their practices with the utilisation of EDMS - sometimes by taking a whole set of drawings or information from the team to input into the database themselves.

A pattern of increasing use of EDMS was found over the course of the research, but a Foucauldian vision of strict control with no choice but to conform does not adequately account for increasing EDMS use on the project. Electronic surveillance, although present, only showed where conformity was or wasn't occurring; it seemed to do little to change it. There were significant limits to the ability of the EDMS system to bring about change in practice, and as these were discovered, different, non-electronic and less instrumental means were used, such as document controllers, to make the system work.

Hospital Project

The BIM implementation studied on the Hospital project differed from that on Terminal. The focus here wasn't on producing BIM models but communicating 'complete' design models and extending them to the work site via portable tablet computers. Another significant variation for the analysis in this paper was that the implementation was project-led (as opposed to client-mandated and top-down) and

system usage was largely voluntary. There were, however, similarities in how the BIM technology was established.

Significant for this was the role of Document Controllers that expanded into a "sub-IT Department function" which drove system development and promoted user adoption. Document Controllers became intermediaries, coming to occupy a similar organisational space to those on Terminal, albeit from a 'project up' rather than an 'IT down' direction. A further similarity was the substantial investment of time in training and support. Digital technology was novel for many users: "there's guys out there are still used to rolling up A3 drawings in the back pocket and then turning on a PC is quite a bit of fear for them actually". As well as formal training, one-to-one support and coaching was needed 'bed-in' the use of the technology: "it literally has been walk around for three of four days, hold their hand".

The other shared feature between the two cases was the central role ascribed to EDMS in 'delivering' BIM:

"You've got to have an electronic document management system that underpins any BIM type environment…because BIM itself doesn't do that".

On the Hospital project EDMS is directly controlled by Document Controllers who manually intervene to issue drawings – rather than automated workflow driving information. This retention of 'traditional' information management extends to accessing digital design information on tablets. The data gets to the tablet by explicitly synchronising them in the site office when the tablets are docked. This act of synchronising is seen as a useful form of control by the Document Controllers:

"… I think it's quite good that we've actually got the control at the moment. So docking information goes up and then you have to pull it down as well, so it makes them – if they want the information, they've got to go to a source to get it"

Despite the emphasis on the importance of controlling information – the reach of ICT-enabled control is limited and tacitly approved – even to the point of being made a virtue of:

"if [a Construction Manager is] in charge of the windows then [he's] going to talk to the person that looks after the windows at the architects or anyone else that's on it and the trade contractors know what's happening as well [...] you do have some guys that have got a very good relationship walking around with advanced copies of drawings because they've just e-mailed it to them instead of putting it on to EDMS so you do get that."

This acceptance of flexibility in use of information systems was limited to ways of getting information out of the project systems. By the construction phase the model was largely seen as a closed, fixed source of data rather than an environment where users can add data in ways that suit them. So for the tablet progress monitoring system (specified largely by Document Controllers in their role as project IT support) there was only one format in which progress data could be entered onto the system. Also on the tablets, the defect system required free-text fields to capture the more unpredictable entities; therefore it was implemented so that defect descriptions entered in the field needed to be approved before they were processed - "it all goes in to an unapproved area so [Document Controllers] will check it, check that everything is correct and then issue it out to the trade contractors". And although the standard drawing viewing software on the tablets enabled users to 'mark-up' drawings on site this wasn't encouraged - "If you let them mark up drawings out on site that was on

EDMS, then you would have anarchy wouldn't you? There would be no control whatsoever."

As well as controlling how they used the software, tablet systems were intended to control the work of Construction Managers themselves, even to the extent of bodily 'helping' them to stay on site where "they should be". Once on site the systems are "controlling them to do their job because it's got to be done in a certain mode. It can't be done any other way [...] what we're forcing the Construction Managers to do is to actually go down the road of actually double checking and job checking everything they're doing and not just sweeping anything under the carpet." However, although the intention was that "people would go out clicking off progress in rooms" limited uptake and availability of tablets meant that this was not universally established. The progress database was still populated, allowing enhanced surveillance of progress, but site data was captured on paper and, "brought it back to the office and [given] to the administrator lady who then put it directly onto the database, as opposed to via a tablet."

DISCUSSION

Construction is a fertile area in which to consider the 'dark side' of ICT: there is inherent tension between empowerment and control (Tuuli etal, 2010a) and between projects' concern with action versus the centre's with compliance (Jacobson & Linderoth, 2010). Control is so pervasive in construction that it is not even perceived as such (Nieminen & Lehtonen, 2008) - Tuuli *et al.* (2010b) identified "the exercise of control in very subtle ways that may not be recognized by those being controlled" (p463). Our research identified numerous examples of intention and realisation of control through ICT but also limits to that control, the continuing need for human controllers, and 'user' resistance.

Evidence from both cases does not support the existence of effective and totalising panoptical surveillance from a single centre, or all-powerful controller which could force the project's staff into specific ways of working. Applying this particular lens to construction ICT was productive in identifying instances of surveillance and control but doesn't provide analytical tools to consider changes in control and how individuals respond to it (Cowton & Dopson, 2002, Knights & McCabe, 2003). One approach to this could be the distinction between 'strategies' and 'tactics' as proposed by de Certeau (1984). 'Strategy' is about manipulating exterior actors from a specific and strong position similar to Foucault's position where surveillance extends from a specific place and has the ability to control or regulate the activities of other actors. 'Tactics' are responses to strategy which, though intentional, are distributed and lack the consistency of strategic attempts to influence and control. The resisting actors may not be able to provide a strong and unified response to a strategy, and indeed may not actually want to, but can find specific weaknesses and gaps in strategy and exploit them.

The idea of tactics versus strategy provides a way to understand the dynamics at work on the Terminal project. The official IT system based on a number of technological artefacts, the single model environment and rigorous coordination of information, can be seen as a centre of strategy. This strategy involves panoptic practices of surveillance and the circulation of intermediaries and enabling supports such as guidance documents and training. The resistance towards using the EDMS system, with discussions about what was or was not considered legitimate activity, was less coordinated, and hence can be seen as tactical. But it was enough to bring about the

gradual escalation of other practices to increase use (such as negotiation, training and eventually, the introduction of Document Controllers). This can be seen as a pattern of strategic responses to this tactical resistance.

On the Hospital project, the lack of a strong mandate to use the BIM systems meant that this pattern of resistance and response was not occurring – use of alternative ways of working was tolerated and even framed as having the ability to transcend automated control. Ironically, a clear use of tactics could be seen on the part of the Document Controllers themselves who implemented the 'controlling' ICT on the project locally, unofficially and "under the radar" without authorisation from corporate IT support.

CONCLUSIONS

The cases discussed here show different ways that issues of control are bound up with the implementation and use of ICT systems like BIM. Rather than see these as neutral progressions or developments of technology use, they can also be seen as having a dark side - as opportunities to enact control over users, through imposition of standardised practices, and through surveillance and monitoring. This is perhaps more explicitly recognition of this on the Terminal project with its centralised system, patterns of resistance and the large scale efforts put in place to encourage use. But the Hospital project also shows the use of technology as a way of enacting control; over limiting access to information, and in using tablet based information on site to produce compliance. However, the implementation on the Hospital project itself can also be seen as tactical, especially in the way the use of tablet PCs on site was kept within the project and away from the gaze of the central organisation IT function. Using the idea of a Foucauldian notion of surveillance, and framing activities around the system as a dialogue of strategy and tactics is useful in revealing the control issues inherent in both the implementation of IT systems, and construction work in general.

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BIM IMPLEMENTATION PLANS: A COMPARATIVE ANALYSIS

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To realise the benefits of BIM in construction management using (4D and 5D applications), it has to be implemented first. There are various BIM implementation plans to select from; with BIM features and guides, companies better understand BIM concepts and can easily choose a plan to apply in their operations. A literature review was conducted and 15 different definitions of BIM were encountered. Twelve different BIM implementation plans were found in publications by academics, software vendors and Architecture/Engineering/Construction (AEC) industry professionals. Those implementation plans were compared using a matrix which covers the complete building lifecycle. This research concludes that out of the 12 implementations plans, three were equipped with additional guides attached to their plans, simplifying project data collection; namely those by Autodesk, Penn State University and Indiana University. One implementation plan that scored very highly (based on 16 key issues identified from the three categories of stakeholders specified in this project) was the implementation plan proposed by a major software vendor. BIM is poised to solve many of the shortcomings reported in the construction industry. However, before realising the full potential of BIM in construction management, it needs to be systematically implemented.

Keywords: implementation plans, BIM, construction management.

INTRODUCTION

Eastman *et al.* (2011, 2008) and Hardin (2009) agreed that BIM use is growing in the AEC Industry. It is undoubtedly important in construction management, but needs to be implemented to reap its benefits. Currently there is no universal BIM implementation solution. Therefore, a question arises, how do you choose a good BIM implementation plan? It is important to first understand the nature and scope of BIM. It is characterised with many features; Isikdag and Zlatanova (2009) noted BIM as object oriented, equipped with spatial relationship between building elements, data rich with functional information about a building, and enabling automation of multi view generation. However, there is no standard universal implementation guide for

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Ahmad A. M; Demian P and Price A.D.F (2012) BIM implementation plans: A comparative analysis *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 33-42.

BIM; standards are being produced by different organisations for different purposes. Eastman *et al.* (2011) stated that the existence of various BIM implementation approaches can change existing working pattern of organisations to allow the implementation of new technology. Howard and Bjork (2008) stated that "many standards relevant to BIM exist but it was suggested that there is a lack of frameworks into which they could fit". They were also of the view that BIM deployment standards are not compatible with all companies due to differences in organisational cultures, procedures, size, company goals and objectives. It is crucial before choosing any implementation plan, to have a good understanding of BIM; Aranda *et al.* (2007, 2008); Succar (2009) agree that BIM means different things to different people.

This research first identifies BIM features from the views of various stakeholders in the building industry. The methodology used in defining BIM and analysing BIM implementation plans is based on a literature review. The overarching aim of this paper is to compare BIM implementation plans; it is of great importance to understand BIM and plan for its implementation, due to the UK Government push to mandate the application of BIM in major public-sector building projects by 2016 and to realise its benefits. Arguably some experts view BIM as either an IT tool or a procedural process, while others views BIM as the combination of both technological tool and a comprehensive building process used in improving building procurement and envisioned to promote collaboration between professionals in the building industry. Eastman *et al.* (2011) agree with Hardin (2009) that BIM is defined by various experts and organisations differently. This paper identifies BIM features within 15 definitions from three categories: A) academic sources; B) software and hardware vendors; and C) AEC organisations. Table 1 was tabulated by identifying seven keywords from the 15 different definitions of BIM. These keywords appeared at least three times in all the 15 different definitions of BIM. The following keywords: "Information"; "modelling"; and "process" had appeared more than any other feature of BIM from the keywords mentioned in Table 1. Therefore, BIM for the purpose of this research can be defined as the process of using information technology for sharing, modelling, evaluation, collaboration, and management of a virtually building model within a building life cycle. BIM was also classified into three groups: building model (simulation, automation and presentation); building process (thinking, scheduling and organisation) and information management (preservation, sharing and organisation) within a building life cycle.

BIM Implementation Plans

Related Researches on BIM Implementation Plans

Stebbins (2009) considered BIM as a process rather than a piece of software. He clearly identified BIM as a business decision and the method of implementing BIM as a management decision. BIM implementation is strongly related to managerial aspects of professional practices; most industries have different working styles and cultures. AGC of America (2006) stated that "each project is unique, and the implementation of BIM should be tailored to the needs of the project", therefore, standard implementation plans must be sensitive and can be tailored to the individual characteristics of each project. Fisher (2011) stated that a BIM plan: "defines scope of BIM implementation and information exchange; identifies the process flow for BIM tasks; and describes infrastructure needed for support". He also noted that it provides a better understanding of goals, responsibilities attached to each personnel, teams, department, and management. BIM implementation plans also help to reduce

unknown variables with competence to schedule and outline expected training and resources required for construction management.

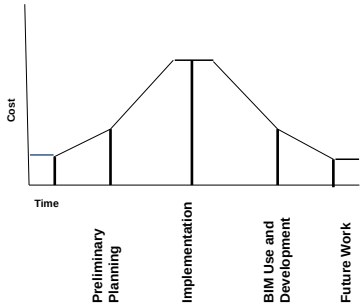
Table 1: BIM features described by three different categories.

A. BIM Definition by Academics							
References	Information	Management	Modelling	Process	Technology	Analysis	Collaboration
1. Weygant (2011:vii)	x	x	x	x	x		x
2. Eastman *et al.* (2011)	x	x	x	x	x	x	
4. Hardin (2009:4)	x			x			
6. Smith and Tardiff (2009:xi)	x			x			
7. Howard and Bjork (2008)				x			
9. Sweet and Scheier (2008:375)	x		x		x		
B. BIM Definitions by Software Vendors							
12. Bentley (2011)	x	x	x	x	x	x	
13. Nemetschek`s Vectorworks (2010)	x		x	x	x	x	
14. Graphisoft (2002:5)	x		x	x	x	x	x
15. Autodesk (2002:1)	x	x	x	x	x	x	x
C. BIM Definitions by Architecture Engineering and Construction Industry and others							
16. BIM Journal (2011)	x			x			x
17. BuildingSmart (2008)	x	x					x
19. VTT (2006:25)	x	x		x			
20. AGC (2006)	x						
21. State of Ohio (2010)	x	x	x	x			x

Classification of BIM implementation Plans Levels

There are various methods of implementing BIM. The following methods were identified from literature: Top-down; bottom-up; slow and drawn out; using a selected team; using multiple teams; and implementing on a specific projects, all projects or the entire organisation. Jung and Joo (2010) described BIM implementation to be of

three levels; industry, organisational and project levels. At the industry level, BIM standards are successfully developed, but the organisational and project level standards are different due to their formats, details and purpose, and are also related to managerial corporate strategy issues. Ashcraft and Sheldon (2008) noted that BIM adoption is divided into three groups of activities covering different scopes: Within an office: Selecting software; addressing IT issues; and training up and rolling out. Across the design team: Selecting software: addressing IT issues: and also legal and contractual issues. Across the project delivery team: Procedural scope (design, coordination, estimating, scheduling, submittal review, fabrication, agency review and facility management); and also legal and contractual issues. While the cost of BIM implementation is one of the major limitations of BIM adoption. There is no specific standardised amount designated to the cost of Implementation, nor a clear understanding of how to precisely estimate such cost. Hardin (2009) described that the cost of BIM implementation is higher when implementing; this involves the cost of training and software. In the life cycle cost of BIM implementation, the cost gradually reduces during the use and development phase. BIM users experiences lesser cost during the "future work" phase; perhaps training and (software and hardware purchasing) are the most expensive issues to think through when implementing BIM.



Figures 1: Cost of BIM implementation plans (Hardin, 2009).

Benefits of BIM in Construction Management

Weygant (2011); Autodesk (2002); Succar (2009); Hardin (2009); Aranda Mena *et al.* (2008); Eastman *et al.* (2008, 2011); AGC of America (2010) agreed that 4D and 5D modelling, helps clients and contractor to make inform decisions, by estimation, coordination and scheduling the construction process. The client can get a better scope and nature of the design and construction with BIM visualisation. Construction sequence can be visualised systematically, showing construction progress with time and cost implications attached. It also helps in synchronising the procurement of design and construction planning for early error detections. BIM is also used in managing existing facilities, by fully modelling and linking the structure to the virtual model. This way, energy consumption and operational faults can be detected from the model for management purposes. For example, the Sydney-Opera House is currently managed using a BIM model for facility management. It is also evident in literature that BIM is used more (higher percentage of use) on the construction compare to the design phase; perhaps BIM is effective in achieve quality and efficiency in construction management.

Barriers of BIM

Yan and Demian (2008) noted that people barrier seems to be the most challenging factor: companies have to provide time; human resources; and to training, forming a business case for BIM. Howard and Björk (2008:23) described the need of education, sharing, standards and legal issues to implement BIM, weygant (2011) and Eastman *et al.* (2008) agreed that legal issues are also barriers to implementation, Aranda Mena *et al.* (2008:14) suggested that due to the nature, size, relationship of private and public sectors involved, it will be difficult to assign a standard implementation plan for each firm to observe. Eastman *et al.* (2008) is on the view that there are both technological and sociological barriers to BIM implementation. Succar (2009:363); Aranda Mena *et al.* (2008); Eastman *et al.* (2008, 2011); AGC of America (2010); Howard and Bjork (2008) agreed that interoperability is a major issue of the use of BIM in the building industry. Succar (2009:363) defined interoperability as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged.

RESEARCH METHODOLOGY

Literature review was used to define BIM: BIM implementations plans; levels of BIM implementation; identified best practices; barriers and benefits. About 20 high quality articles relating to BIM were selected for a comprehensive state of the art literature review. Research defined and compared BIM implementation plans from three stakeholder groups, academics; software vendors and professional AEC industry organisations. The objective was to find the common key factors used to deploy BIM. Comparability is defined by Kotabe and Helsen (2009), as the similarity and difference features of one research results to another. It is important to compare studies to illustrate the significance of choosing an implementation plan by identifying its features. BIM can be understood from a building life cycle point of view, therefore the BIM implementation plans (key factors) were categorised into pre-implementation, implementation and post-implementation. The comparison matrix was based on the criteria by Fisher (2011) who noted critical issues in adopting BIM execution Plan as: Goals; Participants; Level of detail; Infrastructures; Software platforms and Workflow. A total of sixteen key factors were identified, from which 14 were mentioned in at least 3 different implementation plans among the 13 plans. Two other key factors were identified by (Arayici *et al.* 2011; Messner *et al.* 2010) and Eastman *et al.* (2011) as vital issue of BIM implementation, there are: (specifying level of BIM implementation; and spreading BIM implementation from one team to others) respectively. Three of the 12 different implementation plans described from the three categories (stakeholders) in this paper, had additional data collection formatted documents, which are Indiana University, Penn State University and Autodesk.

COMPARISON SYNTHESIS

Table 2 shows categories of BIM implementation plans classified into three (A-C) and numbered (1-12): A. Software: Autodesk, (2010) [1]; and Dell, (2011) [2]. B. Academic: Eastman *et al.* (2011) [3]; Arayici *et al.* (2011) [4]; Hardin, (2009) [5]; Succar, (2009) [6]; (Penn State)-Messner *et al.* (2010) [7]; Indiana University [8]. C. AEC Industry and others: AGC of America, (2010) [9]; (BuildingSmart) - Lin *et al.* (2005) [10]; AIA, (2008) [9] [11]; and BIM Road Map, (2011) [12]. Table 2 was tabulated based on the 16 key issues identified within the 12 implementation plans cited by this paper. Each implementation plan that had one of the listed 16 key issues

was ticked with an "x". There is a 100 percent agreement with regards to ten key issues identified within the 12 implementation plans, and a gap on starting BIM implementation from a team and also spreading from a team to entire organisation.

Table 2: Comparison of BIM implementation plans from three different categories.

	Analysis of BIM Implementation plans numbered (1-12)												
	Pre-BIM Implementation Phase	1	2	3	4	5	6	7	8	9	10	11	12
1	Define BIM goals	x	x	x	x	x	x	x	x	x	x	x	x
2	Plan BIM uses	x	x	x	x	x	x	x	x	x	x	x	x
3	Start with a team			x						x			x
4	Leadership	x	x	x	x	x	x	x	x	x	x	x	x
5	Managerial support	x	x	x	x	x	x	x	x	x	x	x	x
6	Specify level of BIM implementation	x	x	x	x	x	x	x	x	x	x	x	
7	All stakeholder involvement	x	x				x	x	x				x
8	Identify current skill and list required skills	x	x	x	x	x	x	x	x	x	x	x	x
	BIM Implementation Phase												
9	Continuous training and development	x	x	x	x	x	x	x	x	x	x	x	x
10	Collaboration	x	x	x	x	x	x	x	x	x	x	x	x
11	Information exchange execution	x	x	x	x	x	x	x	x	x	x	x	x
12	Appropriate hardware and software	x	x	x	x	x	x	x	x	x	x	x	x
13	Conformity to standardisation	x	x	x	x	x	x	x	x	x	x	x	x
	Post BIM Implementation Phase												
14	Educational BIM awareness	x			x		x	x		x			
15	Spreading implementation from one team to the others	x		x									
16	Review performance	x					x	x					x

DISCUSSION OF FINDINGS

Table 1 was tabulated from 15 different definitions of BIM. There is an agreement in the features identified from the definitions that BIM is a technology, a process, an information management tool that allows (data storing and sharing). Table 2 shows agreement across the selected BIM implementation plans within the pre-implementation and the implementation phases. There is lack of agreement in two of the 16 keywords listed as: starting with a team; and spreading the implementation to other parts of a given industry. The advantage of starting with a team is that, it can easily be managed rather than starting with the entire professionals with an organisation. Obstacles encountered by a small team could be avoided by an entire organisation; saving project time and cost.

Literature shows that BIM usage has a higher percentage in construction compared to the entire design process; its applications are many and varied. Impact of BIM in Construction management can be categorised into three: 1.) Pre-construction-. It fosters the capability of making designs constructible, providing clash detections analysis, estimations, and other detailing such as BIM prefabrication modelling and information management for manufacturers specifications. 2.) Construction -

Autodesk (2002) described BIM in this phase to improve construction quality through 4D and 5D modelling. This involves time scheduling and information generation to make informed decisions. After analysing models in the pre-construction phase, the data can be used for organising and scheduling construction work progress with cost and time implications. This will eventually reduce errors and possible construction reworks. 3.) And management phase - the building life cycle includes inception, completion, and operational building management to demolition phases. Information for concurrent use of facility can be used to analyse the performance of a building for energy performance, utilisation analysis and their financial implications. The operational phase of a building is advised to always be linked to the first cost of a building, as the cost of running a building over some years could be more than the first time cost of a building. It is therefore important to analyse and compare the virtual analysis of a building performance to its real time performance. This can be used to improve the performance where it is deficient. The information on the performance of a building can also be used for managing the operation of a building.

BIM allows the architect and engineer time to collaborate within a project. Hardin (2009) stated that BIM "is mostly ineffective" in design-bid-build; this is one of the most traditional delivery methods that follow a linear sequence where the design precedes the construction, the ability of BIM to allow collaboration is hereby limited. Nevertheless, BIM can help with many other tasks such as quick financial quantification. BIM as a coordination tool for construction management works well with the design and build method; it is a combined service, with the full responsibility for design and construction, and could be architect or contractor lead. It allows BIM application to be fully explored and used to realise its benefits for construction management. However BIM has to be implemented before apprehending its benefits.

Olofsson *et al.* (2008) described that when using BIM in a building life cycle, the client is understood to achieve more benefits. Some of the most common barriers mentioned among the 3 stakeholders were the cost of training, software and hardware, perhaps when Implementing BIM organisations should be clear on the reality of their capabilities (Jason and Isikdag (2010:88). Implementation plans forms the basis for the use of BIM in practice, Jung and Joo (2010) stated that “it is important that the proposed framework be used as an evaluation criterion for practical implementation”. Messner *et al.* (2010) described key challenges of BIM implementation when developing an execution plan as defining appropriate purpose for the use of BIM, and information exchange. Indiana University (2009) and Autodesk (2010), have made recommendations to improve information exchange, they suggested one professional from each stakeholder group to form a team and agree a common naming and file format system, which makes each files easily identified to other professionals. Some parties tend not to share their process of achieving success with BIM (Howard and Björk 2008:26). It is important to start with the best team before spreading BIM implementation to other teams and projects, this will require smaller budgets, with ease in controlling difficulties when they arise; findings can easily be shared with the organisation at large and peer review for evidence based practice

Fisher (2011) highlighted six key issues for BIM adoption; this research identified 16 key issues adopted and modified from Fisher (2011) and as seen from the 12 different BIM implementation plans. Perhaps BIM can be implemented efficient and effectively following these 16 key issues identified in Table 2 as a primary guide for a general BIM implementation before the benefits of BIM can be realised.

Limitation of research

In Table 1, some of the keywords were not directly quoted from the various definitions of BIM, but indirectly described. For example; "information" category was considered as: data; database; characteristics; features; and documentation. In table 2, there are various others key issues that appeared in at least 3 different BIM implementation plans, but the selected key issues were based on Fisher (2011) description of important factors considered for BIM adoption.

CONCLUSIONS

BIM implementation standards are being produced by different organisation for different purposes consequently, according to Howard and Bjork (2008:274) "many standards relevant to BIM exist but it was suggested that there is a lack of a framework into which they could fit" they are also on the view that BIM deployment standard are not compatible with all companies due to difference in culture, organisational traditions, size and company goals and objectives. This makes the standards variable. Table 7 highlight horizontal black shadings showing BIM implementation plan gaps, most of them fail to acknowledge specific levels of implementation plans in their framework or guides. It is important that users know the exact guide to pick which suits their specific needs, implementation at a project level, might not necessary need the same criteria for implementation as at an organisational level, office level, or team level. Provision of multiple options can encourage BIM implementation. The top three implementation plans in this paper starts with the Autodesk plan, it has identified most key issues of implementing BIM, followed by BIM execution plan by Penn State University, with a similar plan from Indiana University. Apart from prescribing key issues to BIM implementation, all three plans have guides that can easily facilitate information collection from users and help provide the appropriate guide to implementation. Further research can be done with future emergence of more implementations plans. This research will further develop a framework for applying BIM in the design of flexible healthcare space.

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CONSTRUCTION DESIGN AND TECHNOLOGY

THE ROLES OF REPRESENTATIONS IN BUILDING DESIGN: MATERIALITY AND VISUALISATION

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Mock-ups, scale models and drawings are ubiquitous in building design processes, circulating between various stakeholders. They contribute to the gradual evolution of design, but what else can specific material representations do for the building design and project? The full scale model of a hospital single bed room can be different in terms of detail and medium, but in what sense might it perform different and similar functions? The mobilization of multiple forms of representations and visualizations suggest that design materialization might have several important roles to play in negotiating the building design and project, including in the exposition and resolution of controversy in the design process. The paper compares the use of two different forms of representation of the same imagined space – a single room in a hospital, and produced for similar purposes – to ascertain what the optimum (or minimum) spatial requirements should be to allow effective care of patients. The first representation is a three dimensional augmented reality model of a single room for a new hospital in the UK, using a CAVE (Cave Automatic Virtual Environment) where the room is reproduced virtually at one-to-one scale, and which can be explored or navigated using head-tracker technology and a joystick controller. The second is a physical mock up of a single room for a Danish hospital where actual medical procedures are simulated using real equipment and real people. Drawing on Latour's concepts of matters of concern and matters of fact, we compare these two representations to provide insights into the way different media produce specific senses of the design or imagined space, with consequences for on-going design work, and for the settling of controversy.

Keywords: simulation, hospital design, matters of concern,

INTRODUCTION

The cover image of the book 'Reassembling the social' (Latour, 2005) depicts a construction site with the people, equipment, building material and scaffolding. Front stage, two men are having a conversation over what seems to be a document, perhaps it is a plan or a drawing for a building. Behind them and closer to the perimeter of the construction site, several armed soldiers keep a watchful eye on the surroundings. The

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Harty C and Tryggestad K **(**2012) The roles of representations in building design: materiality and visualisation *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 45-55.

building site seems controversial and many human and non-human entities are required to hold the project together. When the building has been completed it might be used and taken for granted by people that pursue their own projects. From Latour (2005) we can say that the building has become a 'matter of fact'. However, the author urges us to consider the building as 'matter of concern' rather than as a 'matter of fact', i.e., as an ongoing accomplishment; from its inception, during construction and in use. A building "is not a static object but a moving project" (Latour and Yaneva 2008, p.80). As a matter of concern the building and project is never finalized. The concept 'matter of concern' is in line with actor-network theory's (ANT) questioning of the fact/value distinction in the social and natural sciences and the assumption that objects such as a building can be represented in a value neutral manner.[3] Technologies of representation and visualization are not just considered as neutral and passive (Latour, 1986). Rather the ANT approach puts emphasis on revealing the more active role of technologies in shaping designs and in enacting and negotiating design options, users and use. Designs are matters of concern that are distributed and produced in heterogeneous networks consisting of both humans and technologies (Latour, 2008). The approach has been used to examine building projects and topics such as; visions and goals (Harty, 2008; Tryggestad *et al.* 2010), design practices (Whyte *et al.* 2007, Yaneva, 2005; Våland, 2010), innovation (Harty, 2005), business performance (Justesen and Mouritsen, 2009; Kjellberg, 2010) and the relative visibility and difference between building design and integrated chip design (Kreiner and Tryggestad, 2002). In this paper we will examine different forms of representation and visualization and the ways in which they participate in negotiating the hospital building as 'matter of concern'.

METHODS

Our inquiry is built around two cases on the concept and design of a "single bed patient room" in hospital building projects in UK and Denmark respectively. The approach is processual and aims to reconstruct the complex chain of events concerning the design. The collection of empirical material involves in the first case visits at the design lab and design exhibition at Region S, reports and images documenting the design process, and interviews with members of the project management offices, including project management at Region S and Region H. The data for the second case is a combination of attendance at design meetings, informal interviews with the project team, and a series of video-recorded and direct observations of design review activities within a virtual reality facility at the University of Reading.

While both cases are emerging we present preliminary findings concerning how different technologies of representation such as 2D, 3D and full scale 4D 'physical' simulation models participate in the materialization and valuation of the single bed patient room design. Both cases account for the simulations and demonstrations of how large the room should be, the further design requirements of other things such as equipment and furniture that emerges in the design process, and finally, the different materialities that participate in constituting the room and designed space.

[3] Evidence based design (EBD) is a relevant example of an approach that seeks to turn facts into design, with the potential downside that matters of concern are ignored or not taken sufficiently into account.

CASE 1: HOW LARGE SHOULD THE ROOM BE? THE DANISH SINGLE-BED CONCEPT

The Danish state has established a program ('Kvalitetsfonden') with approximately 40 billion DKK dedicated to fund hospital construction projects within the public healthcare sector and regions. It is one of the largest societal infrastructure investments in Denmark, ever. Currently there are some 16 hospitals on the drawing board or under construction within the programme. The projects are of different types, ranging from mega projects such as the large green field investments in new 'super hospitals' within the major cities and regions in Denmark, to upgrading of existing hospitals. Each hospital project within the program must pass the state's screening body, the 'Expert panel'. It is an iterative process through which the region's original project proposals are evaluated and eventually refined before dedicated funds are allocated to a hospital project. The case of the Danish single-bed concept consists of two vignettes that reconstruct the evolution of the design concept and the related concerns and controversies. The first vignette accounts for the Expert panel's concept and evaluation of the single bed patient room. The second vignette shows the different ways the design concept is enacted and negotiated between the regions and the Expert panel. Together the two case vignettes show how the single bed concept is represented, visualized, re-conceptualized and negotiated through time and space. The case description accounts for different devices such as numeric calculations/budget estimates, comparative case analysis of different types of rooms and sizes, full scale physical mock-ups and how these individually and together validate the design concept in relation to future use and users.

Economic valuations of room size: The hospital program and budget

In their report the Expert panel (Regeringens ekspertpanel 2008) considered the design of the single bed patient room in terms of how large it should be. The expert panel did not question the premise and value that the room should be a single bed rather than a multi bed room. Instead, there were further considerations about the maximum size. The room should not be too large because that will incur unnecessary costs both to the individual hospital's project budget as well to the future hospital facility and operating budget. The expert panel's future budget concerns are further translated into an estimation of the appropriate size for the single bed room: 40 square meters is considered too large, and 33-35 square meters is considered appropriate, for all hospitals and projects in the program. In order to qualify their estimation of the appropriate size and design standard, the expert panel uses a production cost calculus for the construction of a single bed room that demonstrates the economic effect of a too large 40 square meters room. The economic calculations of the production costs and the two cost budgets (for the project and hospital in operation respectively) help the expert panel to explicate the value of a cost efficient hospital design and to define its appropriate size. The question and concern about the appropriate design and size is thus resolved through the economic calculation and the budgets. The report further helps to visualize this economic design value. More implicitly, the single bed concept also takes other values and concerns into account such infection risks and the prospective patient's need for privacy. However, and to be further described below, these different design values and concerns are only temporary resolved by the Expert panel's economic calculations and report.

Juxtaposition of clinical and economic valuations of room size

At the Capitol region a project team was established during fall 2009. Among its tasks was to consider the question of how large a normal single bed patient room should be. The management and team were well aware of the Expert panel's report and view. Instead of subscribing to the Expert panel's design the project team raised new questions concerning what the design might have excluded or not considered sufficiently well. These questions and issues included values such as the patient's clinical treatment and the staff's work conditions. The budget and efficiency concerns explicated by the Expert panel were not considered irrelevant but rather as one among many relevant concerns that the design needed to take into account.

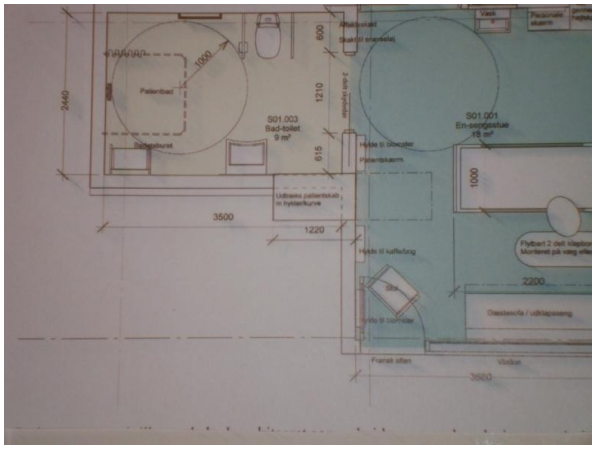
In order to sort out the design issues and possible implications in a more precise way the project team used a comparative case method. The team did not limit their empirical inquiries to own hospitals but assembled data and empirical material from existing hospital designs in Denmark and abroad (Norway in particular). In this way the team could bench-mark the new and smaller design standard proposed by the Expert panel with a broad range of cases and experiences from hospital designs in use or under construction. The case material showed that the room size for a majority of the hospitals and projects in their study were larger than the expert panel's and closer to 40 square meters. In addition, the case material included a prognosis concerning the size of the future patient's body. The average size of the body was expected to increase quite significantly with further possible design implications concerning the size of the patient room. In the resulting report (Region Hovedstaden 2009) new concerns are raised that were at odds with the Expert panel. For example, the team and region argued that it is necessary to take into account the particular hospital project and design before deciding on a specific room size. However, the report also concluded that the health and safety of the patient might be at risk if the Expert panel's area standard is established as the norm. In terms of the specific design implications the report concludes that the capitol region is opting for a larger room size than the expert panel and is willing to accept higher costs in their hospital construction projects and in operations in order to secure the design for the future patient and body. Like the report from the Expert panel, the report from the capitol region uses cost and budget estimates to qualify their conclusion regarding the design. But unlike the Expert panel, the region uses additional empirical material and experiences from current hospital design and projects as well as extrapolations and scenarios about the future patient and body size.

The project management at Region south was informed about the Expert panel's 33-35 square meters design standard but uncertainties still prevailed. The design would perhaps be economically feasible, but would it also be clinical feasible? In order to sort out the question about the clinical feasibility project management at Region south decided to contract the task to a nearby design laboratory, the Centre for User Driven Innovation. The laboratory consisted of clinical professionals with training in ethnographical methods and action research. The laboratory approached the task by building a full scale physical mock up of a patient room according to the design standard and size set forth by the Expert panel. The room was further equipped with a standard hospital bed and furniture, medical equipment and a living person playing the role as patient. Then there were a number of other persons playing the roles as nurses and doctors. Prior to the simulation all persons in the room were instructed according to a manuscript which included the simulation of a heart attack along with immediate treatment on site. The simulation was filmed and further documented with

photographs and feedback from those involved. A report concluded the simulation (Center for brugerdrevet innovation, 2010).

Figure 1: the laboratory simulation. Source : Center for brugerfokuseret Innovation (2010)

Figure 2: the room layout for a possible design based on the simulation results Source: Center for brugerfokuseret Innovation (2010)



The simulation revealed the frictions between bodies and between bodies, equipment and furniture when in motion during the heart attack and treatment. The main conclusion from the report concerns the context of treatment: if the patient or other persons in the room are larger than average, then the Expert panel's design standard might hamper a swift and adequate treatment. This is especially so in acute situations such as heart attack in which medical equipment must be mobilized together with a number of medical professionals. Extra time for these logistics will be required due to the limited space. In contrast to the report from the Capitol region, the report from Region south does not include economic calculations. However, there were instances of economic judgments of a more qualitative nature. For example, the report points out that it might be possible to accommodate concerns for the patient's health and safety within the limited space implied by the Expert panel's design standard. This however, will require further investment in new technological solutions, equipment and furniture in particular such as the 'intelligent bed' and robotics for logistics and waste management. The report does not attempt to estimate the extra economic costs associated with these mitigating investments.

CASE 2: IS THE ROOM BIG ENOUGH? THE UK CASE

This case involves the design of a new specialist hospital in the UK. Currently, the project is in the late stages of tendering, with the announcement of the successful consortium due later in the year. The requirements for the hospital are that all in-patient accommodation has to be single room with en-suite faculties. This is in line with a general shift in opinion within the National Health Service (NHS) in the UK towards the advantages single rooms offer in terms of patient privacy and dignity, control of hospital acquired infection, and access for visitors. But single room only accommodation is unusual in the UK – the first all single room NHS hospital opened in January this year. Various other requirements were specified about natural daylight penetration and visibility of patients from nursing stations, and these presented the design and construction consortia tendering for the project significant challenges in terms of design, but also in communicating to the NHS Trust client that their design fulfilled those requirements.

Our involvement as researchers in this particular case begins with discussions with one of the bidding consortia – 'Consortco' – to explore whether advanced virtual reality technologies could be used to show the client that their design fulfilled, and indeed exceeded the requirements. For the upper floors of the hospital where the in-patient accommodation is located, the design they had developed had an elliptical shape with a central light-well, allowing single rooms to be placed on each side of a corridor and to have external windows (facing either outward or into the light well) extending around the building envelope. This maximized natural daylight, allowed good visibility of several rooms from each nursing station in the corridor, and produced an impressive design. However, this presented some issues. Although not necessarily a firm requirement, the NHS produce various guidelines for hospital design – the Health Building Notes (HBN) and Health Technical Memoranda (HTM). The nature of the design meant that the single rooms were all slightly different (due to the curve in the outer wall) and slightly smaller that the guidelines. So there was a challenge to convince the client that the rooms were big enough, not just for in-patient accommodation, but also for access by crash teams in the case of emergencies.

One way to demonstrate this is through building physical, 1:1 scale mock up (as in the Danish case above) but this is very costly - perhaps £100,000 per model. Physical models are also inflexible - if changes are suggested this would require significant rework. So an exploratory conversation was begun with the University of Reading to see whether the immersive virtual reality facilities within the Visualisation and Interactive Technologies Centre (VIT-C) could be used as an alternative to physical models to establish that the size of the single rooms were adequate. In particular, the CAVE (Cave Automatic Virtual Environment) presented opportunities to show the single room model in an immersive environment, with a 1:1 scale, calibrated to the dimensions of the design model. The CAVE works by simultaneously projecting images of the model onto three walls and the floor or an approximately 4m² space, using active glasses to produce the 3D effect, and head tracking to coordinate the four sets of images. The particular ambitions of Consortco were significant; a decision had been made that the design would be developed in a 3D / BIM environment, so a more-or-less complete model of the hospital had been produced. The initial conversations were therefore to establish how technically difficult (and hence expensive) would it be to take existing BIM models and transfer them into the CAVE, and to see whether they would be of a high enough quality to show the client, be able to demonstrate the scale and configuration of the single room accurately enough to establish that they

were big enough, and be user friendly and intuitive enough for a non-construction client to understand and engage with. After establishing that the models could be transferred, a total of seven separate sessions were held in the CAVE, culminating with the visit of seven client representatives to review the models. For the purposes of discussion, we will divide these into two periods; initially establishing viability, and increasing scale and scope of the simulation.

Fig 3: The CAVE showing the en-suite bathroom

Once the technological possibility of displaying the existing models within the CAVE was established, the next step was to check whether the technology, and the simulation, would be a suitable medium for the client demonstration. An initial session was set up where several senior members of the bid team came to the CAVE to assess the single room model. The session exposed a number of interesting issues around the use of the technology, the simulation itself and the design of the room.

As the session began, it became clear very quickly that some time was required for the users to 'orient' themselves to both the CAVE itself (a quite dark space enclosed on three sides) the peripheral artefacts (wearing the stereo glasses, the head tracker and protective footwear) and to the previously un-experienced 1:1 perspective of the model. For instance, proximity to the head tracker (from the position of which the hardware works out how to synchronise the four separate projectors) is needed to keep the correct perspective of the model, and the users quickly worked out that they needed to stand close to the person who was using it, and that it had to be passed around the group to make sure everyone was 'seeing the same thing'. The tension between the scale and size of the simulation - a reasonably large room - and the physical space of the CAVE itself - which is much smaller - became apparent, but this was a different sort of materiality than that seen in the Danish case. At various points, several of the group, fully immersed in the virtual space, walked into the CAVEs projection screens (much to the amusement of the others), forgetting that they were in a smaller space than the virtual room. This was the materiality of the CAVE pushing back onto the 'virtual materiality' of the simulation.

But the users quickly became familiar with both the CAVE itself, and what they were seeing, and the discussions moved onto aspects of the 'fit for purpose-ness' of the simulation. It was agreed that it would be possible, and that the simulation gave a clear indication that the room was indeed 'big enough'. Thus a matter of concern - would it work - was shifted to something else. But this was not, arguably, into a matter of fact, but more into a proliferation of other matters of concern. There were

several discussions about how specific aspects might be refined - both in terms of what the 'process' of showing the client the models would be like (free navigation or predefined route? Leave them to it, or provide a 'guided commentary?), and in refining some parts of the model (such as adding more textures to objects, making some objects (such as bed-tables) moveable and so on). The simulation also raised unexpected matters of concern. For instance, on entering the en-suite bathroom of the single room, they were surprised to see so many different fixtures (grab rails etc), many of which seemed to be in the wrong location. This provoked a discussion of why that was - a problem with the perspective of the simulation? An error in the model? A mistake that wasn't picked up through the CAD model on the computer screen or printout? This both made connections between this particular simulation and the design process behind it, as well as to ways to re-design the layout of the bathroom to improve it.

At the close of the meeting, several follow up sessions were planned, to get the modellers and visualisers working on the project to come to see the model, and work out what to do to add the required refinements. Over the course of these sessions, the simulation evolved to incorporate these finer details, but also the scope and scale of the exercise - which was originally just to establish with the client that the room was big enough - escalated significantly. The first request was to expand from a single room to a corridor with four rooms on each side. This would provide a better sense of how the single rooms fit into the overall design, and would establish lines of site from nursing stations - one of the drawbacks of single room only designs. Then it was decided to also produce a simulation of one of the operating theatres complete with all the medical equipment, to show the client the efficiency of the design, and finally to model the main entrance and atrium - very large spaces which were the centre piece of the design. This would allow the client to get a sense of the space, but also to 'walk through' and explore these large open spaces. This represented a significant shift in the role of the simulation - from a tool to address a particular matter of concern - the size of the room - to an integral part of the bid and a way of demonstrating commitment to client engagement, embracement of innovative design technologies and the impressiveness of the design itself. This also showed how the specific matter of concern became re-connected to the rest of the hospital design, through simulating corridors, lines of sight, signage systems in the main areas, and developing a 'virtual tour' and commentary to perform when the client visited. There were other connections established, notably the inclusion of a display of pictures of previous incarnations of the hospital (which began as temporary TB sheds) on the corridor linking the main entrance and atrium, to establish the new design's association with the hospital's legacy.

DISCUSSION

The two cases demonstrate that size matters, but in different ways due to the different material devices of representation and visualization. While both cases use full scale mock ups to simulate the single bed room design, there were also important differences in terms of the material and physical setup. In the UK case the physical setup of the virtual simulation allowed further exploration of links between the room and the building envelope such as the outer curve and the view from nursing stations or reception desks in the atrium. In the Danish case, the physical simulation did not produce further concerns and links between the room and the building envelope. Instead, the concerns remained inside the room's spatial boundary and were taken care of through further refinements of the interior design, for example in the form of

more advanced and costly furniture and technological installations. Compared to the Danish case the UK case produce more and closer links to the building envelope and the overall hospital design and concept. The links and boundary of the single bed room can thus be considered to be produced in different ways due to the different methods of design representation and visualization. The boundary appears to be more open and flexible in the UK case.

However, the explanation of this difference can be developed further by considering additional forms of representation and visualization. The Danish case suggests an important role for budgets in making the boundary less open and flexible. Equipped with the program budget the expert panel is prompted to articulate a concern about an economic size for the single bed room. An economic (cost) boundary is drawn for what constitutes a feasible design and room size. This in turn produced a whole array of additional visualizations, representations and clinical concerns among the regions and prospective project and hospital owners. In the physical mock up and simulation these clinical concerns are delimited to focus on the interactions and the treatment taking place inside the economic feasible patient room. In the Danish case it thus appears that the room's eventual links to the building envelope and the overall hospital design becomes relatively more difficult to explore due to this array of interlinked devices and concerns. This circumstance is also one of the emerging concerns expressed by the Capitol region (Region Hovedstaden 2009). But the UK case evolved to be much more concerned with flow and joining up and connecting to what begun as disparate spaces. Throughout these simulations, there was no substantive discussion of cost or budgets. These discussions would, of course, have been taking place elsewhere, but remained separate from establishing and developing the role of these particular simulations.

There are further interesting differencing in the specific materialities of the simulations. For the Danish case the physical simulation produced a concern about friction between bodies and things in motion, that the room placed physical constraints on the ability to perform necessary activities within, it. The UK case had no such physical constraints to the model itself, but the materiality of the CAVE technology did play a part; whether through the necessity of glasses and the head tracker, or through 'forgetting' the physical limitations of the space and bumping into the projection walls.

In terms of the implications for practitioners, the cases reveal two insights. The first is the way that such simulations may be intended to reduce controversy, or establish fact, but in fact can open up new issues, whether as potential problems, or as opportunities to improve the design. The second is that simulations do not exist in isolation; they establish connections to other simulations and concerns, whether other spaces within the hospital, budgets, or policy debates about the size of future patients. Understanding the dynamics of simulation and the way they become enmeshed into other representations and debates, is important to acknowledge.

CONCLUSIONS

Both of these cases are rife with matters of concern; initially over room sizes, but then over suitability of simulations, budgets and political implications, ways to impress clients and so on. Both cases demonstrate how these simulations addressed, but also raised, such matters of concern, and that the simulations were central to holding things together, but also not disconnected from other issues, debates and spaces.

In contrast to the UK, the Danish case pointed to the role and importance of the budget and the 'matter of fact' quality of the economic patient room and size. However the Danish case also suggests that there are costs associated with such premature attempts to reach closure. Other important concerns such as clinical treatment and the room's links to the building envelope and the overall hospital design and concept might be disregarded. In this sense the two cases complement each other by showing that size matters and that it matters in different ways in building design and health care depending upon how the boundaries around a particular design and object are drawn. The material devices for representation and visualization play important and distinct roles in drawing and negotiating the design, its links and more or less open and flexible boundaries. They are central parts of the "on-going accomplishment" of design practices.

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STANDARDISATION OF SPECIFICATION DRIVEN BUILDINGS WITH SERIAL AND REPEAT ORDER DESIGNS

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Government policy-makers are continuing to affirm the need for greater economies through standardisation. The benefits of standardisation seem straightforward: repeated designs offering economies through rationalisation and greater use of preassembled manufactured components as a result of a closer engagement with supply chains. However, a closer investigation of standardisation shows it to be more complex; individual client needs, unique site conditions, planning legislation, late contractor engagement, inadequate knowledge and intermittent manufacturer supply are some of the factors that conspire to limit the benefits of standardisation. This research, as part of an Engineering Doctorate study, examines repeat- and serial-order standardised buildings through multiple case studies where the reasons for their adoption are explored from various stakeholder perspectives. It tests existing theories from literature on standardisation in design and construction efficiency, with an emphasis on specification driven 'non-iconic' buildings. With one-off projects the benefits of standardisation are expected to be limited to efficiencies within a project, and there may be limited engagement with a supply-chain. On multiple projects, with dimensionally standard spaces, even in multi-stage tender situations, standardisation is also limited and clients are not strongly motivated to engage with manufacturing. However, there are other projects where clients, designers and contractors have taken an 'enlightened self-interest' to collaborate, particularly for repeat order projects, and this leads to an optimised process between the design team, the contractor and their supply chains. These latter projects have better defined briefs and benefit from successive refinements of more linear rationalised design processes with increased use of standardisation and preassembly, particularly for the more dimensionally standard areas of the buildings.

Keywords: client, briefing, design, standardisation, prefabrication

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Robinson A; Gibb A and Austin S **(**2012) Standardisation of specification driven buildings with serial and repeat order designs *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 57-66.

INTRODUCTION

The inefficiencies of construction in the UK have been extensively documented (Latham 1994; Egan 1998; Woodhuysen & Abley 2004). In response, recent government policy continues to affirm greater economies through standardisation: rationalisation of briefs, greater use of repeated standardised designs, better integration of design and construction and closer engagement with supply chains (Cabinet Office 2011).

This research, as part of an Engineering Doctorate study, examines repeat- and serial-order standardised buildings through multiple case studies where the reasons for their adoption are explored from various stakeholder perspectives. It tests existing theories from literature on standardisation in design and construction efficiency, with an emphasis on specification driven 'non-iconic' buildings with a significant degree of dimensionally standardised spaces.

DEFINITIONS

Standardisation has been described as the "extensive use of processes and components with regularity and repetition" (CIRIA 2000). Standardisation exists in building products, standard forms of construction, procedures and techniques. The benefits of standardised designs and an increased use of supply chain manufacture through preassembly are well known (CIB 1998; CIRIA 1999; CIB 2010: Gibb 2000): predictability, reliability, efficiencies in system processes, reduced waste, increased speed of construction (CIB 1998) being the most noted benefits.

Few buildings are totally standardised, and most can be classified as being on a range of individualised and rationalised building spectra (CIB 2010; Robinson *et al.* 2011a). The building design brief can be similarly described as ranging between "Bespoke" and Standardised (Gibb 2001), with intermediate conditions described as "Hybrid" and "Customised" (Fox & Cockerham 2000b).

Figure 1: Brief, Frequency, and Design Type for Rationalised and Individualised Buildings,

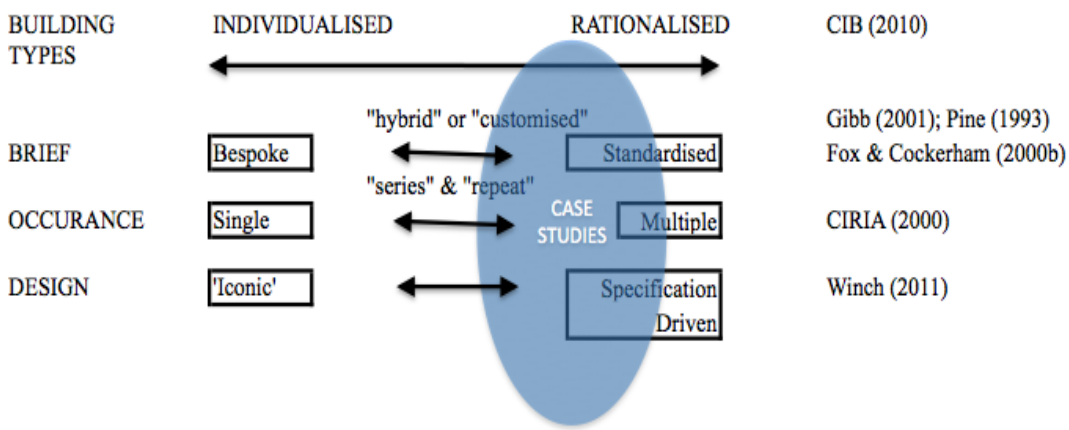

Figure 1 shows a generalised model for building type, brief, design and project frequency. Highly individualised buildings occur less regularly (CIRIA 2000) and have more bespoke briefs, possibly with a strong cultural significance, and are therefore classed as "iconic" (Winch 2011). Similarly multiple projects tend to be

more rationalised, suiting more a standardised brief, and having a "specification driven" design (Winch 2011). Furthermore, site issues in culturally significant and individualised buildings may be highly specific, whereas specification driven buildings by their nature may tend to have significant elements that are less site specific.

The principal focus for case studies in this research as highlighted in figure 1, is for rationalised buildings with more standard briefs, with specification driven designs for repeat- and serial-order clients. On these projects the motives for standardisation are more easily isolated and less prone to cultural issues.

The proposition of this research is that standardisation is limited, even for specification driven, and is strongly dependent on stakeholder behaviour. This is a rival scenario to the case implied by government where standardisation will naturally follow-on through more rationalised briefs (Cabinet Office 2011).

The reasons for different degrees of standardisation in buildings are compound; they are based on a combination of individual client needs (Gibb 2000), unique site conditions and planning legislation (Fox & Cockerham 2000a), timing of contractor engagement (Groak 1992), technical knowledge (CIRIA 2000) and reliability of manufacturer supply (Gann 1996). All these factors to a greater or lesser extent conspire to limit the benefits of standardisation. With bespoke 'one-off' projects this could be predicted, but for repeat projects a client and their design and construction team could be expected look for economies of scale and increased predictability through repeat processes when working on similar buildings (CIRIA 2000), particularly if the building has standard, repeated spaces.

RESEARCH DESIGN

A case study approach has been chosen because there are many variables in the data for an accurate experimental method (Fellows & Liu 2003, Yin 2003). Using case study methods (Yin 2003) this research identifies the project and stakeholder conditions for when standard designs are repeated and optimised. It takes a pragmatic theoretical perspective (Creswell 2003) with a qualitative strategy of inquiry (Fellows & Liu 2003, Cresswell 2003).

Research is achieved through multiple case studies, looking at the different stakeholder positions. Three groups of projects have been examined, each group having two or more projects with the same client and design team and in some cases the same construction team and supply chain.

During data collection, the multiple case studies were used to establish a chain of evidence on the characteristics of standardisation to construct validity, both in terms of internal causal relationships between the data and the overall proposition on the limitations of standardisation, and external validity in terms of the generalisation of the findings for different projects and stakeholder groups.

From the development of a model based on existing literature, it looks for trends in repeat projects. The processes being examined are the brief development, the design, procurement, manufacture and construction (CIRIA 1999). In its analysis, the research attempts to isolate variables from the data that could not be used as a generalised model of standardisation to apply to other projects. For example, data relating to the effects of local market (Gann 1996), and team behaviour (Emmitt & Gorse 2003) are ignored.

The individuals/organisations involved are the clients, designers, contractors, and manufacturers. Where possible, the different stakeholders were interviewed for each of the projects. Initial interviews during the exploratory phase used a semi-structured technique around themes. A proposed later phase of the doctorate research will review the conclusions from this research with the key informants to verify the chain of evidence between the project data on the use of standardisation and the initially hypothetical conclusions concerning its limited use and effectiveness.

Table 1: Breakdown of Project Case Study Groups and Interviews

	No. of Projects	Project Type	Client	Designers	Contractors & Manufacturers
Group A	4	Series of projects with same client & design team	0	14	0
Group B	3	Series of projects with same client & design team	1	4	0
Group C	3	Repeat order projects with same client, design and contractor team	1	7	3

EXISTING STAKEHOLDER POSITIONS ON STANDARDISATION

The following theoretical models have been developed through literature. The models look in turn at the perspectives of clients, designers, contractors and manufacturers on standardisation and the accompanying tendency towards preassembly.

Client's Perspective

Clients are end-product focused (Gibb 2000) and therefore less concerned with process; they are looking for individuality (Pine 1993) and will often maintain some degree of 'design authority' (Fox & Cockerham 2000a) throughout the construction process. Clients lack knowledge about what manufacturers can do (Gibb & Isack 2002), and they may tend to overestimate product performance (Blismas *et al.* 2005).

Although quality and the ability to individualise are stronger drivers for preassembly than economic considerations (Gibb 2000, Gann 1996), clients are strongly motivated by initial cost (CIB 1998).

Clients understand the benefits of early contractor engagement, but they will often use competitive tendering up until the later stages of the design to drive capital cost down. The whole-life and operational costs are unlikely to be quantified: life cycle costs, savings through reductions in programme, cost of snagging and health & safety improvements add value to manufacture-led offsite solutions. Preassembly often appears to cost more in capital terms, but performs in a more predictable way (Blismas *et al.* 2005; CIB 1998, CIRIA 2000) and many of the real cost benefits are hidden.

'One-off' building clients will benefit most from the standardisation of smaller-scale standard products, while 'serial building' clients with several sequential projects may benefit from the advantages of customised preassemblies (CIRIA 2000), but it is the 'repeat order' clients who choose to use the same strategic partners in all their projects, that benefit most from standard procedures, products, and close relationships

with suppliers (CIRIA 2000). Furthermore, standardisation of products may increase reliability during operation and maintenance (CIB 1998).

Designer's Perspective

Designers use standard templates for briefing documents, reports, surveys, design drawings, details, specifications and product selections to reduce design effort and therefore design cost on a building projects (CIRIA 1999). They will also design buildings with standardised grids and components to maximise the benefit of repeat details (CIRIA 2000).

More recently, Building Information Models (BIM) have been used to generate and manipulate building information using 3D parametric data for geometric components and their layouts, allowing building information to be generated automatically. BIM works by using data with object orientated representations that can be extracted and manipulated to show the best building arrangements and therefore improve the decision making process (AGCA 2006). BIM have been cited as tools that can assist a more integrated design process by encouraging the earlier resolution of design coordination issues to improve cost control (www.hokrenew.com 2012)

Designers' knowledge of preassembly may sometimes be limited (CIRIA 2000), but those who are familiar with preassembly techniques are more likely to use them again and know that early design freezes are needed to give reasonable lead-in times to manufacturers especially for prototyping and to allow the architect to inspect the works in the factory.

Site factors will influence the ability to standardise (Fox & Cockerham 2000a), but standardisation increases predictability and quality (Gibb 2000; CIB 1998; CIRIA 2000), and a development of generic solutions leads to continuous improvement particularly for more common interfaces and simplified joint designs (Fox & Cockerham 1999, Egan 1998, CIB 1998, CIRIA 2000).

However, standardisation may limit design options (Gibb 2000) and off-the-shelf solutions can lead to less innovative solutions over time. As a result, customisation is used to produce variety through varying standard or modular components (Gibb 2001, Pine 1993, Kieran & Timberlake 2004, CIB 2010).

Designers and builders will bring forward knowledge and ideas from previous projects, albeit usually on an ad hoc basis (CIRIA 2000). Designers are in a unique position to improve compatibility between construction systems (Fox & Cockerham 2000a). Design and construction process is a complex system of mostly non-hierarchical parallel and layered activities (Kieran & Timberlake 2004, Groak 1992) and construction industry products are complex due to the high degree of user involvement and the many interconnected elements: a small change in one element can lead to large changes in another (Winch 1998).

Contractor's Perspective

Contractor-led construction using industrialisation techniques is more prone to using standard solutions with standard building shapes with little variation (Groak 1992), and standardisation provides efficiency benefits though greater familiarisation by the operatives on site. Preassembly eliminates complex interfaces, increases speed and provides more programme certainty, particularly for sties with severe constraints (Blismas *et al.* 2005, CIB 1998, Gibb 1994, CIRIA 2000). Preassembly also reduces

waste on site, and reduces the number of operations and operatives on site, freeing up areas of storage and improving quality and site safety (Blismas *et al.* 2005, CIB 1998).

However, building complexity on site often limits the degree of manufactured components (Groak 1992, Gann 1996), and construction uses 'formless' material to build interfaces between elements (Fox & Cockerham 2000a), making it difficult to predict and therefore standardise.

Manufacturer's Perspective

Manufacturer-led construction uses standard components, modular frameworks and 'kit of parts' approaches with proportional systems and dimensional coordination (Groak 1992, CIB 1998, CIB 2010). An increase in individuality of designs reduces the 'series' size of components (CIB 2010) and client design authority that continues during manufacture will reduce their productivity (Fox & Cockerham 2001).

In preassembly, working conditions are more easily controlled away from the point of installation. Preassembly allows optimisation of work through increased use of specialised equipment (CIRIA 2000), although automation is limited due to the complexity of the parts involved (Gann 1996). Buildings are closer to complex systems than volume manufacturing; elements are rarely made to forecast (Kendal & Sewada 1997), and almost always operate on a 'pull' basis, designed and built to order (Winch 2003). This means they cannot be easily improved by process re-engineering (Winch 2003).

A major limit on the size and extent of preassembly is the ability to transport subassemblies. Manufacturers will adjust factory to suit individualised solutions, many off-site factory are set-up as building sites under a roof, with pre-assemblies created to a size that can be reasonably transported to site (Gibb & Isack 2002, Winch 2010). Cost of products will be adjusted to suit market, rather than to reflect true economies. Working within a modularity or platform will increase costs (Pine 1993) and may therefore reduce design flexibility, as a result mostly lower 'levels' of preassembly are used (CIB 2010).

ANALYSIS OF CASE STUDY DATA

Data was collected through 30 semi-structured interviews with stakeholders on ten projects in three case study groups. The interview discussions were focused on topic themes based on literature on project brief, design strategy, commercial issues, construction and manufacturing strategies. Data has been extracted and mapped against the stakeholder positions established from the previous published research.

Findings for the different stakeholder positions are identified below.

Case Study Client's Perspective

The case studies confirmed that clients are more interested in the outcomes of the building process than the building process itself. However, as found in case study B, end user clients, working on a series of projects became increasingly sophisticated in their understanding of operational needs, and this influenced their decisions on building solutions being offered to them.

The multiple repeat projects in case study group C were lower specification buildings, and tended to have more standard briefs compared to the other case study groups. Groups A and B had higher specification buildings and more individualised design needs.

All the clients preferred to appoint contractors later in the design process, or to use a two-stage tender process to involve the contractor gradually. A two-stage process can give the client a degree of design control, while still being able to transfer risk to the contractor during the negotiated second stage. The other advantage of early engagement should be to allow construction process to be discussed. However, in all the case studies with a two stage design & build tender, financial negotiations dominated discussions at the first stage, and the construction process was not considered in any detail until the second stage, when suppliers were on board.

Case Study Designer's Perspective

In case study groups A and B, the standardisation of approach rather than standardisation of layouts and elements was a more valuable outcome for building design, but in case study group C, where there were larger numbers of repeat designs, this was reflected in design product as well as the process. In all cases, there was progressive learning through several sequential projects, with the refinement of the process and products tending to happen on live projects, not through a prototyping process

Building elements in group C with standard dimensions for rooms, stairs, lifts, and car parking were the areas most consistently standardised. It was possible to rationalise the production of these elements with increased levels of industrialisation either off or on site. On projects in groups A & B, when offsite techniques were used, these were less successful, and were not attempted or scaled back for follow-on projects.

In the higher specification projects in groups A & B, the architects were more comfortable with the standardisation of small size components, such as discrete building elements. Spatial layouts appear to be driven by a complex number of needs, and a rationalisation of structure would be over-ridden by operational needs on the non-standard spaces. The differences in the site and programme for all the case studies influenced any standard designs being rolled-out over several sites.

Even on a series of specification driven buildings, such as in case study group B, the complexities of some of the legislative and operational requirements were not realised until the plan was fully developed for the scheme, and this led to some re-design.

Case Study Contractors' Perspective

Unlike group C, for every project in group B, the client engaged a different contractor team. These contractors were brought on board for a two-stage tender, but they did not appear to place much importance on construction methods during the early stages. They focussed mostly on cost negotiation during the first stage, and started discussing construction methods at the second stage when a supplier was being selected.

Contractors have preferred supply chains, which will influence their choice of construction methods as well as project type and site conditions. In the case study group C, where the same contractor was engaged on repeat projects, this led to significant economies in the design process. In case study groups A and B, it was difficult for the design team to anticipate the likely construction method until the contractors were fully appointed. Contractors appointed late in the design process working on more individualised designs will work most efficiently on a 'pull' basis, and they will treat the site as the factory using 'lean' techniques to maximize efficiency and minimise waste. They will drive-down cost by ordering as late as possible, and include manufactured solutions only where there is clear responsibility and realistic possibility of timely installation. Due to late ordering, the scale of these

assemblies for major building fabric such as the supporting structure may be necessarily quite small.

Case Study Manufacturers' Perspective

The manufacturers in group C who were involved earlier in the design process were offering a 'kit of parts' (Groak 1992) approach to building design as a tool for rapid design.

Individuality in building designs is a major challenge for manufacturing, and even in very linear, repeated building elements as found in case study groups B & C, there were changing criteria linked to the layout and functioning of the building. The design and manufacturing team had to work very effectively to develop building layouts and details using manufactured systems that could be adjusted to suit different scenarios. Transportation can also be a major shaper in the design of large assemblies, and as routes and their accompanying constraints vary for each project, these become difficult to optimise except through an improved process that looks beyond manufacture and installation.

Due to the intermittent nature of construction, full scale manufacturing facilities that maximise the benefits of offsite assembly are challenging to maintain, with investment in plant. Factory production is associated with quality, so when the output does not meet expectations of a superior product to onsite construction, this can be very disappointing for the rest of the construction team. Combined with the issues of individuality in case study group B, this led to an abandonment of larger preassemblies as a solution for later projects.

However, the process of involving manufacturers early through a partnering process can lead to more streamlined and integrated designs leading to economies and process efficiencies through repeat projects. Elements that would be traditionally separated in standard construction become integral with the structure.

CONCLUSIONS

The research identifies motives for using standardisation from the different stakeholder perspectives of client, designer, contractor and manufacturer.

The client is most interested in the design outcome in terms of cost and operational performance, which is achieved through discussions with the design team and single or multiple stage tender process with the contractor. In most projects the negotiations with the manufacturers were delayed until the later stages of the tender process, and this significantly limited the degree to which standardisation techniques could be used to optimise the design. The three repeat-order projects investigated were part of a much larger construction programme, and under a more collaborative approach, where all stakeholders had an 'enlightened self-interest' (Winch 2011) to collaborate. As a result the designer, contractor and manufacturer were able to make more significant contributions to economies through standardisation. In these three repeat-order projects, where contractor and manufacturer were engaged early in the process, there were more benefits in terms of standardisation through repetition and refinement in the products as well as the process.

As found in case study groups A & B, if the contractor did not have a long-term motive to improve the production process through sequential or repeat projects, they tended to maximise profits through late ordering of materials and manufactured components, leading to increased on-site assemblies rather than extensive off-site

manufacture. On the rarer occasions, when the contractor and their supply chain are allowed to offer design savings through a shared process with the client and design team, a more rationalised standardised design can be achieved through repeat projects, by eliminating separate elements, and generally more efficient standardised processes.

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BEYOND SCORING: ADVANCING A NEW APPROACH TO THE DESIGN EVALUATION OF NHS BUILDINGS

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The engagement of project stakeholders in the design evaluation of National Health Service (NHS) buildings is critiqued to evaluate the current effectiveness of NHS policy which prescribes the use of quantitative, positivist survey instruments to capture stakeholder views. An alternative conceptual framework for design evaluation is presented that privileges the practice of design evaluation as the social interaction of project stakeholders. Empirical evidence from two longitudinal case studies of newly-constructed mental health facilities illustrate the success of this innovative approach in improving patient healthcare outcomes and reducing operating costs. It elucidates and enhances both the praxis and practices stimulated by current approaches to design evaluation. It raises important implications for the future development of UK Government policy to substantively improve the design quality of NHS healthcare buildings and, in turn, improve patient healthcare outcomes.

Keywords: design evaluation, design quality, NHS policy, practice, praxis, social interaction.

INTRODUCTION

UK National Health Service (NHS) organisations have historically experienced policy regimes that seek improved healthcare outcomes, typified recently by Lord Darzi's report (Department of Health, 2008). The design quality of healthcare buildings (henceforth termed 'hospitals') is recognised as an important contributor to healthcare outcomes (Ulrich, 1984; De Jager, 2007). The evaluation of hospital design quality is therefore strategically important to the NHS. It is a key component of prescribed and mandatory NHS design quality policy. Despite this, design quality evaluation has not yet been critically examined. It is argued that, whilst of merit, current approaches are insufficient and in certain aspects problematic. A gulf between the intent, theory and practice of design and design evaluation of NHS hospitals exists. The current NHS process arguably fails to recognise the importance of social interaction between stakeholders engaged in design development.

These issues suggest a need for a new design evaluation approach that seeks enhanced praxis and practice of NHS design evaluation. The new approach must augment current theory by attending to the practices of actors involved in constituting the design. In contrast to the current process, it explicitly regards the nature of the reality of design evaluation as complex, situated, social and contingent.

O'Keeffe D. J.; D. S. Thomson and A. R. J. Dainty **(**2012) Beyond Scoring: Advancing a new approach to the design evaluation of NHS buildings *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 67-76.

CONTEXT

In 2000 the NHS embarked upon a 'once in a life-time' national programme of capital investment into new hospitals that was amongst the largest of its kind anywhere in the world. This 10-year programme has built over 110 new hospitals, 749 primary care schemes and 2848 general practitioner surgeries (Department of Health, 2007). Consistent with New Labour's manifesto, in 2004 it introduced - for the first time in NHS history - a prescribed design quality policy that remains current today. This policy mandates the participation of project stakeholders in iterative design evaluation workshops that must use prescribed design quality instruments (henceforth abbreviated to 'instruments') in an effort to improve hospital design quality.

This policy (including its instruments, published guidance and associated initiatives and directives)[1] are, for the sake of brevity, henceforth termed the NHS's 'Design Quality Project' (DQP). The DQP mandates pre-construction use of instruments (AEDET and ASPECT)[2] at key stages of design progression to iteratively elicit stakeholder 'scores' of predicted design performance-in-use against predetermined criteria derived from evidenced-based design and other notions of 'good' hospital design.

THE MERITS OF THE DQP

An understanding of the merits of the DQP provides an insight into the history of design quality evaluation within the NHS. Francis *et al.* (1999) characterise policy prior to the DQP by a narrow view of functionality that sought standardisation and systemisation of hospital construction to realise economies of scale. Little post-occupancy evaluation took place and research into design quality was limited. Active participation in the project design process by clinicians or public-patient representatives did not exist, either as a policy or as guidance. This narrow functionalist approach proliferated prescriptive design standards and codes that constrained and dictated hospital design practice. It eventually took its toll: Prasad in Macmillan (2004, p. 176) points out that this approach inevitably led to a *"condition where there is so much mediocre and worse-than-average design"* and a need to *"reach in a direct way those commissioning buildings and provide them with the means to raise the game"*. The DQP was a response to these failings. AEDET and ASPECT have been endorsed and used by CABE in nation-wide research studies (CABE, 2008) to assess design quality in particular types of procurement. Prescribed instruments have empowered stakeholders by allowing them to participate with designers at various (including early) design stages. Further aspects of the DQP have mandated 'Design Champions' and 'Design Reviews' (NHS Estates, 2001) and the sponsorship of studies aimed at improving design quality (CABE, 2011). The DQP has raised the profile and significance of hospital design to NHS investment decision makers, NHS staff, members of the public acting as patient representatives, the design community and the wider UK construction industry.

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[1]Typified by NHS Scotland's Design Quality Policy CEL (19) 2010, available at http://www.sehd.scot.nhs.uk/mels/cel2010_19.pdf*[Accessed 16th June, 2011]*

[2] Achieving Excellence Design Evaluation Tool ; A Staff and Patient Environment Calibration Toolkit

A CRITIQUE OF THE DQP'S DESIGN EVALUATION INSTRUMENTS

Despite its influence, several conceptual problems render the DQP flawed as the theoretical basis of its prescribed design evaluation methods is compromised the incommensurability of the theoretical basis of the prescribed design evaluation instruments (AEDET and ASPECT) with the practice of design.

Epistemologically, AEDET and ASPECT are similar. AEDET is theory-based. It is endowed with a theory of architecture developed by Marcus Vitruvius based on Platonic and Aristotelian ideals of beauty and symmetry contained in his architectural treatise, *De architectura libri decem* (Ten Books of Architecture) published c. 15 BC (Vitruvius, n.d.). Vitruvius' theory is conceptually based on an idealistic triad of abstractions that he considered the tenets of design for all 'good' buildings: *firmitas, utilitas* and *venustas* (*ibid,* p.17).

Building on the work of Gann *et al.* (2003), NHS Estates, the Construction Industry Council and the University of Sheffield enshrined the Vitruvian triad in AEDET. By therefore being based on ultimately Platonic and Aristotelian ideologies, AEDET is epistemologically universal, rationalistic, atemporal and context-independent. However, by the same token it is also epistemologically confined, narrow and problematic because its theoretical perspective ignores the significant body of literature that contests what counts as *'design knowledge'* (Simon, 1996; Schön, 1995; Rowe, 1991; Krippendorff, 2007). For example, Rowe (1991) conceptualises the form of knowledge used in design as intuitionism. AEDET makes no reference to such design knowledge. Intuitionism is considered a received source of knowledge, which is to say that integrated knowledge may be intuited - acquired - in a 'flash of insight' as a gestalt that is both complete and holistic (Duggan, 2007). This relationship between the design problem and intuition causes Rowe (1991), like Rittel and Weber (1973), to characterise design problems as complex, ill-defined or wicked and messy. This precludes their assessment by a simple, rational theoretical approach such as that of AEDET. Moreover, the narrow theoretical basis of AEDET does not acknowledge literature concerned with the actual practice of architectural design. In practice, such problems require heuristic reasoning embedded in a priori knowledge and experience (Rowe, *ibid*).

The prescribed instrument's conflation of subjectivities and values of stakeholders with notions of the 'scoring' of design quality

Notwithstanding its use to represent subjective values in the DQP, adopting the term 'Impact' as an Anglicisation for Vitruvius's venustas is problematic. The term is an adaptation rather than a translation, as evident from an exegesis of the Ten Books of Architecture (*ibid).* Vitruvius develops venustas to mean "when the appearance of the work is pleasing and in good taste, and when its members are in due proportion according to the correct principles of symmetry" (*ibid,* p.17). It solely concerns matters of visual symmetry and proportion. In a genealogical sense, Vitruvius' conception is consistent with the pervasive ocularcentric paradigm originated by the Greeks in western culture (Pallasmaa, 2005). As used in the DQP, by contrast, the term is concerned with several values and opinions. It is addressed by a total of 22 questions within AEDET, each of which elicits stakeholder scores on subjective matters such as "does this building appropriately express the values of the NHS?"

A further, more substantive fact-value problem is created by AEDET's evaluation of subjective elements when considering 'impact'. Subjective elements necessitate consideration of values, whereas the evaluation of objective elements concerns facts. Values do not lend themselves to measurement by virtue of their inherent subjectivity. This is referred to in the philosophical literature as the 'fact-value problem' (Schwartz 2009). Philosophically, values cannot be quantified objectively: they are always subjective and must be regarded as originating from the first person. When operationalising Vitruvian principles to develop the Design Quality Indicator from which AEDET is derived, Gann *et al.* (2003) acknowledged this problem several times (pp. 319, 320, 322).

Finally, subjective impact scores are simply, but erroneously, agglomerated with further scores addressing functionality and build-quality criteria. The fact-value measurement problem is thus further exacerbated by AEDET's intent to lead stakeholders through a normative 'scoring' of an emerging design solution. Gelser *et al.* (2004) expand on the detrimental consequences of such preoccupations by considering an actuality "reflecting complex social power relations" and the "priorities of the 'experts'" who produced the instrument.

The uncritical use of DQP instruments such as AEDET brings risk. Prasad (*ibid*, p183) identified the "intrinsic ossification of evidence orientated bureaucracies" which provides a good example of what Collier (1994) referred to as 'misplaced concretedness', important design abilities such as creativity; innovation; novelty; that can produce the ineffable; the surprising; the civilising; the rebellious; all risk erosion. None of these considerations are included in the Impact quality field yet they distinguish architecture from mediocre building design (Shai *et al.* 2009; Hatchuel, 2002). If used uncritically as 'quality thresholds' for approval purposes as suggested by CABE (2008), the scores provided by prescribed instruments risk reification.

TOWARDS A NEW APPROACH

Based on the critique above, the several risks stemming from the inherent determinism of the approach and this represents in essence an 'epistemic fallacy' (Bhaskar, 1978). This occurs because the positivist paradigm that sits behind the instruments fails to recognise and identify the depth of the reality (ontology) of design evaluation by effectively conflating and reducing the subjective values of the stakeholders to objective categories. This effectively distorts and flattens the ontology of design evaluation to the detriment of understanding of the nature of design evaluation by the project design evaluation stakeholders.

Towards a new approach

Taking these shortcomings into account a new approach is proposed. The primary aim of this approach is to go beyond considerations of the epistemic incommensurability of what is regarded as 'design knowledge' and problems caused by conflating values with facts with its preoccupation of 'scoring' the designs.

The new approach is grounded in the 'actuality' (Cicmil et.al. 2006) of the practice of design evaluation. In the new approach, design evaluation is viewed as a complex, situated, contingent and adaptive practice that is socially negotiated between the designers and all of the other stakeholders until consensus is reached. Thus, this approach regards the design evaluation as a manifestation of the practice of social interaction of the participants as essentially a form of distributed social accomplishment. It draws on a critical realist paradigm and method described by

Danermark *et al.* (2008, pp.73-114). The point of departure for the underlying paradigm used is that of critical realism. In application this means that design evaluation is regarded in a critical realist paradigm as a) having an objective existence (outside the minds of the design evaluation participants) but, b) such an existence is one that is always mediated by the interpretative views of such participants. Specifically, it is this mediation of theory by, in effect, the social interaction of the design evaluation participants that represents a profound and fundamental paradigmatic difference between the existing NHS process and the new approach in the pursuit of enhanced patient outcomes.

The new design evaluation approach uses a heuristic set of theories and concepts abductively (as a means of theoretical redescription) and retroductively. In the context of design evaluation, this approach amounts to applying multiple theories to serve as a framework for interpretation and as tools for retroduction (see Danermark *et al.* p. 146). This approach asks a fundamental retroductive research question: "what enabling mechanisms are fundamental for design evaluation to exist". An answer to this question led to the new approach being founded upon an investigation of the extent to which the social interaction of the participants involved in design evaluation may, as a fundamental enabling mechanism, influence design quality. This relates to the social interaction and the creation (Krippendorff, 2006) of meaning and understanding between the stakeholders involved in design evaluation and draws on sociological and anthropological literature. In particular, it includes consideration of the synthesis of complexity theory (Bryne, 1998) and theory of practice (Schatzki, *et al.* 2008) .

Three aspects of practice theory considered pertinent to design evaluation are emphasised. First is that design evaluation a situated practice increasingly constituted by information technology, in particular the use of computer assisted design (CAD), computer generated imagery (CGI), building information modelling (BIM) and other modelling, simulation and visualisation (MSV) technologies. The critical observation here is that these technologies serve to transcend the boundaries and influences of the actions of individual designers to permit and encourage the accomplishment of design evaluation as a social activity distributed amongst the participants. Second is the consideration of the role of objects: the practice of design and design evaluation by participants is entangled with the consideration of objects which may be manifest as products and artefacts such as drawings and models, mock ups and physical samples. These distinguish design and design evaluation as embodied skills from routine. The third aspect of practice theory to be emphasised is the role of knowledge in design evaluation. A practice theory perspective avoids the alternatives provided in theories that focus on individuals' *a priori* thinking, or at the level of social norms, or what goes on in language, for example. Knowledge, in theory of practice, is a social accomplishment situated in the on-going routines of bodily and mental activities (Schatzki *et al.* 2008).

Critical realism as a paradigm can be elaborated by its integration with complexity theory (Blaikie, 2009, p. 213). Emergence, a key theme within complexity theory, is most simply described as the relationship which makes it possible for a whole to be more than the sum of its parts. A key element also of critical realism, Bhaskar (1994, p.73) provides a more elaborate definition of emergence within complexity theory that takes on board the relationship between diachronic and synchronic events: this, it is suggested, resonates with the practice of design evaluation. In the practice of design evaluation synchronic events occur simultaneously between the professional designers

and the end-users within design evaluation workshops. They are also, by virtue of the iterative nature of design evaluation workshops held at different times, diachronically linked and thus considered over the design development cycle as supporting notions of emergence and complexity. As Archer (1995) strongly points out, the notion of emergence introduces a time dimension to analysis; emergence is a process. It is suggested that emergence better reflects the reality of the iterative outcome of successions of design evaluation workshops.

As Thomson (2011) points out there is an improbability about the prospect of end-users fully defining in advance their "requirements" from the outset of their participation in the design process. Such activities are rarely simply linear; they involve human beings and therefore will be mediated by human subjectivities, values and motivations. They often be complex and will necessitate involved negotiations in order to reach a consensus.

Introducing new analytical devices

All of the above considerations of complexity, emergence, practice and context that coherently sit within a critical realist paradigm are synthesised by way of introducing a pair of concepts: 'design evaluation as practice' and 'design evaluation in practice.' These analytical devices transcend some of the deterministic, reductionist and individualistic shortcomings of the current NHS design evaluation approach.

Introducing the concept of 'design evaluation as practice' interprets design evaluations as a habitual array of complex human activity distributed and constituted between the participants. As such, the nature of their reality is regarded as being emergent, adaptive, and contingent and one that comprises several elements as articulated by Reckwitz in his definition of an ideal-type of practice theory. Reckwitz defines practice as "a routinized type of behaviour which consists of several elements interconnected to one another: forms of bodily activities; forms of mental activities; 'things' and their use, a background of knowledge in the form of understanding, know how, states of emotion and motivational knowledge" (2002, p. 249).

'Design evaluation in practice' refers to the temporal and contextual aspects of design evaluation. The term acknowledges the emergent nature of design evaluation as enacted in practice. Design evaluation in practice also draws attention to improbability of there ever being a completely satisfactory design in terms of design quality. It points to the reality that when an NHS healthcare facility is built and commissioned and handed over to end-users, the work of design is still not complete. Through their everyday involvement with the design in practice, the end-users continue to be involved in constituting the evaluation of the design and thus seek new opportunities further enhancements.

APPLICATION OF THE NEW APPROACH: TWO CASE STUDIES

The Elmview and Muirview Units: description and context

The case studies comprise the design processes associated with two adjacent mental health units at NHS Fife's Stratheden Hospital near Cupar in Fife, Scotland. These are known as the Elmview and Muirview units. The Elmview Unit was opened in July 2009 and the Muirview Unit in August 2010. Both projects transferred most of the existing staff and patients from Kirkcaldy to Stratheden so for, all practical purposes, the attendant difference in healthcare was caused by the change of physical

environment from old facilities to new facilities. The cases provided an opportunity to investigate the influence of these relocations on the healthcare outcomes of patients and on their visitors and staff all as 'end-users' of these facilities.

The application of the new approach within the design development life cycle

Wotherspoon's (2001) framework for understanding temporal change was adopted and related to the familiar design development life-cycle. Within this framework, the concepts of sensemaking, seeding, negotiation and accomplishment are introduced. They serve as distinct phases through which the new design evaluation approach proceeded in practice. Space only permits an abridged summary as below:

Sensemaking:
Dervin, et. al. (2003) explain “Sense-making reconceptualizes 'factizing' (the making of facts which tap the assumed-to be-real) as one of the useful verbings humans use to make sense of their worlds." Sensemaking is a phenomenological concept focused on enactment (Weick, 2005) . Used in practice, it provided the first step of an action-oriented process that the design evaluation participants were exposed to in order to integrate their identities, tacit knowledge and experiences into the practice of design evaluation. This was achieved by a series of workshop sessions facilitated by the design champion with the design evaluation participants only at this stage. The designers were not invited to these workshops. The decision to exclude the designers at this stage was made to encourage and to allow the participants to rehearse the use of the instruments. It also provided them with an opportunity to ask elementary questions about design and design evaluation without any inhibition or possible embarrassment owing to lack of experience or training in such activities.

Seeding: In this stage, the practice concern was defining and refining the design. This entailed significant use of face to face dialogue and boundary objects (Ewenstein & Whyte, 2009; Luck, 2007) such as drawings and computer generated images to generate a diverse and shared understanding (Valkenburg, 1998) of different design ideas between the design evaluation participants. This was achieved in practice via a series of c. ten separate meetings between the design evaluation participants and the designers in which the importance of face-to-face dialogue was evident (Gorse & Emmitt, 2009), and verified Valkenburgh's (*ibid)* consideration of its role in project management and project organisation in practice as conducive to generating shared understanding. The social interaction of clinician with designers during this stage surfaced the innovative notion of "dementia does not equal inactivity" as a profound and fundamental agreed design principle that significantly influenced a hierarchy and novel provision of circulation space. This notion represented, in effect, an example of how the social interaction between the participants facilitated an exchange of values between the practice of the clinicians and those of the designers. The clinicians, as practitioners of observing and treating patients, brought their notions of how the patients actually use space within the facility. The designers, also as practitioners, brought their values of spatial expertise and of the design domain. Both of these values sets will have been internalised and independently held by the clinicians and designers prior to commencing the design evaluation. However, and as actually observed, it was during the social interaction of these participants, in the course of actually practicing design evaluation, that they were revealed and facilitated the exchange and emergence of the notion.

Negotiation: The negotiation stage focused on the detailed specification of sub-elements of the design (e.g. patient bedrooms, nurse-call stations) and their integration

into the process artefacts (such as drawings and room-data sheets) that collectively constituted the design as a whole. In practice, these artefacts acted in this stage as further, more refined boundary objects playing a key role in reaching a shared understanding of the design as it relates to each of stakeholders. It is during this stage that 'conflicts' are fully articulated and openly debated. The notion of "dementia does not equal inactivity" was refined and manifested in agreed hierarchical use of space ranging from 'private space' (e.g. bedrooms) to 'semi-private' and 'public spaces' promoting varying degrees of social interaction of the in-patients and visitors.

Accomplishment: The Royal Institution of British Architects (RIBA) design development stages 'C' and 'E' reflect formal outline planning and building warrant submissions respectively and were used as milestones for accomplishment. They represented the accomplishment of a negotiated consensus across the diverse perspectives and social worlds of the designers and the stakeholders. At these stages, AEDET workshops were held and the 'design' immediately thereafter was formally 'signed-off'. These practices were regarded as a symbolic act of documented consensus and as a means of complying with the DQP.

KEY RESULTS

For both the Elmview and Muirview units, two key results followed from the use of the new design evaluation approach. The first comprised several prestigious annual national design awards bestowed by independent bodies such as Health Facilities Scotland (an agency of the Scottish Government), the RIBA and the Better Building campaign. Second, and regarded as much more profound, was the improvement in patient outcomes measured by proxy by reductions in challenging behaviour and by feedback from post occupancy surveys and focus groups that characterised high levels of staff and visitor satisfaction. Analysis of statutory incident records in the first twelve months of operational use identified average reductions in challenging behaviour incidents in the order of almost half (46%) and 80% for the Elmview and Muirview units respectively, when compared with the averages over the previous 5 years. A notional average monetary cost of managing each such incident was projected over the anticipated building life-cycle of 50 years to derive yield a total cost avoidance revenue sum. This sum was discounted using established HM Treasury Green Book Net Present Value methods and to give an equivalent present value. Expressed as percentages of the outturn construction costs (which included build costs, fees and VAT) they amounted to savings of 8.5% and 48% respectively for the Elmview and Muirview units. Subsequent analysis after the first year of occupation shows marginally lower levels of challenging behaviour reduction (of the order of 40% and 70% respectively) but with still significant cost savings accruing; the overall reduction being attributed to higher occupancy levels in both units.

CONCLUSION

This paper has addressed shortcomings in the existing NHS design evaluation approach to augment its theory and re-orientate its practice by introducing a new approach with new analytical devices, viz., 'design evaluation as practice' and 'design evaluation in practice'. The successful use of this new approach in two case studies has been illustrated. The approach is clearly capable of providing an input into an appropriate evidence-base that can underpin tools that can show how hospitals impact on patient outcomes. As such it is consistent with the second of Fröst et. al.'s (2010) guiding principles for the development of an international best-practice framework for healthcare buildings. This paper is offered to open up a robust debate about enhancing

and elucidating current NHS design evaluation approaches pursuant to improving the design quality and of hospitals and the healthcare outcomes of the patients that use them. There are clear limitations to the approach espoused here, notably that it is based on only two case studies. Further work is required to generate more empirical insights into the social interaction of the practice of design evaluation.

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EXPLORING PROCESS, PRODUCTIVITY AND STRUCTURE IN DESIGN

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It is increasingly difficult to benchmark performance and record, manage and transfer information effectively. Modern construction projects are complex and the roles and responsibilities of designers are inconsistent. This raises concerns about rework and inefficiencies in construction projects. To address these concerns is an opportunity to improve project performance and profit margins. Increasing calls for innovation, growing client involvement and input from a range of stakeholders have led to the creation of complex project management structures. This has added to the centrality of the design process, underlining the need to understand and assess the design process and its productivity. The research forms part of a project intended to investigate the productivity of designers and engineers, with the aim of enhancing design process productivity. An improved understanding of design processes and identification of the factors that may contribute to design productivity within a design-led organisation is intended to help improve the management of design activities. As part of an ongoing PhD project, the aim is to present a critical review of literature in order to understand the complexity of design and to explore the roles of effective management, organizational structures and emerging tools in the potential success of design. The literature reveals that the design process and interactions with stakeholders increasingly requires operational and managerial complexity. The relationships between technical, operational and managerial complexity requires a better understanding of what design actually is, why it is complex and how this impacts project organizational structure. It would be useful to focus the next stage of the research on the effectiveness of the design process, than its efficiency.

Keywords: design complexity, design process, organizational structure, productivity.

INTRODUCTION

Modern construction projects are complex and the roles and responsibilities of designers are inconsistent. It is becoming increasingly difficult to benchmark performance and record, manage and transfer information and knowledge effectively (Zhao *et al.* 2007). This adds to concerns regarding inefficiencies in construction projects. An improved understanding of design processes and identification of the factors that contribute to design productivity within a design-led organisation will help

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Shah M. I. A.; Tang L. C.M. and Hughes W **(**2012) Exploring Process, Productivity and Structure in Design *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 77-87.

improve the effectiveness and efficiency of design activities and quality for the lifetime benefit of all users.

Demand for innovation, growing client involvement and input from a growing number of internal and external stakeholders has led to the creation of a complex project structure for management (Hughes and Murdoch 2001). This has also added to the central importance of the design process, underlining the need to understand and assess the design process and its productivity in a scenario where 'design is constituted both by designers and by non-designers through their consumption of and engagement with the outcomes of designing' (Kimbell 2009: 3). Examining the construction design process to understand and assess its productivity needs an understanding of the construction context, and of the complexity of the design process and the associated challenges. The aim of this paper is to explore and review the literature on this topic in order to form a context for future research.

BACKGROUND

Organizations are becoming increasingly dependent on the productivity of their knowledge workers (KWs) (Ramírez and Nembhard 2004). The manual aspects of production have largely been automated and so it is the KW which gains organizations the edge in their markets. Like all industries, production in the construction industry has been moving towards knowledge-driven processes while manual work has become increasingly automated. Drucker (1988) explained this as an outcome of a broader shift from industrial to post-industrial age. This shift underpins the changing ratio of manual workers to KWs from 2:1 in 1920 to 1:2 in 1980 (Davenport 2002), with the result that the KWs are emerging as the single largest group in the workforce of any developed country (Drucker 1988). This requires increasing these KWs' performance and productivity by involving them in the research and research-informed organisational strategic plans if companies wish to make substantial gains.

Organizations across all fields of production are faced with the challenge of recovering the rising costs of materials, labour and other production expenses, as well as the challenge of creating opportunities to increase profits for future growth, development and sustainability. Some potential options include raising product prices to meet the increasing costs, cutting production costs, and improving the production process to make it more cost-effective. However, all these strategies have relative value in the local and global industry contexts where 'hard to measure' KW is replacing 'measurable' manual work (MW). The measurable nature of MW made it possible to develop frameworks or approaches for evaluating its productivity, which underpinned improvement of related processes and practices. Ramírez and Nembhard (2004: 603) argue that 'Measuring manual worker productivity was a critical step in laying the groundwork for improvement efforts in the manufacturing sector during the first half of the twentieth century'. Recognising the importance of KW in productivity, the focus of research has to shift to KW which needs to be explored for quality, efficiency and output among other things.

Design work in construction is commonly defined as complex and creative, aligning with KW. In addition to the complexity of the design work itself, the nature of this work is also becoming highly competitive and demanding. Calls for cost-cutting while a reduced construction demand in some previously high-demand-areas such as the Middle East has meant a decrease in work for many international companies; the previous momentum of demand for workforce has reduced. The emphasis is no longer on bringing more people in, but on using the work force, which has increasing number

of KWs, more efficiently and strategically. Organizations are trying to use expertise and resources based at different sites effectively for global work, reinforcing the significance of communication, new technologies, and strategic deployment which require use of advanced technology and improved management. Physical transfers or relocations of the knowledge/expertise resources spread at different international bases, in response to demands at different locations/countries can be expensive. The current scenario necessitates an informed development and deployment of sustainable strategies, frameworks, and processes for managing a range of resources, which has added to the centrality of design and design-related applications in the construction industry.

DESIGN AND DESIGN PRODUCTIVITY

Examining the design process and its productivity requires an understanding of the concept in the context of construction, its drivers, and the nature of the product. The 'term design has different meanings to different researchers' (Love 2000: 296). Conway (1963: 260) offers various interpretations of design and designers and argues that 'Different people, even engineers, do not ascribe the same meaning to the word Design, or function to a Designer' (p.260). These range from design as a rational activity to design as an art or design as a creative activity. Generally, it is used both as a noun and a verb. As a noun it is understood as a concept or a product; for example, a plan or drawing that is produced to show the look and function or workings of a building or any other object before it is made. It is the art or action of conceiving of and producing a plan or drawing of something before it is made, presenting the purpose or planning that exists behind an action, fact, or object. A good design can help its reader understand complicated information through a clear presentation that can be an end product in itself. However, design as a verb is an ongoing activity, a process or procedure, where the design itself is in a constant process of development. The BS 7000-10 (2008) defines design as generation of 'information by which a product can become a reality'. This vagueness of the definition is suggestive of the complexity, and multiple dynamics of the design process, underlining the need for research to improve its understanding.

Gray and Hughes (2001: 24) describe design as 'a creative and very personal activity The architect takes the client's brief and uses design skills to develop a three-dimensional interpretation which other designers use as a basis for their own work'. This definition points to two elements of design – creativity to realize the design, and the translation of that realisation into delivering an output to meet the needs/requirements. Potter (2002: 10)defines design as the product of 'a plan conceived in the mind; not only as a set of drawings or instructions, but as the ultimate outcome from manufacture'.Walsh (1996: 513) claims that all design terms 'involve the creative visualisation of concepts, plans and ideas; and the representation of those ideas (as sketches, blueprints, models or prototypes) so as to provide the instructions for making something that did not exist before, or not in quite that form'. Similarly, Khandani (2005: 4) explains that 'Engineering is the creative process of turning abstract ideas into physical representations This creative act is called design'(2005). The construction design process is a specialized and highly demanding form of problem solving (Lawson 1997). It is widely claimed to be the key project process (Cockshaw 2001). According to Cross (2006) designers are solution focussed and their mode of thinking is constructive or generative. Gray and Hughes (2001: 24) argued that in spite of design process being a very personal creative activity, the whole project's design becomes a combination of the motivation and expressions from

many individuals and is 'viewed by the separate members of the team from many different directions and, in particular, with regards to how well it will accommodate their own needs and wishes'. Due to the complexity of design work, many designers with specific expertise are involved in the construction design process. Tribelsky and Sacks (2011: 85) rightly claim that in the current construction contexts managing 'smooth and continual flow of information among teams of independent designers is one of the central difficulties in detailed design of complex civil engineering projects'. They recommend high quality design documents and flow of information to achieve the performance targets. Another significant point to note here is the potential challenges of 'complex project structure for management', underlined by Gray and Hughes and Murdoch (2001), as mentioned above.

Design has been the basis of construction industry irrespective of the nature or details of the design. Bibby (2003: 1) explains it as 'a dynamic and complex multidisciplinary process, involving many parties and performed in a series of iterative steps to conceive, describe and justify increasingly detailed solutions to meet stakeholder needs'. From earlier sketchy outlines and drawings to more detailed architectural blue prints and now highly elaborate digitized multi-dimensional designs is a process reflecting increasing emphasis on the significance of design in the construction industry, and a widening of the aspects of related activities to be considered in the design. This has extended the work and responsibilities as well as influence of the designers, requiring greater communication and higher collaboration among different actors and stakeholders for achieving desired outcomes which are cost-effective and efficient. Kimbell (2009: 9)argues that 'taking the plural noun form of "design" which can mean the outputs created during a process of designing, such as blueprints, models, specifications and what is finally assembled in products and services, the term designs-in-practice draws attention to the impossibility of there being a singular design'.

Kimbell (2009) discusses and explains two dimensions of design as design-as-practice and designs-in-practice. She argues that 'design-as-practice mobilizes a way of thinking about the work of designing that acknowledges that design practices are habitual, possibly rule governed, often shared, routinized, conscious or unconscious, and that they are embodied and situated' (p.9), while the concept of 'designs-in-practice … acknowledges the emergent nature of design outcomes as they are enacted in practice' (p.9). The design embodiments such as visual artefacts are certainly a part of the design process and KW, and as (Whyte *et al.* 2008) evidenced 'visual artefacts which constitute part of the practices of designers and others, play important roles in knowledge work' (quoted in Kimbell 2009: 9). However, Kimbell (2009: 10) continues to argue that:

'The idea of designs-in-practice foregrounds the incomplete nature of the process and outcomes of designing (Garud, Jain and Tuertscher 2008). When the designers have finished their work and the engineers and manufacturers have finished theirs, and the marketers and retailers have finished theirs, and the customer or end user has taken or engaged with a product or service artefact, the work of design is still not over. Through their engagement with a product or service, the user or stakeholder continues to be involved in constituting what the design is.'

The idea of designs-in-practice emphasizes the incomplete nature of the process (Garud, Jain and Tuertscher 2008). Designers need to be flexible, spontaneous, and creative to accommodate the demands of different stakeholders. An important aspect

of design is that although it is prepared by designers, the 'non-designers' (Kimbell 2009) need to understand it as they will be involved in giving life to the design. Design is the converging point where various skills and disciplines link together in a process where 'a product can become a reality' (British Standards Institution 2008). A better understanding of design and design processes would therefore, allow a reduction in time, re-working, and cost and therefore optimisation of designs for the lifetime benefit of all the users (Raisbeck and Tang 2009).

Design guides, controls, and determines the project work. The growing emphasis on design research and centrality of design reflects the need to develop solutions that can be used 'in various organizational contexts to achieve specific objectives' (Vahidov 2006). Development of design from basic drawings to the advanced design software such as CAD and Building Information Modelling (BIM) reflects responsiveness to emerging needs for enhancing design productivity. A good design is not just sound and strong construction but it also necessitates giving full considerations to all its complex dimensions. This raises questions such as: what is the required information for design process? Who is involved in the process? Who is the information generated for? How is the information generated?

The discussion above indicates that the input required for the design process comprises of multifaceted information, knowledge and expertise. Those involved in the process include various direct and indirect contributors, and the information generated is for interactive use across all those involved in the design process over its extended life span. This non-linear multifaceted nature of input requires specialist knowledge, complex tools for information generation and informed project management. The increased technical complexity of design has led to increased operational and managerial complexity. Organizational structure and the structure of design teams directly relate to the operation and management of design and its efficiency and effectiveness. Drucker (1977) explained that efficiency is doing things right and effectiveness is doing the right thing, and the two complement each other for organisational performance.

TECHNICAL COMPLEXITY OF DESIGN AND DESIGN TOOLS

The increased technical complexity of design has led from basic drawings to highly advanced design software. The introduction of Computer Aided Design (CAD) which presented a huge shift from manual drafts, saving time and cost, and facilitating improved collaboration, document distribution, and data management. CAD has been appreciated 'for accelerating the production of drawings and documentation, for supporting the exchange of design information among groups using the same CAD systems and for providing visualization tools', but with some critique that CAD users often 'are solving computer problems about how to draw, not architectural problems' (Cad for Principals, online). Other critique included its costs in terms of training and equipment and an isolated activity that did not support a communicative team environment. However, project profiles from a relevant organisation (Halcrow, online) acknowledge CAD as providing opportunity to all stakeholders including the engineers and the CAD team to 'work together in a more integrated and efficient way, sharing drawings between themselves, external team members and the client' (Halcrow, online). CAD is perceived as a quicker and more efficient way to share drawings and facilitates closer collaboration through online communication and review of drafts. Technically CAD offers improved design presentations by providing 2D and more recently 3D visual representation of design information. Better

presentation and representation of information has helped for instance to reduce design errors and contributes to increased efficiency and productivity in construction.

Another significant technical development in this field is Building Information Modelling (BIM) with associated technologies and processes. American Institute of Architects (2008) defines BIM as the digital representation of the physical and functional characteristics of a project. It is a platform which integrates information about a project from design through construction and into operations and facilities management. This 3D technology has the potential to create more precise visualisations, giving accurate information regarding the cost, appearance and performance of a project. As multiple dimensions of design are made visible with all associated details, co-ordination, quality and efficiency are increased, and delays, risk, environmental damage, and waste are reduced. BIM users emphasize that BIM is not a mere improvement on CAD but a new solution to construction challenges, as explained by Richard Waterhouse Chief Executive, RIBA Enterprises (National Building Specification 2011).

BIM appears to respond well to increasingly complex demands in the construction industry today. It 'facilitates complex processes and analyses that were previously too laborious or complex to perform' (Autodesk 2005: 1). It is argued that 'BIM could help improve the quality and speed of project related decision making; manage supply chains; sequence workflow; improve data accuracy; reduce time spent on data entry; reduce design and engineering conflicts and subsequent rework; and improve lifecycle management of buildings and infrastructure'(Mcgraw-Hill 2009). It is not just switching software but a culture and organisational change, requiring high level collaboration and responsibility, highlighting the operational and managerial complexity of the design activities. The users need to be more efficient and proficient. In a UK survey National Building Specification (2011: 14) found that 'BIM brings better co-ordination of construction documents (81 per cent agree), improves productivity, (84 per cent), increases delivery speed (51 per cent) and improves visualisation (85 per cent)'; but it also highlighted that nearly 90 per cent of people will need to change their workflow practices and procedures.

There are clear signals of the increasing use of advanced applications such as BIM in the construction industry, particularly for large projects. It can be argued that BIM as a design-centric technology, with emphasis on sharing and collaboration, can be the answer to multiple challenges in the construction sector. However, it needs to be recognized that all these processes and applications work in an organisational context and are influenced by organisational structure, functions and activities requiring informed project management and leadership skills and expertise.

ORGANIZATIONAL STRUCTURES

As discussed above, design increasingly becoming technically complex. To address this technical complexity engineers and designers are needed to become specialized in specific aspects of the design. One consequence of this growing emphasis on specialisations is that the designers/engineers with their specialism fields may become less involved with other aspects of design work, thus being responsible primarily for a certain "fragment" of the design. In addition to that, inter-organizational and contractual relationships further isolate the experts, and complicate the work relationships across these individual "disciplines" or specialized designers underpinned by a lack of clarity regarding their actual and contractual responsibilities and their obligations to one and another. A complex managerial task emerging at the

organizational level is to integrate and co-ordinate these 'specialists' from multi-disciplinary teams in such a way that the 'team members strive to contribute beyond their disciplines' traditional boundaries' (Busseri and Palmer 2000: 224)

People involved in design process are nodes in design processes where one person output can be input for another person, making it a complex system that needs to be investigated and understood. 'Complexity scientists' contend that unpredictable behaviours and new laws arise as more complex systems emerge, which is the reason those systems must be studied at the levels of their emergence' (Davis and Sumara 2005: 455).Furthermore, they argue that although 'complex phenomena represent interactions of events, activities, and practices that coalesce in ways that are unpredictable but nonetheless highly patterned' (p.161). Searching for patterns among unpredictable phenomenon can contribute to structural and systemic efficiency and effectiveness, leading to improved project management.

Senge (1990: 43) argued that complex systems exhibit networked rather than hierarchical structures. They have multiple branches extending in many directions rather than vertical lines of control. Senge advises to 'look into the underlying structures that shape individual actions and create the conditions where types of events become likely'. Bergstrand (2009), drawing on Burrell and Morgan's (1979) framework for categorising sociological paradigms presents a model relevant for KW productivity management systems in business contexts, labelling the four quadrants as Envision, Design, Build, and Operate. Bergstrand posits that 'Within the design process these four units can be seen as parts of whole, requiring complex mental models to define the work and correspondingly complex structures and processes to productively manage the work (p. 89). A complex phenomenon demands paying informed attention to all situated aspects. Complexity drivers are multiple and 'complexity-aware approaches ensure that change is linked into the natural complexity of local environment' (Beautement and Broenner 2011: 26). 'A complexity approach [in an organisational context] would suggest that encouraging and empowering people to make small changes in their own spheres of influence and activity can be a highly effective way of transforming an organisation' (Mcmillan 2004: 86).

Structures underpin activities and processes and 'the system causes its own behaviour' ((Meadows 1982) quoted in Senge 1990: 43). People develop their behaviour, activities, and responses in the context of organisational structure and system/s. '"Systemic structure" is concerned with the key interrelationships that influence behaviour over time' (Senge 1990: 44). To survive in a competitive field and to continuously transform itself, an organisation needs to enhance its capacity to learn and innovate as a structure and also to facilitate the learning and development of its members. Archambault (1974)was one of the most well-known advocates of hands on learning who emphasized learning through interaction, experience and reflection. Reflection on practice was theorized as reflective practice by Schon who explained it as organisational learning. (Schön 1983)emphasized the value and contributions of organisational learning and reflective thinking, maintaining that organizations and individuals should be able to incorporate lessons learned throughout their lifespans. However, developing learning organisations also has challenges in the context of complex organisations as this signals on-going learning. This learning is both for the individual and the organisation. Admittedly, 'organisations and individuals are complex adaptive systems and therefore have the ability to transform themselves in order to adapt to changing' (Mcmillan 2004: 102).Nevertheless, when the two are not learning simultaneously and interactively, they lose their capacity to develop.

A learning organisation is different from the traditional concept of organisation with linear structures and lines of command, therefore they demand a new view of leadership. (Senge 1990: 342) conceptualizes leaders as designers and argues that 'the essence of design is seeing how the parts fit together to perform as a whole'. In this learning organisation 'the leaders' task is designing the learning processes whereby people throughout the organisation can deal productively with the critical issues they face, and develop their mastery in the learning disciplines' (p.345). Senge (1990: 69) suggests "systems thinking" 'for seeing the "structures" that underlie complex situations'. Senge (1990: 12) presents systems thinking as the fifth discipline 'that integrates the disciplines, fusing them into a coherent body of theory and practice'. The other four disciplines are Vision, Mental Model, Personal Mastery and Team Learning. According toSenge (1990: 7), systems thinking is 'a conceptual framework, a body of knowledge and tools that has been developed over the past fifty years, to make the full patterns clearer, and to help us see how to change them effectively'. The five disciplines jointly make the organisation into a 'learning organisation'. If an organization fails to embrace all the necessary aspects, problems can obstruct the process of learning and development. Senge emphasizes that a learning organisation 'is continually expanding its capacity to create its future … [through] generative learning' (p.14). Senge underlines the significance of systems and structures and claims that "more often than we realize, systems cause their own crises, not external forces or individuals' mistakes" (p.40). Therefore, emphasizing the need to see and detect those 'gradual processes that often pose the greatest threats' (p.24) because we do not take notice of them while they are gradually weakening the systems or slowing the progress. Design is also a complex process with the risk of many activities going undetected that could negatively impact on design productivity. Systems thinking can be a relevant tool for analysing design productivity because it is a problem solving approach and a framework for understanding how things influence one another within a whole. In organizations, systems consist of people, structures, processes and technologies that work together towards a whole. While the whole is in the process of becoming, some or many interdependent parts may display choice and/or behave independently, posing challenges that slow the progress. Today's complex organisations and systems are made up of diverse sub-units that perform specialized functions. 'Systems thinking' focuses on understanding of a system by examining the linkages and interactions between the elements that compose the entirety of the system to eliminate or control such possibilities.

The complexity and uncertainty of the construction design process requires the application of significant management efforts for project success (Bibby 2003, Gray and Hughes 2001). The nature of the work involved in the design process which tends to be invisible and creative heightens the challenges. The difference between KW and manual work is that manual work can be automated while KWs (engineers/designers) need to make professional judgements that are subjective, and such judgements can have a huge impact on the final product. Misha Black, (1969) the British architect and designer described the "profession" of design as 'the offering to the public of a specialized skill, depending largely upon judgement, in which both the experience and established knowledge are of equal weight, while the person possessing the skill is bound by an ethical code and may be accounted by law for a proper degree of skill in exercising this judgment' (quoted in (Potter 2002: 15)). Focusing on the product of design, avoiding exploration of possibilities, carries the risk of creating a generation of engineers shy of making professional judgements, and relying heavily on

standardization. This is particularly counterproductive when considering the need for innovation to beat the competition in a very strong industry.

CONCLUSION

The design process generates and requires diverse information, knowledge and expertise. In addition, the design process is influenced by, and must cater for direct and indirect stakeholders of numerous disciplines and interests. This along with the specialist knowledge and increased technical complexity has led to increased operational and managerial complexity. The key role of tools such as BIM is not simply to increase technical capabilities, but rather the emphasis placed on sharing and collaboration. The impact of such tools on organisational structure, functions and activities merits further exploration.

The literature reviewed unveils the technical complexity of design, and operational and managerial complexity of design process, requiring exploring and debating how they impact on each another. This demands deeper consideration of what design actually is, what makes it complex and how this is linked to the organizational structure. It would be useful to focus the next stage of the research on the effectiveness of design in order to deliver long term benefits for all the stakeholders, rather than a short-term focus on making a particular aspect more efficient.

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INDUSTRIALISED BUILDING SYSTEM (IBS) IN MALAYSIAN HOUSING: AN EMERGING INNOVATION SYSTEM EXPLANATION

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The building industry has many challenges, such as growing demand for affordable housing, increasing construction costs, relying on unskilled labour and failing to produce acceptable quality of construction outputs. These challenges are prevalent in most country in the world including Malaysia and have always been associated with adherence to existing practices and a reluctance to accept innovations. This situation has prompted policy-makers in Malaysia to set targets for the introduction of Industrialised Building System (IBS) but the aims have yet to be accomplished. Based on the System Functions approach, this paper aims to create an understanding of the IBS development pattern in Malaysian housing construction from 1963 to 2010. The data was collected from archive data and verified with interviews. From the findings, positive perception in IBS and government policy on IBS development are the two inducement mechanisms identified. Meanwhile, uncertainties of IBS opportunities among potential construction clients, inadequate knowledge of relative between investments and benefits, inconsistencies of demand for IBS application, lack of IBS suppliers, and unpreparedness among construction designers and contractors are the discovered blocking mechanism. Based on this development pattern, the blocking mechanisms identified are stronger vigorous and have decelerated IBS development in Malaysian housing projects.

Keywords: Malaysian housing construction, industrialised building system, technological transition, innovation system, system function.

INTRODUCTION

Historically, IBS was introduced for housing construction in 1964 in Malaysia when the first prefabrication project was constructed in Kuala Lumpur. IBS is defined as a "construction technique in which components are manufactured in a controlled environment (on-site or off-site), transported, positioned and installed into a structure with minimal additional site works" (CIDB 2003a). This system has been regarded as a solution to the weaknesses in the existing practices, such as low quality, safety

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Sazalli S. A. A. H; Greenwood D; Morton D and Agnew B **(**2012) Industrialised Building System (IBS) in Malaysian housing: An emerging innovation system explanation *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 89-98.

issues, wastage and excessive reliance on unskilled foreign workers (e.g. Abdul-Rahman and Alidrisyi 1994, Agus 1997, CIDB 1998, CIDB 2001, Din 1984, Lim and Zain 2000). The construction practices that rely on large number of wet trade labours and construction processes mainly done on-site are common for Malaysian construction industry (CIDB 2003a). Therefore, several housing projects were constructed using IBS, such as, Pekeliling flat, Kuala Lumpur, flat at Rifle Range, Penang, Taman Tun Sardon flat, Penang and few housing developments in the state of Selangor. However, most of the housing projects were constructed using the conventional practices, as IBS Survey 2003 indicates only 15% of construction projects in the year 2003 used IBS (CIDB, 2003b).

At the end of 1990s, IBS was believed by the Malaysian government to be a better approach for the construction industry in Malaysia. The IBS Strategic Plan was published in 1999. The Malaysian government thought IBS created better conditions in the construction industry, such as through the reduction of unskilled workers[2], less wastage, less volume of building materials, increased environmental and construction site cleanliness and better quality control (CIDB 2003a). In 2003, the government set the industry to use IBS in all construction projects by the year 2010. To achieve the objective, numerous actions have been implemented such as providing IBS training programmes to public and private sectors, creating IBS construction projects, forming labour policy, implementing research on IBS and also marketing of the IBS application. However, these efforts have not made head-way. In 2006, only 10% out of total construction projects were constructed using IBS (CIDB 2007a). Meanwhile, the percentage of foreign workers in the construction industry increased from 44% of the total workforce in 2006 to 69% in 2007 (CIDB 2007b) which is far more than the target of 55% by the 2005. Therefore, this paper aims to create an understanding on the IBS trajectory in Malaysian housing construction from 1964 to 2010. In order to fulfil the purpose, this paper has chosen to proceed from the technological innovation system framework. A thorough understanding of the importance of functional fulfilment in the context of technological innovation system will help the policymaker in Malaysia accelerate the diffusion of IBS in the Malaysian housing industry.

The paper is structured as follows. First, an overview of technological change literature will be presented and will introduce the Technological Innovation System and System Functions that will be used in this paper. Second, the paper will describe how the data is collected and analysed. Third, the paper will explain the results of this study and this is followed by a discussion and conclusions.

TECHNOLOGICAL CHANGE

This study focuses on the lock-in of the existing system, which according to Lovell and Smith (2010) means the extent to which the entrepreneurs face difficulty to develop, diffuse and implement their new idea into the market. The UK housing study by Lovell and Smith (2010) argue that the method of housing construction based on labour incentives have been locked through several changes in technology and institution. Hence, they labelled this phenomenon as ‘masonry agencement lock-in’:

[2]By reducing wet-trades through IBS, the dependency on foreign workers will also diminish, thus gaining the billions of Ringgit currently being transferred out by the foreign workers to their home countries, and reducing inherent social problems involving these foreign workers (CIDB 2003a)

when efforts to bring the new methods have been unsuccessful although the new methods offer more benefits.

Lovell and Smith (2010) argue that this lock-in happens because the interaction between the technological system and the governing institutions keeps the infrastructure of the existing practices in place despite the known weaknesses in existence practices. Thus, the technological systems are seen to be complicated as they are linked with the social system that comprises the public and private sectors. In addition, it is impossible to focus on a single factor to unlock the system, but it cannot be denied that this factor would lower the existing system viability when it changes the selection environment (Schot *et al.* 1994). Hence, when the new technologies are developed and in the same time the changes in the selection environment occur, these will lead to the emergence of a new TIS. However, the changes in the selection of environment do not necessarily favour any specific technology. This has been shown in previous research by Finnimore (1989) where the growth of houses from factories was explained by analysing the development of an emerging TIS in the construction industry in the UK.

The growth of an emerging TIS can be categorised by identifying the development phases of the technology, for example the exploration phase, take-off phase and stabilisation phase (Rotmans *et al.* 2001). To unlock the existing practices, it is important that the new TIS develops successfully and takes over the existing practices' system. Thus, what are the factors that explain this successful growth of a specific TIS and how can we trace it?

The determining factors of the successful development, diffusion and implementation of a related technology can be traced from all activities within the innovation systems (Edquist, 2001). These activities are also called as 'System Functions' (Johnson, 2001). This approach was developed by Jacobsson and Johnson (2000), who defined it as "a contribution of a component or a set of components to a system's performance'. Hence, in order to understand how technology is developed, diffused and implemented, the functional pattern of TIS will be described and analysed through time in this study. As indicated by (Edquist, 2001), the study expects that the more the functions are fulfilled, the better the TIS will perform, and therefore the better the development, diffusion and implementation of innovations.

Drawing from the System Functions derived from the literature, the mapping of tentative technological change activities will be presented. It includes only the most relevant activities in the technological change process. By mapping these functions that occur over time, it provides a structure to explain the process of technological change and contributes to understand how the innovation system emerges, changes and could be encouraged appropriately. In this paper, the point of departure is the seven functions identified from the literature review. The following activities will briefly describe each function in Table 1.

The System Functions can be expected to interact with and reinforce each other in multiple ways (i.e. positively or negatively) which will influence the performance of the technology change. Bergek *et al.* (2007) indicates positive System Function fulfilment can lead to virtuous cycles of processes that strengthen each other and lead to the momentum build-up and create a process of creative destruction within the existing system. In contrast, a declining System Function is characterised by one or more vicious cycles when the System Functions interact and reinforce each other in a negative way. Thus, this paper maps the functional patterns in the case of IBS

implementation in Malaysian housing construction to provide insights into how the process of momentum builds-up in this system happens.

Table 1: Set of System Functions

System Functions	Description
Entrepreneurial Activities	This function is measured by using the number of new entrants, diversifying established firms, number of pilot projects, and number of different types of applications
Knowledge Creation and Development	Three typical indicators are used to measure this capability over time; number of training programmes, number of R&D programmes, and investments in R&D and training
Positive External Development	This function needs to capture the strength of these functional dynamics by searching for external economies in the form of political power, pooled labour markets, specialized intermediaries and information knowledge flows
Direction of Search	This function is analysed by using three different sources of information; from the government policies that set targets to use a specific technology, extending new regulatory pressure and tax regimes, and incentives for new technology; from new articles/reports and future development of technologies that indicate the potential growth of emerging technology; from the articulation and perception emerging from the demand side
Market Formation	This function is analysed by number of niche markets out of market size, number of lead users, customer groups and specific incentives that can improve the chances for new specific technology
Resource Mobilisation	This function is analysed by detecting whether or not construction actors perceive access to sufficient resources as problematic, the changes in volume of human resources, and also changes in complementary assets in IBS construction
Legitimisation Mechanisms	This function involves analysis of the interest group's growth that could be expected to engage in the emerging technology that may increase this legitimacy

DATA COLLECTION AND DATA ANALYSIS

In order to map the system functions of IBS development in Malaysian housing from 1963 to 2010, the data was collected from archive data and verified in the interviews. The archive data was mainly taken from publicly available documentation. It included official reports produced by public entities, case studies, press releases, academic reports and information from other sources, such as websites. Later, the interviews were conducted with key actors in the IBS technological system in Malaysia. Respondents are believed to be the most experienced on IBS development and have played an essential role in the effort to bring all the IBS related issues in a framework in Malaysia. Thirty one interviews were conducted with respondents falling into the following categories: government head of department, company director, project manager, architect, engineer, quantity surveyor and researcher.

From the data collected, the data was grouped and stored in the database according to time and the System Functions classification. To build functional patterns, the indicators for each function were similarly weighted. Some of the indicators had positive contributions to the development of the technology while others had negative contributions, such as negative perception of the innovation. Each indicator was counted and distinguished with either positive or negative scores.

RESULTS

From the data collected, the functional fulfilment of IBS development in housing construction in Malaysia from 1963 to 2010 was examined. By analysing the functional pattern of IBS's innovation system, it will explain the IBS development pattern in Malaysia.

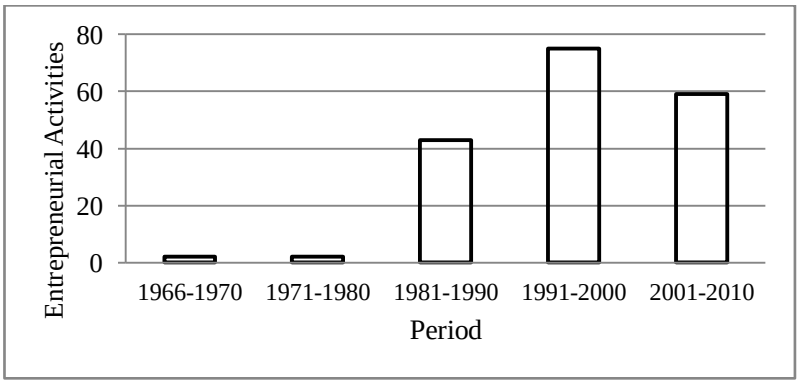

Figure 1: Movement pattern of System Function 1: Entrepreneurial Activities

At the beginning of the period 1964-1975, there were entrepreneurial activities via market formation for IBS housing projects by the Ministry of Local Government and Housing (Figure 1 and Figure 5). These projects were influenced by the direction of search (Figure 4). Later, the inability to achieve the expectation in the direction of search after the completion of the projects had lead to negative perspectives on IBS (Figure 4). Unorganized entrepreneurial activities and lack of support that favour IBS more than the existing system had let down the direction of search. Therefore, there was no correlation between the functions. This failed to lead to the build-up of a virtuous cycle among functions that are needed to propel this emerging method of construction in Malaysia as the functions were not fulfilled.

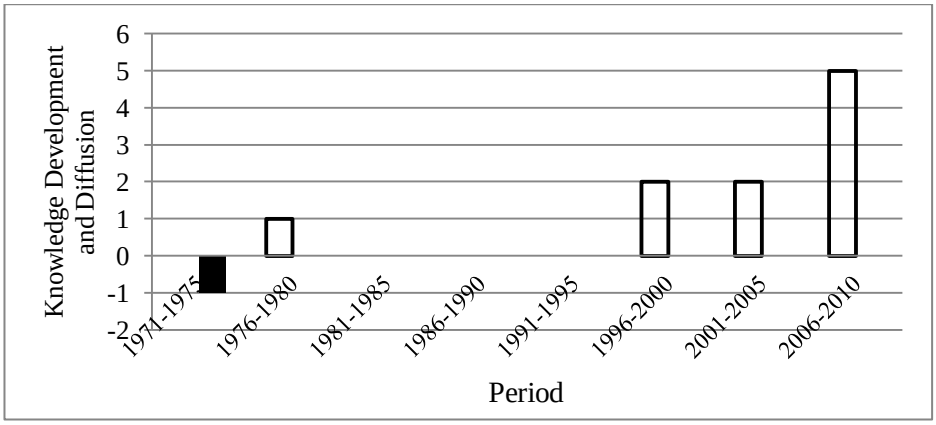

Figure 2: Movement pattern of System Function 2: Knowledge Development and Diffusion

Between 1978 to 1989 the cycle of system function identified started with knowledge development and diffusion activities (Figure 2) and positive externalities development (Figure 3) which later lead to entrepreneurial activities (Figure 1). However, the acceleration of entrepreneurial activity did not take place widely. An explanation for this can be found in the small market formation (Figure 5, i.e. IBS was applied for only low-cost housing projects) and with the limited positive expectation on IBS (Figure 4, i.e. to lower the construction cost). Furthermore, the fixed ceiling price requirement for low-cost housing was too low to be fulfilled by IBS as the technology suffers from a poor price to performance ratio and uncertainties exist in many

dimensions of the system. In conclusion, during this period, there were interactions between the system functions, i.e. direction of search, entrepreneurial activity and knowledge development and diffusion, compared to the earlier period, but the strength of the collective functions was not enough for a breakthrough.

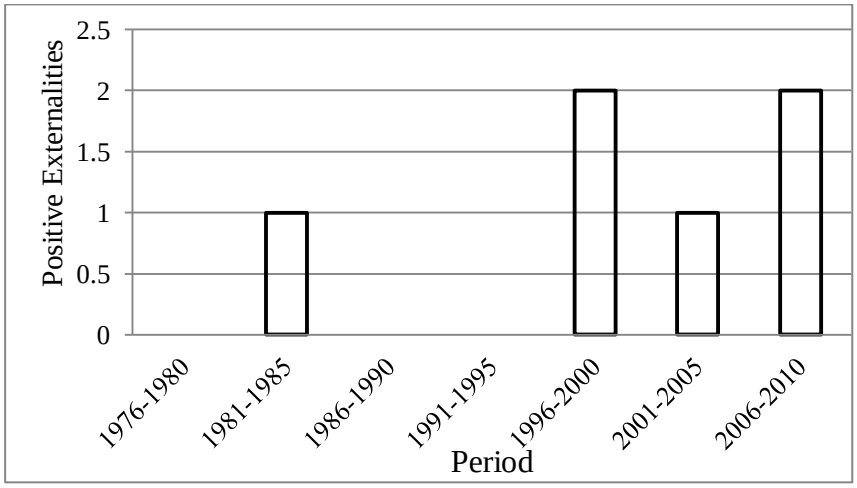

Figure 3: Movement pattern of System Function 3: Positive Externalities Development

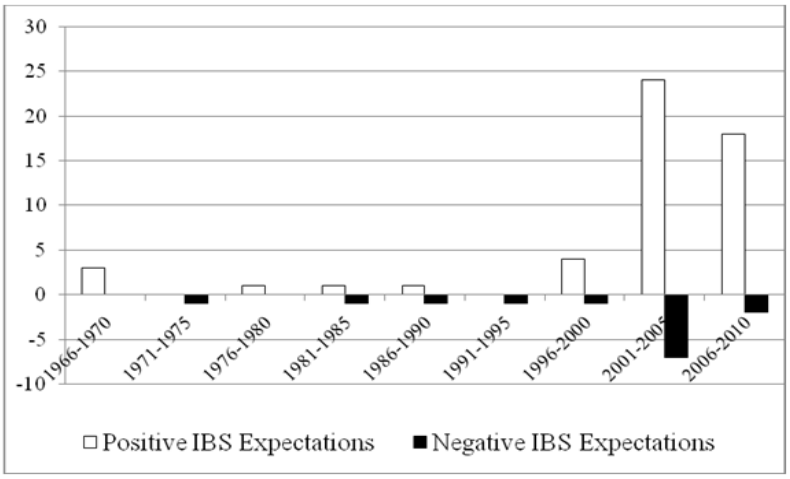

Figure 4: Movement pattern of System Function 4: Direction of Search

In the early 1990s, the entrepreneurial activities were identified. These activities were influenced by the government direction of search to provide houses for every Malaysia and the positive expectations on the IBS. The application of IBS in the construction of sports facilities for the Commonwealth Games in 1998 contributed to positive externalities development (Figure 3) as it gave impact to IBS in housing construction in Malaysia (Figure 1). It also lead to knowledge development and diffusion (Figure 2) where there was interests for research activities related to the production of cheaper building materials and techniques, particularly in IBS. However, the positive IBS development in housing construction in Malaysia was blocked due to the economic downturn at the end of 1990s (Figure 3). To conclude, the negative externality had blocked the dynamics of the other functions such as direction of searching for knowledge development and diffusion, entrepreneurial activities and market formation which favour the IBS development over the existing system during the early of this period.

Figure 5: Movement pattern of System Function 5: Market Formation

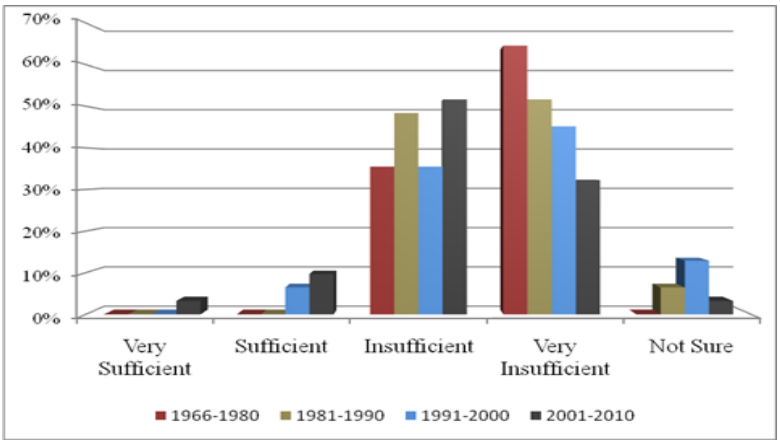

Figure 6: Movement pattern of System Function 6: Resource Mobilisation

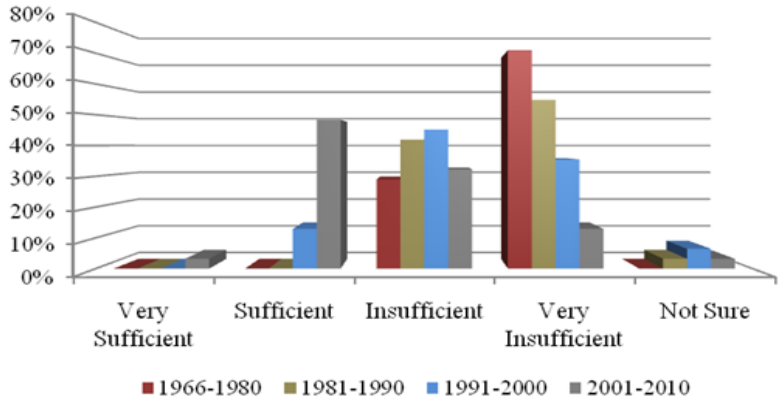

Figure 7: Movement pattern of System Function 7: Legitimisation Mechanisms

Since the beginning of 2000, there has been various functions fulfilment on IBS's innovation system in Malaysia. With the influence from direction of search, the government saw great opportunities to promote IBS in Malaysia (Legitimisation by government). In addition, the knowledge development and diffusion (Figure 2) activities have also strengthened the government decision to adopt IBS in all public projects which are valued above RM10 millions starting from 2008 (Figure 7). It has influenced the entrepreneurial activities (Figure 1) through market formation (Figure 5) for IBS in public projects. However, the lack of resource mobilisation on IBS has affected the entrepreneurial activities and direction of search for IBS to break through the existing practices. In summary, this period can be considered as a more positive period for IBS as compared to other periods. However, the weakness in the technological resources mobilisation has failed to create the dynamic interaction between the overall system functions of IBS in Malaysia.

DISCUSSION

The chronological description of IBS development in Malaysia housing construction can be summarised in the functional patterns which are:

Entrepreneurial activities– a few construction firms, such as contractor, consultant and developers have adopted IBS in their housing projects;

Knowledge development and diffusion – several IBS housing projects and training on IBS which are mostly organised by the public sector;

Positive externalities development – the application of IBS in all public projects;

Direction of search – government R&D funding, positive expectation on IBS market;

Market formation – two pilot projects, allocation of number of IBS houses, all public project, albeit fragmented;

Resource mobilisation – Government projects funding, poor adjustment by the higher educational sector.

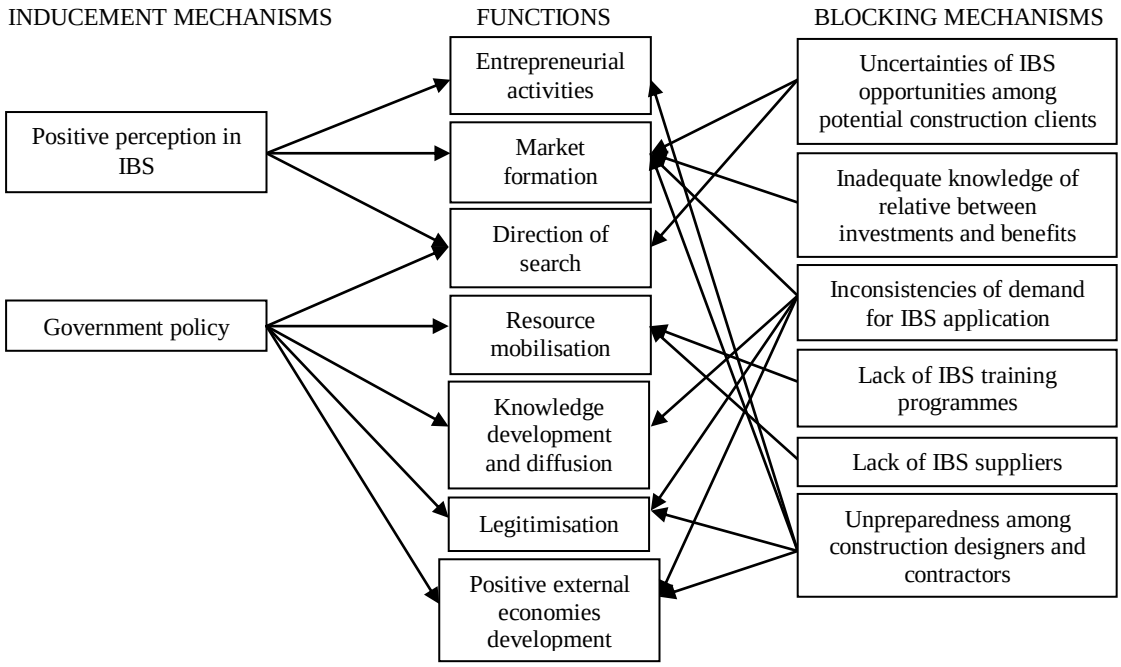

Figure 8: Inducement and blocking mechanisms

Figure 8 indicates that the current functional pattern is shaped by both inducement and blocking mechanisms. There are two significant inducement mechanisms, i.e. positive perception in IBS and government policy. The former is driven by a range of factors, such as IBS in public projects allocation and emerging IBS technological opportunities. This inducement mechanism has influenced the function 'direction of search', 'entrepreneurial activities' and 'positive external economies development'. The latter inducement mechanism strengthens the functional dynamics of 'direction of search', 'resource mobilisation', 'knowledge development and diffusion' and 'legitimisation'. Indirectly, the government policy on IBS has also created market formation and strengthens 'entrepreneurial activities' as a consequence of its positive influence on the system.

The blocking mechanisms are, however, strong and diverse. 'Market formation' is blocked by poor awareness among potential construction clients which leads to inconsistencies of demand for IBS application, unpreparedness among construction designers and contractors, and inadequate knowledge of relative between investments and benefits. Additionally, 'entrepreneurial activities', 'direction of search', 'resource mobilisation', 'negative external economies development' and 'legitimisation', are

each blocked by two mechanisms. These five functions have a common blocking mechanism in the form of a lack of consistencies of IBS demand. This is strengthened by additional but different mechanism in each function.

Some mechanisms block several functions. Moreover, functions are not independent, but rather tend to reinforce each other. A lack of 'market formation' affects negatively on 'entrepreneurial activities', 'direction of search' and 'legitimisation'. This portrays that the impact of blocking mechanisms is magnified by such interdependencies.

CONCLUSIONS

This study investigated the functional patterns of technological innovation system to create insight on the IBS trajectory in Malaysian housing construction. From the findings, the inducement and blocking mechanisms of IBS trajectory in Malaysian housing construction from 1963 to 2010 were identified. The inducement mechanisms identified are: positive perception in IBS and government policy on IBS development. Meanwhile, the blocking mechanisms identified are: uncertainties of IBS opportunities among potential construction clients, inadequate knowledge of ratio between investments and benefits, inconsistencies of demand for IBS application, lack of IBS suppliers, and unpreparedness among construction designers and contractors. Based on this trajectory, the blocking mechanisms identified are stronger vigorous and have decelerated IBS development in Malaysian housing projects. From this paper, the inducement and blocking mechanisms identified in the IBS development could be used as a guide for policy-makers in making better and wiser strategies when dealing with inducing and blocking mechanisms in IBS development. Reducing the strength of the blocking mechanism that have such an extensive effect may lead to a breakthrough for the existing system of construction in Malaysia.

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DISASTER MANAGEMENT

HOSPITAL FACILITY RESILIENCE: AN ADAPTATION FRAMEWORK FOR EXTREME WEATHER EVENTS

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The fragility of hospital built infrastructure to extreme weather events has been widely acknowledged. However, the way in which hospital stakeholders interact with their built environment during such events has not. To address this important but missing element in hospital resilience thinking, a content analysis of thirteen hospitals disaster planning documents is reported. Using resilience and learning theories, the role of built environment assets in disaster management planning strategies is discussed. A conceptual framework is proposed to help hospital stakeholders learn about and adapt to their built environment in response to extreme weather events. This framework provides new insights, both theoretical and practical, into the important role of hospital infrastructure to healthcare delivery during such events.

Keywords: extreme weather events, resilience, built environment, hospitals, organisational learning, content analysis

INTRODUCTION

Extreme weather events (EWEs) are becoming more prevalent (IPCC 2007, Steffen 2009). The demonstrated vulnerability of hospital built infrastructure to such events (Carthey 2010, Loosemore *et al.* 2010) and its recognised criticality for disaster response (Arboleda *et al.* 2009, Achour and Price 2010) highlights the urgent need for research into hospital facility resilience.

From a socio-ecological perspective, resilience is defined as: the ability to absorb disturbance while remaining in the same functional state, the potential for self-organisation and recovery, and the capability for learning and adaptation (Alliance 2007). While the capacity of hospital built infrastructure has been studied from a resilience perspective, the focus has been on the physical aspects of buildings (Bruneau & Reinhorn 2007, Cimellaro *et al.* 2010). The important behavioural dimension of how hospital stakeholders interact with their built environment has been neglected. To address this important issue, the aim of this paper is to explore the extent to which hospital stakeholders see their buildings as a key resource in dealing with an EWE. A conceptual framework is developed to provide new insights into the

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Chand A.M and Loosemore M (2012) Hospital facility resilience: an adaptation framework for extreme weather events *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 101-110.

process by which hospital stakeholders learn about and adapt to their built environment in response to such events.

HOSPITAL FACILITY RESILIENCE

Holling (1996) distinguished between two fundamentally different perspectives of resilience - engineering resilience and ecological resilience. Engineering resilience is the return time to a stable state after a disturbance where the return time determines the measure of stability. Alternatively, ecological resilience is the magnitude of disturbance that can be absorbed before the system redefines its structure by changing the variables and processes that control behaviour. McDaniels *et al.* (2008) summarised the distinction between these two perspectives as: 1) stability and speed of its return, and 2) instability and the tendency to change into new states.

Emerging out of research in this area, the concept of the adaptive cycle has been developed around system dynamics to show how the socio-ecological system changes over time (Folke *et al.* 2002, Holling *et al.* 2002). In this adaptive cycle (Figure 1) there are four phases that illustrate the continuous processes of rapid growth, conservation, release and reorganisation of a system. Rapid growth (r) occurs following a recent disturbance and enters into a mature or stable state (K) with the build-up of resources. These stored resources are released when faced with a disturbance (Ω) and the system begins to reorganise (α) with the newly available resources. This adaptive cycle can be used to provide new insights into how hospitals can become resilient to EWEs. For example, following an EWE more reliable information about the EWEs and the hospital infrastructure vulnerabilities become available. These provide new adaptation options for more informed planning and policy change (r). As hospital stakeholder confidence over their level of preparedness or reliance on their planning structure grows, this in turn increases their rigidity to planning (K). Thus when faced with an EWE rigid plans compromise hospital service delivery (Ω). According to this theory, hospital stakeholders learn from this experience which generates new ideas and information to improve hospital facility resilience to EWEs. In addition the lessons learnt encourage the reorganisation of disaster planning structures and processes to promote greater adaptability of the hospital to EWEs (α).

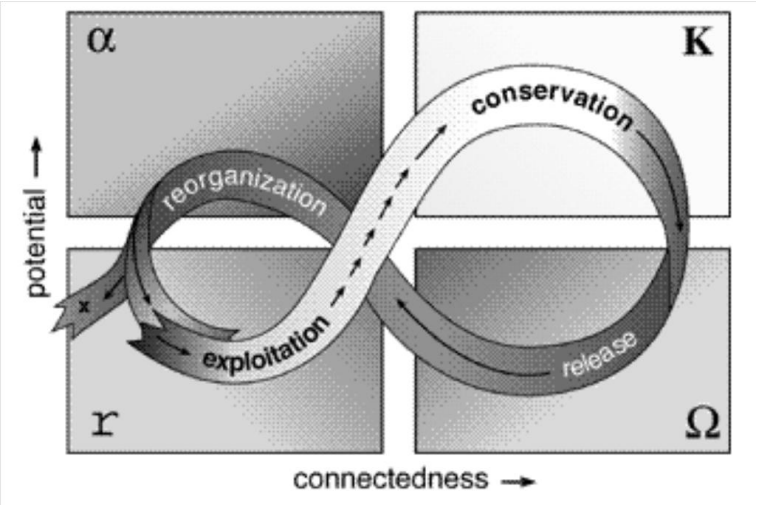

Figure 1: The adaptive cycle (Source: (Gunderson & Holling, 2002)

We argue that the 'learning' aspect of resilience is missing in dealing with hospital building vulnerability to EWEs. It is unclear whether hospitals encourage learning

about the way built facilities perform during disasters. Nor is it clear how the lessons learnt are internalised into revised and improved facility strategies and plans. According to Department of Energy (2004), there is a lack of focus on hospital BE issues during EWEs. This means that hospital stakeholders are unlikely to appreciate the important role of hospital infrastructure to their performance in healthcare delivery in the face of disasters. The inability to see the importance of BE in disaster planning and recovery raises important and as yet unresolved questions about learning in the hospital setting.

HOSPITAL RESILIENCE LEARNING

According to Argyris and Schon (1996) organisational learning outcomes are reflected in the behavioural change in light of the newly acquired knowledge that dictates adaptation to the changing environment. In a hospital context, behavioural change can be related to the changes in disaster management plans and disaster response, as hospital staff acquire new knowledge about EWEs and built infrastructure. Nonaka and Takeuchi's (1995) model of organisational knowledge creation (SECI Model) helps to explain how the transfer and accumulation of tacit and explicit knowledge in hospitals occurs which informs policy. The process of organisational learning requires transferring and capturing individual tacit knowledge to be embedded in organisations memory and structure (Kim 1993, Nonaka and Nishiguchi 2001). Tacit knowledge is highly personal information and personal skills in performing the task and hard to formalise or communicate (Nonaka, 1994). Tacit knowledge also includes subjective insights, intuitions, deeply rooted in actions, values and emotions that dwell in the comprehensive cognisance of human mind and body (Nonaka *et al.* 2000). In a hospital, the process of learning is characterised by the transfer of individual tacit knowledge to explicit knowledge. However, as Fong (2003) noted, the transfer of knowledge requires interaction amongst hospital stakeholders such as sharing their individual past experiences, knowledge and skills.

When theories of resilience represented in the adaptive cycle are combined with learning theory it is possible to propose a new conceptual framework called the Hospital Resilience Learning Cycle (HRLC) (Figure 2) which can help in better understanding hospital resilience to EWEs.

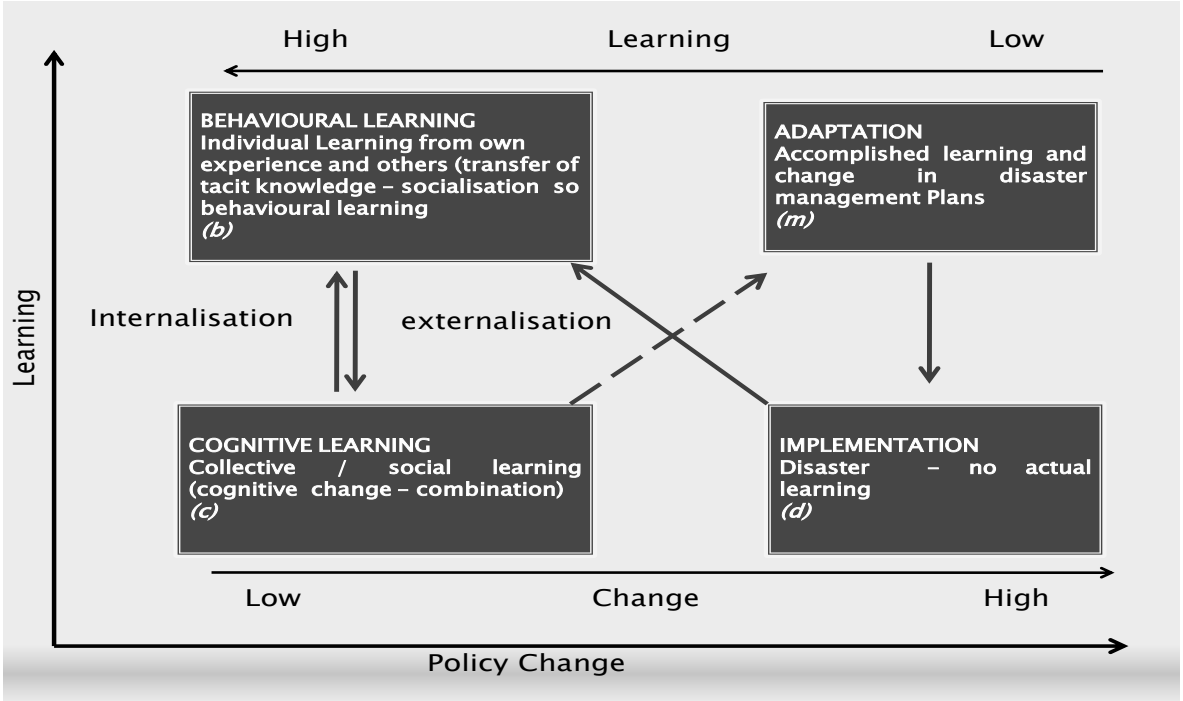

Figure 2: Hospital Resilience Learning Cycle (Source: Authors)

As in the adaptive cycle, the HRLC model also has four phases: adaptation, implementation, behavioural learning and cognitive learning. The first phase is “m” or adaptation, where “m” refers to organisational memory related to policy developed pre-disaster. This phase is called the adaptation phase as adaptation equates to policy change. The second phase is implementation or “d” where “d” refers to disturbance. During this phase, the hospital either faces an actual disaster or conducts a disaster drill that requires exercising the disaster plans. This phase is critical as it not only tests the hospital's disaster preparedness, but also provides fundamental lessons in a real life context. Behavioural learning, or third phase “b”, facilitates accumulation of fundamental internal knowledge that may inform the immediate actions of hospital staff, but may not cause any policy change. This phase indicates that the transfer of tacit knowledge amongst individuals or socialisation results in behavioural learning (Nonaka and Takeuchi 1995).

The third and fourth phases of the HRLC model summarise the knowledge creation process where the flow of knowledge between internal and external stakeholders is continuous. While phase “b” is confined to internal hospital staff and the environment, phase “c” illustrates the externalisation of tacit knowledge to explicit knowledge. This includes external hospital stakeholders such as utility service providers. Consequently, collective learning results in the combination of tacit and explicit knowledge and internalisation of explicit knowledge. The fourth phase is cognitive learning (“c”) which equates to transfer of explicit knowledge that is either internalised or informs policy change. It is important to note that the process of cognitive learning that informs policy planning is represented by a dashed line arrow. The dashed line illustrates that not all knowledge acquired will be reflected in the hospital policy due to barriers in learning. Barriers that hinder learning and hospital facility resilience will be investigated in the next phase of in the research.

Three main issues surface from this conceptual framework: 1) whether existing disaster management plans value the role of hospital infrastructure in providing service delivery, 2) whether the process of learning amongst internal and external

stakeholders that inform hospital disaster planning actually occurs and what barriers influence the collective decision making process, and 3) whether the lessons learnt post disaster are used to review the disaster plans. The remainder of this paper presents findings relating to the first question.

METHODOLOGYAND METHOD

This research is about learning in real-life organisational settings where meaningful learning and knowledge is socially constructed. As such, the research follows a constructivist ontology and qualitative epistemological approach. Within the qualitative framework, constructionism and interpretivism provide an appropriate theoretical and philosophical orientation for the research methodology.

It is important to point out that this paper presents the first stage of a larger ongoing research project. Out method employed a thematic content analysis of disaster plans and supporting plans across thirteen hospitals in New South Wales (NSW). The sample of hospital's that were affected during past EWEs was selected. Another criterion for the sample selection was the significance of the hospital's service delivery in its local area during disasters. The criterion for evaluating the hospital disaster plans and supplementary documents was based on Markus's BPRU model (Markus *et al.* 1972). The BPRU conceptual framework illustrates the relationship between people and the environment they occupy. It also indicates how different elements of the 'built environment system' relate to each other. For instance, the treatment of disaster patients (activity) by hospital staff in an environment (environment) with specific needs and this environment is sustained by the built form (building). The objective (objective) is to ensure that all disaster patients are treated. These four systems determined the coding themes for thematic content analysis of the disaster plans using NVivo software. The use of NVivo software allowed a thorough analysis of each document enabling frequency counts of key terms and facilitated analysis of surface (manifest) and underlying (latent) meanings (Babbie 2007). NVivo software allowed searching for the synonyms and stemmed words of the individual variable of interest. The findings of the analysis are discussed below.

DISCUSSION OF RESULTS

Hospital disaster responses manifest in their disaster plans. Hence it can be argued that failure to recognise BE issues in the disaster plans indicate that those issues are not dealt with in the hospital's disaster response. In addition hospitals also prepare supplementary plans such as business continuity plans or critical operations standing operating procedures (COSOPs) that provide specific guidance and direction for disaster response actions. In contrast, disaster plans are more general document that set out the roles and responsibilities and overall objectives of the organisation. Hence both plans were reviewed to determine their extent of focus on building issues in dealing with disasters. Figure 3 presents the coded reference for all plans according to the four themes.

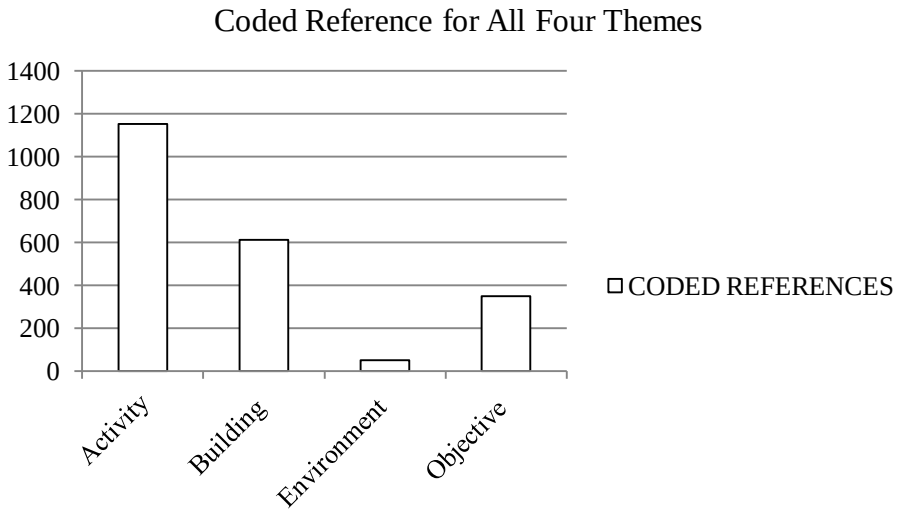

Figure 3: Coded reference for all four themes

The high coded reference for the activity theme indicates that both Disaster and Supplementary plans mainly focus on actions and responses in the face of disasters. To distinguish between Disaster and Supplementary plans, the coded reference for each theme was plotted (Figure 4).

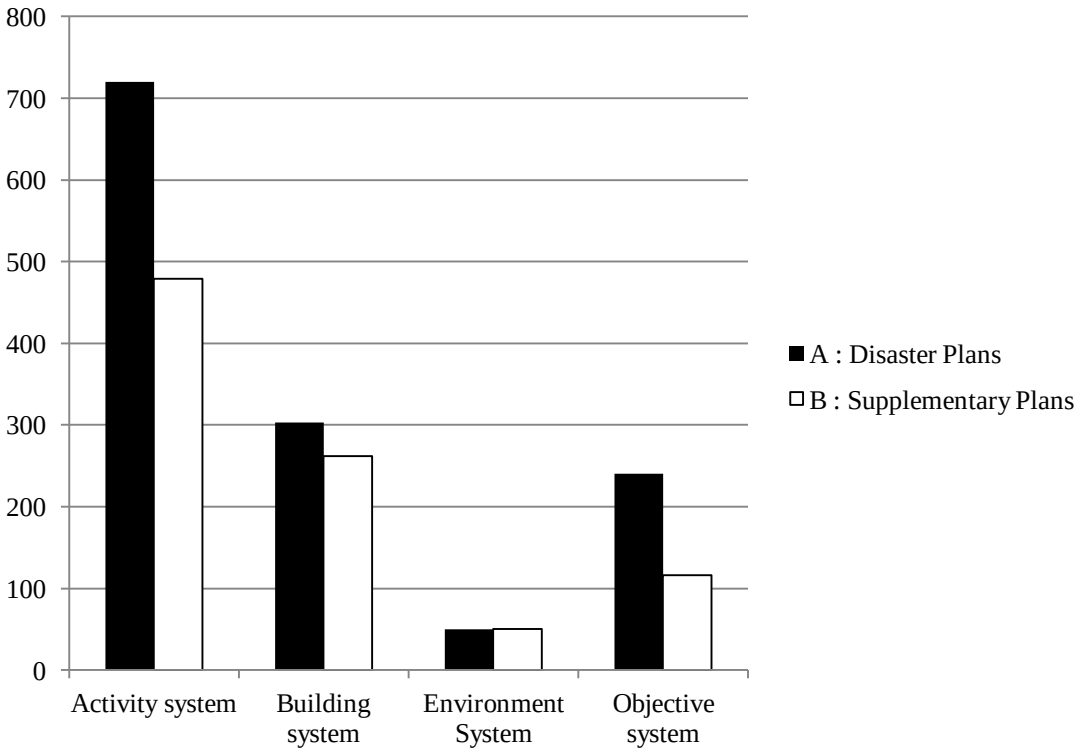

Figure 4: Coding Themes by Source (Disaster Plans and Supplementary Plans)

Figure 4 illustrates that disaster plans have greater emphasis on three themes: activity, building and objective. This result is not surprising as disaster plans are much larger documents compared to supplementary plans. Moreover, as noted earlier, the scope of disaster plans to coordinate disaster response activities is reflected by the high coded reference for activity and objective themes. The little difference between the two

documents for building theme indicates that the focus on building theme in supplementary plans is more significant compared to disaster plans.

The building theme had the second most coded reference in both disaster and supplementary plans. To determine the focus on built aspect, the coded references for building theme was further categorised according to three building sub themes: construction, content and services. Construction relates to all built aspect such as building damaged, repairs, failure of its content and services. Content describes all the hospital facility content such as furniture and fitting that include surgical equipment; beds; diagnostic equipment, alarms and telecommunication systems. Service relates to all the services that the hospital facility depends on such as power, water and sewerage services. Table 1 below shows the coded reference for building sub-theme.

Table 1: Codes reference for building theme

Building Theme	Coded reference	Coded percentage (%)
Construction	157	27
Content	318	54
Services	111	19

Table 1 data reveals the limited focus on construction issues such as the structural vulnerability to disasters in plans reviewed. To substantiate this finding, the building sub themes coded references were further separated according to the two different plans as illustrated in Figure 5.

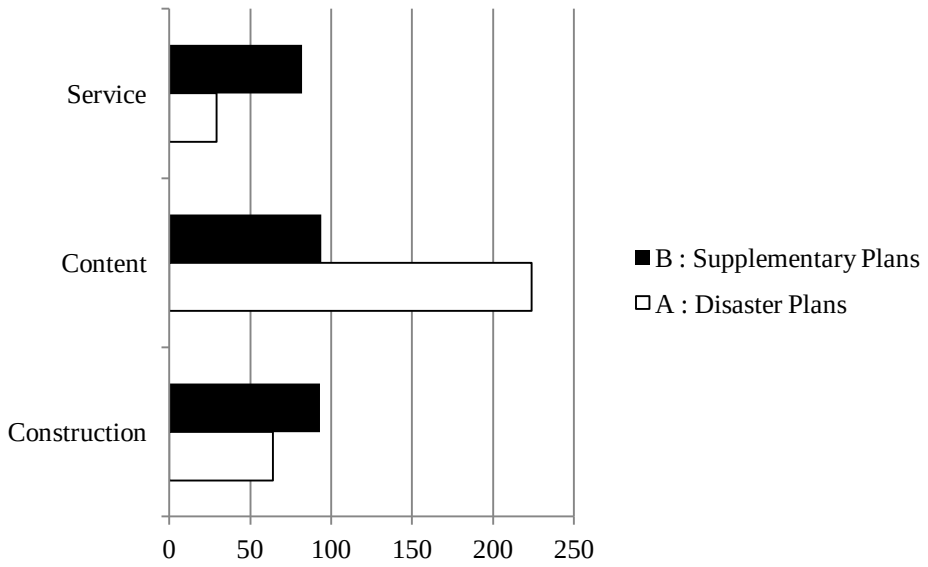

Figure 5: Building Sub-themes by Source (disaster plans & Supplementary plans)

Figure 5 shows that supplementary plans place equal emphasis on the three building sub themes. Whereas disaster plans main focus of on content sub theme indicates that hospitals are more concerned with assessing their immediate impacts and their ability to respond to disaster patients. We argue that the level of focus on building theme in particular the construction sub theme which relates to the hospital BE issues reflect the value placed on BE issues in hospital disaster planning. The extent to which hospital stakeholders value their building as a key resource in dealing with an EWE is minimum.

Finally, the coded references for building theme was plotted for hospital to determine the individual hospitals level of focus on building issues (Figure 6). Figure 6 shows the coded reference for building theme for each hospital.

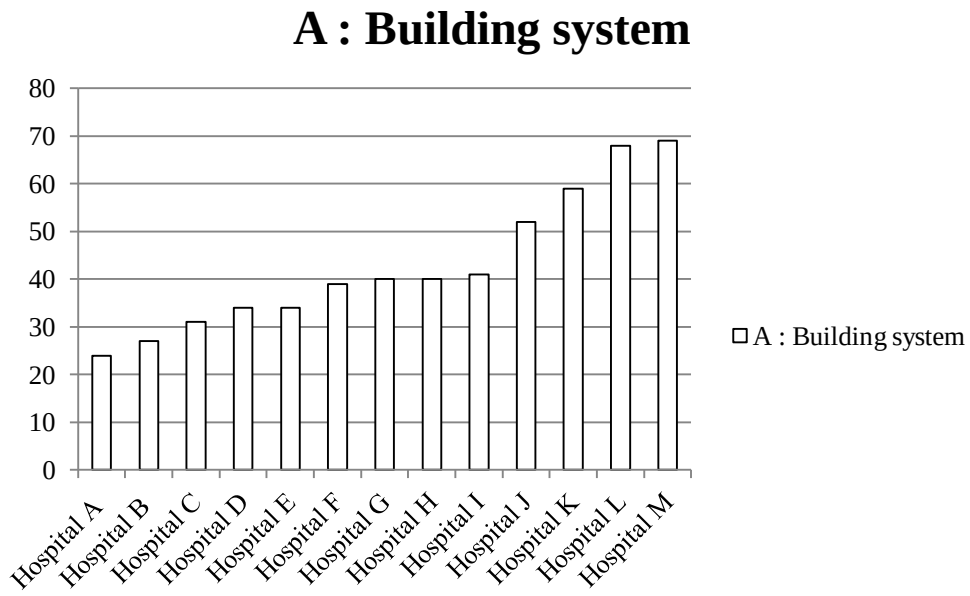

Figure 6: Building theme by hospitals

According to figure 6, the level of focus on building theme varies across all hospitals despite following a state template for disaster and supplementary plans. This difference indicates that each hospital scenario is distinct from one another due to their individual circumstances such as geographical location, local weather, and age of the hospital building. In addition organisations including hospitals place greater emphasis on issues that they are most concerned about. In this context, the low emphasis on building theme in some hospitals reflects their minimal focus on built environment related issues.

The limited focus on construction sub theme in disaster plans reflects hospital's lack of value of built infrastructure issue in their disaster response. This may be due to: 1) that there is no learning in regards to hospital built infrastructure vulnerability's to disasters, or 2) hospital stakeholders are unaware of the building influence in the performance of their service delivery during disasters. From the BPRU model perspective, this indicates that people fail to recognise the important link between building (building system) to their role in hospital service delivery during disasters (activity system). This means that hospital stakeholders are unlikely to appreciate the important role of hospital infrastructure to their performance in hospital service delivery in the face of disasters. In addition, one could argue that the limited focus may indicate that the hospital did not experience much BE related issues or that the facility is well maintained. However the selection of hospitals for thematic analysis was based on their past disaster experiences such as facility damage or disruption to their service delivery. Therefore the low emphasis on BE issues in disaster plans indicates the hospitals stakeholders' lack of understanding or awareness of the built infrastructure vulnerability's to EWEs.

CONCLUSIONS

The aim of this paper has been to present a conceptual framework, based on resilience and learning theories, that indicates how hospital stakeholders learn and adapt their built environment to EWEs. The HRLC outlined three key issues. First, the level of focus on hospital BE issues in the disaster plans that reflects the hospital stakeholders' value of their building in dealing with an EWE. Second, learning amongst hospitals stakeholders and third, how the lessons learnt amongst hospital stakeholders informs adaptation. The specific focus of this paper was to explore the first issue that is the value of built environment in hospital disaster planning using a thematic content analysis of disaster plans and supplementary plans. Using a sample of thirteen hospitals in NSW, the above results illustrate that there is a limited focus on construction issues such as structural damage to the building, or blocked main access to transport patient in both plans. Hospital facilities are one of the critical facilities that have to be operational during disasters. These findings indicate the general assumption that the hospital built infrastructure will be unaffected by the EWEs. Such assumptions reflect how people are unaware that the building influences their day to day activities and the overall performance of their workplace. Consequently, failure to recognise the significance of physical infrastructure of the facilities compromises disaster management planning.

This research highlights that the extent to which hospital stakeholders value their building as a key resource in dealing with an EWE is minimal. As EWEs are becoming more prevalent, the implication of this finding may provide hospital disaster planners the opportunity to rethink their focus on BE issues during disaster planning. Furthermore, it raises the need to investigate whether the hospital stakeholders' lack of value of their building is due to their limited understanding and lack of learning in hospitals. More importantly, the need to explore the process of disaster planning particularly how the lessons learnt from hospital's past disaster experience is internalised into revised and improved facility strategies and plans was recognised. These issues will be further investigated in the next phase of the research. However, suggestions for further research in other areas emerging out of these initial findings might include a resilience measure for learning regarding BE issues in organisations.

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IDENTIFYING THE ADDED-VALUE OF VARIOUS ROLES IN THE POST–DISASTER RESPONSE AND RECOVERY OF CHRISTCHURCH

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Structural and infrastructural damage from the Christchurch earthquakes of September 4th 2010, February 22nd, and June 13th 2011 resulted in necessary and extensive responses from various primarily publicly funded organizations and professional consultants. The multi-disciplinary management framework developed by Kestle (2009) for collaborative international projects was previously tested in scientific, humanitarian aid and post-disaster contexts in Darfur, Aceh, and Antarctica and found to be very effective in modeling and understanding the in-field and management issues related to the provision of aid in remote locations, and following natural disasters. In this paper, the authors extend the application of that framework to identify where value was added (both perceived and actual) by the various roles in the post-disaster response and recovery of Christchurch. Interviews were conducted with a range of operational and consultant participants, to collect data from a representative sample of the wide ranging aid and recovery population involved in the response and recovery post-disaster phases in Christchurch. The Kestle (2009) framework provided the vehicle to compare what was seen and experienced in the field with what may have been planned by management in the various organisations. The data analysis identified the main challenges of this particular disaster as a lack of a relevant management framework in the early recovery phase, gaps in knowledge, and protracted decision processes. The added-value by the various roles was also identified for future reference.

Keywords: added value, Christchurch , framework, management, post-disaster.

INTRODUCTION

The earthquakes that struck Christchurch on September 4th 2010, February 22nd 2011 and June 13th 2011, were unprecedented in their intensity and damage in New Zealand's recorded history. Christchurch is classified as a medium seismic hazard in the NZ Building Code, while Auckland (NZ's largest city) is a low seismic hazard. It was generally anticipated that a significant earthquake event would occur in

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Kestle L and Potangaroa R (2012) Identifying the added-value of various roles in the post–disaster response and recovery of Christchurch *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 111-121.

Wellington city (NZ's capital), which has a high seismic hazard classification. The Christchurch Press, (the local newspaper) in December 2011, stated that "This is seen as the biggest earthquake event ever, in an urban area, anywhere in the world". In early May 2012, The Christchurch Press reported that "Insurers have paid out $7.6 billion dollars in claims, $4.6 billion from private insurers and $3billion from the Earthquake Commission (NZ), but that claims will probably climb to $30 billion".

Civil Defence and Emergency Management (CDEM) plan and prepare for disasters (both natural and man-made), and quickly swung into action, when the February 22nd earthquake struck, supported by Urban Search and Rescue (USAR), and Land Search and Rescue (LANDSAR). The 'response and early recovery phases' were subsequently coordinated by Civil Defence and Emergency Management (CDEM), under a declared state of emergency that remained in place until 22nd April 2011, and then by the Canterbury Earthquake Recovery Authority (CERA), which was established by the Crown in April 2011, in conjunction with the CERA Act (2011).

What then was the contribution made by building professionals during those phases, and moreover what lessons can be drawn and reflected upon for future events? Previously published research work on the added-value of various roles by post-disaster personnel following natural disasters, appears to be scarce. Furthermore, there is an added dilemma that what people say they will do at times of disasters like these, can be quite different from what they actually do. Therefore this research was undertaken to identify how a selected group of participants in their various prescribed/official roles were involved on the post-disaster Christchurch earthquake scenarios, and what challenges they faced. Arguably, and more importantly, how did they prioritise, what processes did they adopt, how did they record and transfer what they learned, and how was decision-making effected in their various roles whilst dealing with the challenges, thereby adding value. The participants were drawn from the governmental, deconstruction, management and consultant sectors in particular. The Kestle (2009) multi-disciplinary management framework was used as a vehicle to establish how well that framework involving four key factors, represented the actual experiences of the selected participants' in the field during the response and recovery stages of the three significant earthquake events in Christchurch, from September 2010 till June 2011.

SELECTED LITERATURE REVIEW

Only a selection of the reviewed and analysed literature, undertaken in the development of the Kestle (2009) framework is included here for the purpose of addressing the added-value focus of this paper. Case-study methodology and grounded theory were adopted given their relevance to the research approach during the initial development stages of the multi-disciplinary management framework. Grounded theory was originally developed by Glaser & Strauss (1967), as a qualitative research method, and was later described by Glaser (1978) and (Strauss and Corbin 1994), as "being important as a process for developing a researcher’s conceptual insights by working in the actual area being researched to obtain experience and expertise", and then "being able to recognise important data and formulate conceptually dense theory”. Research published by Kestle (2009) referred to adding-value, and that the integration of a team with knowledge contributing to planning, design, construction and management, was critical to developing and achieving value on projects for the client and stakeholders. Haigh *et al.* (2006), who are leading researchers in the disaster management area further underpinned the

research on the added-value of various roles and responsibilities on the post-disaster response and recovery phases of the Christchurch project. Haigh *et al.*(2006) stated that "there was ‘a lack of effective information and knowledge dissemination and unsatisfactory management and performance levels and processes in current disaster management practices". Researchers Salvatierra *et al.*(2010), recently noted that the concept of value varies across time, is context dependent, is relative/comparative, and very subjective, and tends to be restricted to just achieving value for end-users and clients, rather than society as a whole. Salvatierra *et al.*(2010), also referred to research by Ballard (2006) who was working on a model of project definition with a value generation perspective. This gives importance to the stakeholders ‘perspective of value'. Development of the ‘Target Value Design model' is ongoing. Stakeholders involvement is considered a key element in generating value, therefore it is important to underline the contribution of Emmitt *et al.* (2005), where the concept of value was divided into 'external value', which is the client/customer value, and the value that the project should end up with, and 'internal value' achieved by and between the delivery team’.

METHODOLOGY

The research used a conceptual multi-disciplinary management model developed earlier by Kestle (2009). That model, now used as a management framework, was originally developed in terms of reviewing and synthesizing theoretical published ‘production principles’ and ‘sociological factors’ associated with design management, and lean design management, having it’s theoretical basis in Just in Time (JIT), Total Quality Management (TQM) and Lean Production theories. The Kestle (2009) framework aimed to reflect the experiences of stakeholders participating in an added-value process on collaboratively managed projects such as developing a shared understanding of what is valued on the project and identifying, and agreeing the objectives for a project with the stakeholders. The Kestle framework has already been applied across a range of differing multi-disciplinary collaborative scientific (Antarctic), humanitarian aid (Darfur), post-disaster projects (Banda Aceh, Pakistan), and found to accurately model the in-the-field experiences of the selected participants. The key factors of the Kestle (2009) multi-disciplinary management framework were established as being, ‘value generation’, ‘knowledge integration’, ‘process integration’ and ‘timely decision making’, and these are discussed briefly below for clarity.

'Value Generation' - refers to the value that the client and stakeholders place on the project outcomes, and will vary according to the differing clients’ and stakeholders’ expectations of the projects, and these can vary not only between stakeholders but also between client groups.

'Knowledge Integration' - is concerned with capturing and integrating the specialist knowledge of all those personnel involved on a particular project, prior to and during the project phases. This suggests that key personnel be involved with any pre-briefing, pre-planning, and in the regular monitoring and review of the planning and operational stages, as the project progresses. Specialist knowledge is required to ensure the best solutions and results, despite frequently working with non-negotiable timelines.

'Process Integration'- involves the timely and cost-effective co-ordination and planning of a range of processes across the total project, such as planning methodology, logistics, information management, and the management of design/

production interface Logistical planning and implementation is complex, as well as critical in post-disaster response and recovery coordination.

'Timely Decision Making'- refers in the main to financial and design decisions, which are critical to the successful management of collaborative international projects. These decisions are made within the context of frequently non-negotiable windows of buildability timeframes (or deconstructability in the case of Christchurch), fixed or controlled budgetary constraints, and/or health and safety concerns.

INTERVIEWS

Participant selection for this research was made on the basis of the participants' roles and disciplines, and were to be representative of the wide ranging aid and recovery population involved in the response and recovery post-disaster phases in Christchurch. The participants represented design consultants, various project and waste management consultants, demolition (deconstruction) contractors, property managers, and voluntary civil defence personnel. The eight participants personally played a management role, or were key players in the various response and recovery teams. The aim of the participant selection and subsequent semi-structured interviews with them, was to try and establish the participants' perceptions and the realities of their first-hand experiences in-the-field.

Figure 1, visually describes the basic roles and responsibilities of the various sectors of the response and recovery phases in post-disaster Christchurch. Civil Defence coordinated the process at the emergency response phase, then under the early recovery phase, the Canterbury Earthquake Recovery Authority (CERA) was set up by the government to lead, and be the decision-makers, managers and coordinators of the recovery phase. Engineers were engaged immediately by CDEM to establish the accessibility of damaged or destroyed buildings, and then individual commercial property owners were required to engage their own engineers to establish the structural integrity of their buildings. Deconstructors were engaged by CDEM if a building was deemed on the verge of collapse, and if it was not, then the building owner could question such a finding. This work continued once CERA was established. However, property owners were drawn into several areas where building professionals would usually be expected to operate, and this is shown in Figure 1 below. The property owners or building managers therefore had a relationship with every sector, whether Health and Safety, Financial, Physical damage or Legal. The selected participants were either representative of each of the four sectors in Figure 1 below, or were able to respond to the interview questions related to the four sectors.

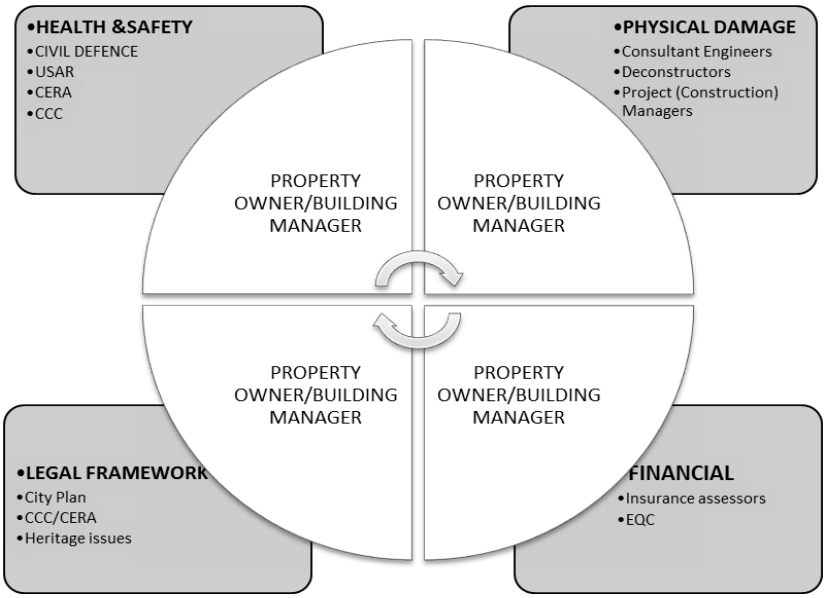

Figure 1.Basic map of the relationships and responsibilities at the Response and Recovery Phases in post-disaster Christchurch.

Semi-structured interviews were conducted with the selected participants over a four month period, in late 2011/ early 2012, and this perhaps allowed participants to reflect on their experiences. The interview questions were directly related to the participants' roles during the response and recovery phases in Christchurch, and to the four key factors of the Kestle (2009) framework. The collected data were clustered using a contextual spreadsheet under these factors, and patterns and themes extracted. These are reported later in the paper with additional commentaries contextually included.

RESULTS/FINDINGS

The results were generally consistent across the selected participants, though some of the respondents appeared to have more autonomy than others. All were faced with slightly differing challenges, for example in terms of whether pre-planning was occurred. According to the participants, there was an overall lack of relevant management guidelines, a lack of timely, and at times untimely decision-making processes, and for some, a lack of health and safety procedures at their organisations. In some instances relevant systems and processes have had to be created 'from scratch'. The scale and ongoing impacts of the 3 major earthquakes and 10000 aftershocks (since September 4 2010) were, and are unprecedented in New Zealand 's history. The participants noted that the emergency response phase was controlled and run by Civil Defence, with Urban Search and Rescue teams (USAR), but then came the recovery phase, and none of the interviewed participants (nor their organisations) had any previous New Zealand benchmarks to work to, for a natural disaster on this scale. This was all new. The selected participants either drafted up, or worked to newly created protocols and guideline procedures whilst at times making decisions 'on the hoof', as plans were formulated for the recovery stage. The eight selected participants interviewed, supported the Kestle (2009) multi-disciplinary management framework, as being representative of their experiences on projects such as the post-disaster response and recovery project in Christchurch, and the following key findings were extracted from the collected data, under the framework's 'factor headings'.

Value Generation

- The clients and stakeholder property owners main concern (and hence value to them) was when, and whether and how they could gain safe access to their buildings, and their data/paperwork/equipment so that their businesses could continue in some form somewhere in the city.
- 'Rules of thumb' for the demolition contractors were not specifically documented, but at the very early stages of response where it was strictly about safety, and dealing with the dangerous buildings first, those 'rules' ranged from 'a floor a week to tear it down, a floor a week to strip it out, deal with the dangerous ones first, then the significant ones (over 5 storeys), and what was the safest and most effective equipment to use', to preparing much more detailed and specific deconstruction plan for each (and often unique) building.
- Using any form of 'rules of thumb' for a project management participant was seen as too risky, and instead they always used agreed protocols and formal guidelines for every job undertaken so as not to put their business, or their clients at risk.
- Feedback from clients/stakeholders was sought and received by all of the participants interviewed, either via weekly meetings with the relevant players (for example, property owners, local government representatives, and consultants), or directly via email from the clients, or via council call centres, or at times feedback was received via the media, with no right of reply.
- Accountability proved to be either easy to answer, or difficult to answer, according to the participants' specific roles. The majority acknowledged and identified the contractual and statutory obligations they had to their clients, (whether commercial property owners, tenants, individual property owners), and to council representatives, their larger community, and to the society in which they worked. A management participant identified that their organisation spent "a deal of time on the pre-planning to minimise risk once the job commenced, and that the guidelines and protocols setup subsequent to the September 4th earthquake, acted as a valuable test-run for the February 22nd and June 13th earthquakes that followed".

Knowledge Integration

- Learnings from the post-disaster project were passed on by regular conversations with employees, or they became part of the organisation's core construction management, or engineering systems (called up as 'continual professional improvement'), or have been collated into formal review processes and passed on via training and restructuring. One example was that workers had to now personally come into the office to lodge the paperwork for completed jobs, get that signed off, before being allocated a new project. The workers were then fully briefed and updated on new and applicable systems to be followed, for the new job package.
- Learnings were also passed on through local and national professional seminars, briefings for 'owner pressure groups', and being open with the media to keep the public informed as well. Another participant noted that learnings could be passed on via education of upcoming peers, and in future publishable research papers.

- Learnings resulting regarding necessary changes to organisational structures, funding measures and legislative changes were not considered to be easy to implement in reality.
- According to the deconstructors, the Crown (and therefore Civil Defence) need to understand what has been done/implemented by the deconstruction parties and roll out a plan of what needs to be done in future natural disasters on this scale, and own that body of knowledge.
- One of the biggest gaps in specialist knowledge, was that the property owners/ property investors had no idea what risk was. They were blind to the reality of the resilience of their buildings, and in particular earthquake resilience.
- Not enough was known in terms of what knowledge was out there, or the number of people with 'knowledge'. No-one had been through this (response and recovery phases), on this scale before, and were feeling their way, even a year or so later.
- Initially, the engineering world acknowledged that they knew certain 'stuff' but probably not enough to respond and advise on a disaster of this intensity, and on this scale. For example, when measuring the structural integrity of a building, they were maybe only looking at the primary structure in the main, they would not look at the stair structure unless specifically briefed to do so by the client/other consultants.
- Another gap in specialist knowledge was identified by a participant regarding the need for more 'testing of reinforcing steel as it related to specific projects. It was noted that only a few engineering consultants have their own testing labs but others have to rely on generalist engineering testing labs' advice.
- There was a general sense amongst the participants that 'old rules and old ways of doing things' were being applied across the board even though this was a new situation, and the old ways did not fit, and only led to frustration with the process(es).
- In terms of 'responses to disasters' there is now a codified response structure, known as the Coordinated Incident Management Structure (CIMS), as Christchurch's disaster showed up big holes in terms of the 'currency' of the management plan, and the people's understanding of it in 'updates in classroom settings', and that in-the field practice is the best way to establish what does and does not work.
- Many of the consultant and management participants are eagerly awaiting the Report from the Royal Commission, new/amended Building Standards, and the geo- technical investigations to be completed.
- At the upcoming rebuild phase, design and build may not be the right answer for Christchurch going forward. A new form of procurement might be needed, and more appropriately called the 'Christchurch Procurement System'.

Process Integration

- In terms of methods and approaches employed to achieve their roles, the participants noted that at the emergency response stage, organisations had a reasonable idea of what their total capability was, but the biggest problem was communications, as all the emergency phones (police *et al.*) which they usually work with, were being used solely for 'victim identification work.
- Civil Defence coordinated the process at the emergency response phase, then under the recovery phase), the Canterbury Earthquake Recovery Authority (CERA), was set up by the government to lead, and be the decision-makers,

managers and coordinators of the recovery phase. The CERA Act 2011 was legislated and implemented in April 2011, and minor amendments made in September 2011. This Act will be in place till 2016, and reviewed annually until then.

- Property files have been created for every property, and these needed to be signed off by the National Controller at the emergency phase, and in the recovery phase by CERA.
- Communication skills were identified by all participants as paramount, noting the best approach as 'review, consult, briefing, question, verify, communicate, then start a review again'.
- In terms of what role HR might play in terms of training, the participants suggested that HR needs to get more multi-skilled generalists into senior management positions. Specialist managers are not well equipped to deal with unknown and unexpected events. Maybe move people between departments so they gain an awareness and understanding of other areas of the business, and how it all works.
- Pre-planning wherever practically possible, was undertaken and paid dividends when all section leaders met, and talked through the challenges and methodologies that best fitted the situation, before undertaking the task(s). According to the selected participants there was no pre-planning time available as it was 'all hands to the pumps' so to speak, job to do, right now.
- Best practice according to the participants would be to try and make sure that trained up teams of managers are ready to go, it is that follow up stuff, as it may not happen again, but people need to be ready. For example, according to one participant. Auckland and Wellington are both in the wrong place if a sizeable earthquake hit.

Timely Decision Making

- One of the participants noted that they were in the process of coming up with a framework that guides the decision-maker by offering 'indicators' . For example, people sometimes knew the decision needing to be made or the task(s) to be done, but they had no reference legislation, or written guides, or management tools, to support and defend the decisions they might make, leaving them vulnerable professionally.
- Decision-making at the recovery stage was centralised with CERA making the key decisions that affected the majority of the participants' operationally, and yet it was also decentralised in terms of the micro-decision-making required on a day to day, on-site or consultancy basis, with regard to what the management consultant participants could undertake or offer advice on.
- At the emergency response phase the National Controller (Civil Defence) authorised by the Crown, signed off on all decisions (they could in fact overrule any law in the land), and the Emergency Response Fund covered the costs of all decisions made (demolitions for example), as this stage was a State of Emergency (categorised as a Level 3 Military Emergency).
- In the recovery phase, the processes changed. Depending on what roles the participants held, they had differing arrangements in respect of who or which organisation was 'holding the purse strings'. Certain participants were and are paid through CERA (government agency) if deconstructors, or they are paid by the property owners, who get their monies from the insurance companies, if insured, (which means there is a typically client consultant relationship).

- Essentially the participants were agreed that budgets were primarily centralised through CERA, and/or heavily influenced by insurance companies' depending on the participants' roles and the nature of the recovery projects.
- Final accounts are a long way off, according to all of the participants.

Summary of selected 'Lessons Learned'

- Operational and management participants identified that if there was another significant earthquake event in another major town/city in New Zealand, there need to be clear 'rules of engagement', and what the Crown probably should or should not do. The participants suggested that there was a sizeable gap in time between USAR leaving and CERA being set up, commenting that they had to "hit the ground running" after the USAR teams did their job and 'up and left'.
- Property manager participants recommended keeping insurance cover relevant and premiums up to date, particularly if a commercial property owner, occupier/tenant..
- Log all jobs and allocated personnel onto a series of matrices and store them /update them in data bases using web-based software, rather than using 'whiteboards in the office', and always backup data files. The 'Cloud ' approach was supported by a few of the participants.
- Keep detailed records of all work undertaken, be micro-detailed so that the organisation /individual operator has a defensible position as needed.
- Keep tabs' on where staff in individual organisations are, (via texting/calling in every 2-4 hours if out on site).With the ongoing aftershocks it is essential to know which personnel are on which sites, and which jobs.
- The need for individuals and organisations to create 'disaster plans', that are practiced regularly and contain guidelines and tools/indicators to guide decisions, and processes and actions in the event of a significant natural disaster in an urban area.

The added-value of the various roles and responsibilities summarised

For added clarity and coherence, this section should be read in conjunction with Figure 1 that was referred to and included in the Interviews section of this paper. The client was the public- at-large initially, via Civil Defence during the emergency response phase. Then at the recovery phase the clients became the property owners, whether engaged via the usual client base of property owners and developers if design and construction project consultants, or via CERA if conducting waste management or deconstruction projects, generally speaking. Even then, some clients were property owners dealing directly with consultants once their insurance claims were approved. It should be noted that the EQC (Earthquake Commission) dealt with residential property owners' claims whereas CERA worked with insured commercial property owners.

The stand-out challenges, and where significant value was added by the various roles was in respect of process integration. For example, having to work from first principles in the creation of new, defensible and resilient office systems, that often included new Health and Safety provisions that applied to daily operations and out-of-office, on-site behaviours, new financial recovery modes, and organisational processes. This also included very different and untried deconstruction methods for high rise buildings in New Zealand. Centralised decision-making obviously had its

benefits and frustrations for everyone involved, whether property owners, deconstructors or engineering and waste management consultants, or project construction managers.

The next level of added-value, was the knowledge integration learnings gained and created in response to this 'first of this scale of natural disaster for New Zealand'. Property owners and building managers realised just how important keeping their commercial properties correctly insured will be in the future. A few property managers had already realised this, and advised their clients to be fully insured ready to evacuate, and have their business/office data backed up or running on web-based software. This definitely added value to their clients' businesses. The added-value of centralised and usually significant public safety decisions was that it offered uniformity and direction initially. The down-side was the protracted process timeframes that occurred when so many people had to be involved before decisions could be made. Fortunately, on-site decisions were often decentralised to allow common sense processes to prevail, according to the majority of the selected participants.

The added-value contributed by the various design consultants and project managers was the reassurance that relatively safe access could be gained by the property owners/ tenants to their business properties, and repairs initiated. Similarly, the added value of the deconstructors was in the innovative methods they employed on the classified 'dangerous', and then 'significant buildings over 5 storeys', (1400 commercial buildings have been cited for demolition/deconstruction in the city).The scope of the work was off-the-scale of previous experience, but it was a challenge they fervently and professionally undertook. This then was the value generated by them for Civil Defence initially and then for CERA.

CONCLUSIONS

The research undertaken aimed to identify how a selected group of participants in their various prescribed/official roles were involved on the post-disaster Christchurch earthquake phases, what challenges they faced, and how their efforts and/or management systems were coordinated. In addition, the research aimed to establish the ways in which the selected participants' might have added-value to the processes/ systems, and to the current outcomes, particularly from a management perspective. The Kestle (2009) multi-disciplinary management framework was the vehicle used to establish whether the framework modelled the experiences of a selection of participants from various sectors, ranging from civil defence volunteers, to engineering, waste and project management consultants, property managers and deconstruction contractors, who were directly involved on the response and recovery phases. Interestingly, there were common threads that emerged even though the participants were playing quite different, and at times disconnected roles from each other. Those threads were the frustrations with the lengthy time periods and processes to get access to their business premises/properties, decisions/approvals to proceed with deconstruction or repairs, and a lack of any central /accessible management framework, or guidelines at the early recovery phase in particular. The added-value of the various roles in terms of the objectives of this research paper were, for example, the creation of new, defensible and resilient office systems, that often included new Health and Safety provisions applied to daily operations, and out-of-office, on-site behaviours. New financial recovery modes, and organisational processes, including very different and previously untried deconstruction methods for high-rise buildings in

New Zealand were created and implemented. Property managers who had already advised their clients to be fully insured, ready to evacuate, and have their business/office data backed up, or running on web-based software definitely added value to their clients' businesses. Similarly the challenges faced by all of the selected participants involved at the response and recovery phases of this project, caused them to reflect on and acknowledge their added-value experiences, in terms of gaining and creating new knowledge on a personal and organisational level, and of being encouraged to be innovative and creative when responding to post-disaster challenges.

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BUILDING CAPABILITY FOR DISASTER RESILIENCE

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All levels of government recognise the widespread devastation of communities by natural or other disasters. They have responded with emergency management arrangements and policies to enhance government and community capacity to anticipate, withstand and recover from disastrous events. Although the construction industry has a significant role to play, particularly in recovery and reconstruction, it has not generally been considered as a key stakeholder in building capability for disaster resilience. One barrier to more active involvement of the construction industry in disaster response and management is that traditional methods of construction project management have been criticised as too time consuming and inflexible for use under circumstances of high uncertainty, requiring rapid response in complex multi-stakeholder environments. The 2011 Queensland floods represent one of the most disastrous extreme weather events of recent times. Using this event as a case study, this paper presents results of analysis of institutionalised discourse concerning structures, policies and procedures for disaster management, and official inquiry reports providing details of response and recovery activity. The aim of the research is to identify the positioning of project management in the disaster management discourse as a first step towards earlier and more proactive involvement by the construction industry and use of project management approaches that contribute to disaster resilience.

Keywords: project management, construction, disaster, response, resilience.

INTRODUCTION

In recent years the world has experienced a number of disastrous events both natural and man-made. The 2004 Indian Ocean Tsunami, and Hurricane Katrina in 2005 had far reaching consequences. In 2011, 185 people died as a result of an earthquake that severely damaged New Zealand's second-largest city, Christchurch. This event was closely followed by the earthquake and tsunami that devastated large areas of Japan. Disasters caused by extreme weather events including bushfires, floods, storms, and cyclones that have significant impacts on communities, the economy, infrastructure and the environment are regular occurrences in Australia. As a result, all levels of

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Australian government have developed emergency management arrangements and policies to enhance government and community capacity to anticipate, withstand and recover from disastrous events (National Emergency Management Committee, 2009). In response to the apparent frequency and inevitability of disastrous events such as the Black Saturday fires in Victoria, in 2009, and more recent widespread flooding in Queensland and other parts of Australia, there is a focus on development of community resilience.

It is generally recognised that disaster response and recovery is implemented through multiple projects, and it might be expected that project and program management capability would be an important contributor to disaster resilience.

The concept of project management is arguably best known in disaster management through the construction industry for which it is the primary management approach. However, traditional methods of project management, as used by the construction industry, have been criticised as too time consuming and inflexible for use under circumstances of high uncertainty, requiring rapid response in complex multi-stakeholder environments (Steinfort, 2010). Further, the involvement of the construction industry is primarily in recovery and extended reconstruction phases of disaster management, rather than in prevention, preparedness and response. It has been suggested that there is potential benefit in earlier involvement of the construction industry in the disaster management cycle (Bosher, Dainty, Carrillo, Glass, & Price, 2007).

The aim in this paper is to draw upon a specific case study to increase understanding of the treatment of project management in existing regulatory frameworks for disaster management as a basis for further research that would explore opportunities for increasing the role of project and program management in disaster management through innovation and development beyond traditional approaches.

LITERATURE REVIEW

Projects and project management

The term "project" is widely used and there is a general understanding that it implies a one-off endeavour or initiative as distinct to an on-going or repetitive task. Projects may be undertaken or managed in many ways but there are specific meanings for the term "project management" that have been developed first by communities of practitioners and since the 1980s by project management professional associations. Through these associations practitioners have worked to define distinct bodies of project management knowledge as the basis for standards and certification of project management knowledge and practice (for example PMI, 2008; International Project Management Association, 2006; APM, 2006; Australian Institute of Project Management, 2008).

These established understandings of project management are based on a linear and rational (Hodgson & Cicmil, 2006) and top down approach most suited to what are described by Crawford & Pollack (2004) as “hard” projects characterized by clear goals and boundaries, tangible end products, low permeability, and a focus on monitoring and control. In recent times, faced with changing societal values, persistent demand for improved performance, pressures towards sustainability, advances in technology and increasingly complex contractual arrangements including partnering and alliances, even projects in the construction industry have become less amenable to linear rational approaches.

This has led to questioning of the traditional project management approaches represented by professional standards in initiatives such as the Rethinking Project Management Network sponsored by the UK EPSRC (Winter, Smith, Morris, & Cicmil, 2006). Another interesting development in management of projects, is based on the Agile Manifesto for software development (Cockburn, 2006). Based on a process view of human collaboration, the Agile project management approach involves a series of relatively small tasks defined and implemented incrementally as the situation demands, in a flexible and adaptive manner, rather than as part of a fully pre-planned process.

Application of project management to disaster events

Disaster management has been described as a form of public project management (Tun & Pathranarakul, 2006). On this basis, all phases of disaster management, from prediction and prevention, to response, recovery and reconstruction may benefit from a project management approach.

Experienced contractors have commonly applied their established project management techniques to the physical reconstruction aspects of disaster events, and the Project Management Institute, responding to the Indian Ocean tsunami disaster of 2004, has developed a Project Management Methodology for Post Disaster Reconstruction (PMI, 2005; Curlee & Sterling, 2008). While this methodology has been recognised as helpful for rebuilding of simple infrastructure, it has been criticised in terms of its wider applicability to chaotic environments encountered in disaster-related contexts (Steinfort & Walker, 2008).

The Project Management Institute has sponsored research on aid relief projects with results showing several common traits in successful relief projects, including effective engagement enabling stakeholders to share a common vision of the project as the team works toward successful outcomes (Steinfort & Walker, 2011). In October 2011 the Project Management Institute presented testimony to a US Senate Subcommittee on accountability of the Federal Emergency Management Agency (FEMA), claiming that project management expertise has practical applications for FEMA in providing disaster relief efforts (Learnard, 2011).

Although there is a considerable literature on disaster management, there is very little reference within it to the application of project management. Hayes & Hammons (2002) use the term “disaster recovery project management” in reporting on recovery of a refinery stopped by hurricane damage. They provide useful guidance on challenges faced in disaster recovery projects. Farris & Wilkerson (2001), again using case studies, discuss aspects of management from initial scope definition through project closeout and propose a performance based contracting system that allows contractors to recommend alternatives that provide best value to the client. Le Masurier *et al.* (2006) in comparing routine and post-disaster reconstruction across New Zealand case studies, concluded that although routine construction processes had proved adequate for small-scale disasters, larger programs of reconstruction following major disasters required a greater degree of coordination that was not adequately addressed in policy and legislation. However, they did not specifically address project management.

In summary, other than in an indirect manner, the project management literature has little to say about its application to disaster management, and the literature on disaster management has little to say about project management. If we accept that disaster response and recovery is implemented through multiple projects and that as Tun and

Pathranarakul (2006) suggest, disaster management is a form of public project management whereby all phases of disaster management, from prediction and prevention, to response, recovery and reconstruction may benefit from a project management approach, then it is interesting that there is so little interaction between the two bodies of literature.

Having investigated the relationship between project and disaster management in the literature, the next step is to examine the disaster management framework in Queensland followed by treatment of project management in existing regulatory frameworks for disaster management using the 2011 Queensland Floods as a case study.

DISASTER MANAGEMENT FRAMEWORK IN QUEENSLAND

In order to provide the context for analysing institutional discourses on the recent Queensland flooding of 2011, it is important to first understand the disaster management (DM) framework in Queensland. This paper first discusses the key principles for disaster management followed by a review of legislation and planning policies relating to DM and lastly an analysis of governance structure for DM with explanation of the roles of different levels of government.

Key principles for disaster management in Queensland

The Australian disaster management system takes an integrated approach to deal with a range of hazards that are likely to affect a locality (Queensland Government, 2011). The five guiding principles for disaster management in Queensland are:

- comprehensive approach
- all hazards approach
- all agencies approach
- local disaster management capability and
- a prepared resilient community

The comprehensive disaster management principle entails reducing risks and building community resilience while making sure there is capability for effective response and recovery. The “all hazards” principle places emphasis on developing a disaster management plan that can deal with various types of hazard as activities and functions for one hazard may be applicable to other types of hazard as well. Likewise, the “all agencies” approach emphasises the importance of coordinating activities of different organisations including all levels of government, non-government and private sectors. The “local disaster management capability” principle recognises the key role that local government should play in managing disasters at the local level. Lastly, the “prepared resilient community principle” highlights the need for awareness, preparedness and resilience of communities by ensuring that all individuals in the community share the responsibility to deal with disaster event.

Legislation and State planning policies for disaster management

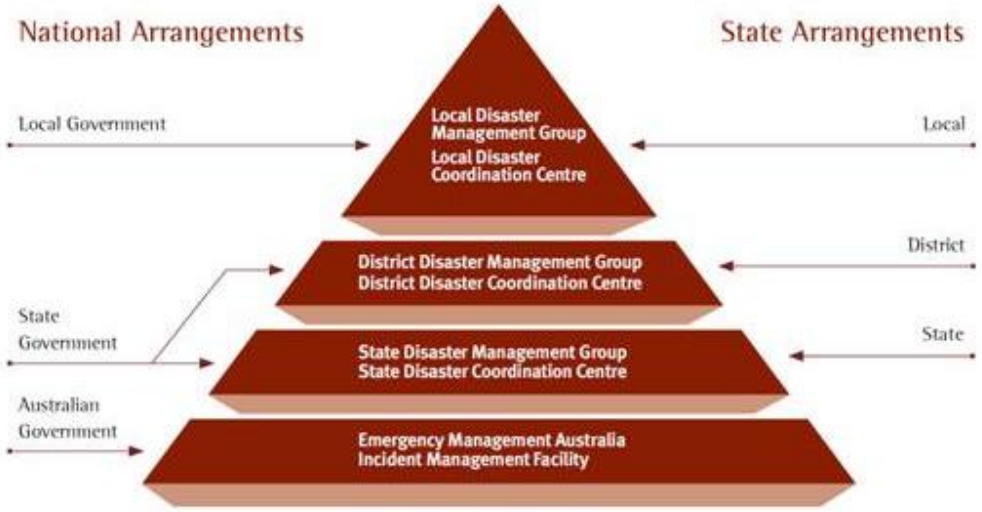
The Queensland Disaster Management Act (2003) forms the legislative basis for disaster management by requiring establishment of disaster management groups for the state, disaster districts and local government areas as well as to prepare disaster management plans and guidelines (Queensland Government, 2011). A relevant policy is the State Planning Policy 1/03: Mitigating the adverse impacts of flood, bushfire and landslide (SPP 1/03) which sets out the State’s interest in ensuring that the natural

hazards are adequately considered when making land use decisions about development. The policy requires council planning schemes and development assessment decisions to minimise community vulnerability and financial impacts of hazards.

Governance structure for disaster management

Disaster management in Australia is structured in a 'tiered' framework involving all levels of government (EMA, 2004). Disaster management groups are established at local, district and State levels and supported by disaster coordination centres at all levels. Responsibility for disaster management is progressively taken up through the local, district, state and national tiers depending on the severity and extent of natural disasters. Figure 1 explains the governance arrangement for disaster management in Australia.

Figure 1: Queensland disaster management arrangements (Queensland Government, 2011)



Local government is clearly identified as the key agency to deal with local disaster events and has important responsibilities that include establishing local disaster management groups and developing and maintaining a local disaster management plan.

Besides the local disaster management groups, there is also provision for district disaster management groups to support local governments in disaster operations. This group has representations from all state agencies responsible for disaster management activities and coordinates activities at district level.

The State Disaster Management group is the peak body providing strategic advice to state government. It is responsible for developing a state disaster management plan as well as providing policy guidelines for local governments in Queensland.

At the federal level, Emergency Management Australia is the peak body dealing with national level disasters. The Council of Australian Governments has recently agreed to adopt a whole-of-nation resilience-based approach to disaster management with focus on national coordinated and cooperative efforts to withstand and recover from disasters. This approach was built on National Strategy for Disaster Resilience (National Emergency Management Committee, 2009).

CASE STUDY: THE 2011 QUEENSLAND FLOODS

The Queensland Minister for Police, Corrective Services and Emergency Services, in his foreword to the Queensland State Disaster Management Plan (2011, p.3), said that the past few years had "upheld Queensland's reputation as Australia's most disaster prone state". From September to November 2010, Queensland experienced a wet spring that meant that by early January 2011 the river catchments were already saturated before the onset of extreme rainfall.

Beginning in December 2010 floods affected an area larger than France and Germany including at least 70 towns and over 200,000 people (BBC News, 2010). Three-quarters of the State of Queensland was declared a disaster zone (Hurst, 2011) and by the end of January 2011, 35 people had died in flood related incidents (Queensland Police Service, 2011).

Brisbane, the capital city of Queensland, Australia, is not unfamiliar with flooding but on the 13th of January 2011 the city experienced the highest and most serious flooding since 1974. Flooding was experienced throughout most of the Brisbane River catchment. The floods caused loss of life; an estimated 18,000 properties were inundated in the Brisbane River Valley and according to the Insurance Council of Australia, about 56,200 insurance claims were received with payouts estimated at $2.55 billion. Around 3,570 business premises were flooded, and commercial losses of approximately $4 billion were reported across the agriculture, mining and tourism sectors. Over 19,000 kilometres of roads and around 28 percent of the Queensland rail network were damaged and three major ports were significantly impacted. The Australian Emergency Management Australia Disasters Database estimates that 28,000 homes would need to be rebuilt, while vast numbers of dwellings require extensive repairs (van den Honert & McAneney, 2011).

METHOD

The approach adopted for increasing understanding of the treatment of project management in existing regulatory frameworks and disaster management practice is to use discourse analysis in the context of a specific case study as outlined above.

Discourses are structured collections or bodies of meaningful text which can be studied through systematic analysis of the texts as well as their "production, dissemination, and consumption – in order to explore the relationship between discourse and social reality" (Phillips, Lawrence, & Hardy, 2004, p.636). The approach is concerned not only with what is present in a discourse but with what is excluded and is particularly relevant in dealing with socially constructed phenomena such as disaster management and project management - "analysing text involves much more than attending to what is 'in' those texts [...t]he point [...] is not to get the text to lay bare its meanings (or its prejudices), but to trace some of the threads that connect that text to others" (MacLure, 2003, p.43). There is precedent for use of discourse analysis in studying disaster management (e.g. Wyatt-Nichol & Abel (2007).

This paper reports specifically on results of a summative content analysis that was undertaken as a first step in understanding the treatment of project management concepts and approaches in the discourse represented by regulatory frameworks and practice of disaster management. The summative content analysis was undertaken using qualitative analysis software, ATLAS.ti 6.2 (Friese, 2012) and focused on identifying the frequency of occurrence of terms that would indicate the positioning of project management in the disaster management discourse. Occurrences of the terms

were searched using ATLAS.ti, then coded and counted. The qualitative data analysis software enabled the researchers to review all occurrences of terms to assess the nature of their use in context.

Two sets of texts provided the basis for analysis. The first set of texts form the institutionalised discourse represented by policies, guidelines and procedures for disaster management at local, district and state level within Queensland, and at national level. The second text is the inquiry report into the 2011 Queensland floods. The first set of documents sets the framework for disaster management and the second text represents the reality of its implementation. The full list of documents used in analysis is shown in Table 1.

Table 1: Documents used in analysis

1. Institutionalised discourse: policies, guidelines and procedures for disaster management	
– **National** – P:1 National Strategy for Disaster Resilience (National Emergency Management Committee, 2009) – P:2 EMA (Emergency Management Australia) 2004, Emergency management in Australia: concepts and principles, Australian Emergency Manual Series – Manual 1. (EMA, 2004) • **State** – P:3 Queensland Disaster Management Act (2003) – P:4 Queensland Disaster Management and Other Legislation Act 2010: Act No. 40 of 2010 – P:5 State Planning Policy 1/03: Mitigating the adverse impacts of flood, bushfire and landslide (SPP 1/03) – P:6 State Planning Policy Guideline – P:7 Queensland State Disaster Management Plan 2011 (Queensland Government, 2011)	• **District** – P:8District Disaster Management Guidelines (Queensland Government, 2010) – P:9 Rockhampton District Disaster Management Plan (Rockhampton District Disaster Management Group, 2012) – P:10 Cairns District Disaster Management Plan (Cairns District Disaster Management Group, 2011) • **Local** – P:11 Cairns Local Disaster Management Plan (Local Disaster Management Group - Cairns Region, 2008) – P:12 Rockhampton Regional Council Local Disaster Management Plan (Rockhampton Regional Council, 2009)
2. P:13 Queensland Floods Commission of Inquiry: Final Report – March 2012	

RESULTS

For purposes of analysis, the documents identified in Table 1 were first searched for concepts that might be considered as central to the discourse of disaster management. They were then searched for references to project, program and risk management in order to identify how they are treated relative to these terms in the disaster management discourse and how far they might be from centrality in that discourse.

To establish a sense of scale and focus, all of the thirteen documents identified in Table 1 were analysed for occurrence of references to key disaster management terms "preparedness", "prevention", "resilience", "response" and "recovery". Of these terms, response and recovery are by far the most popular, each being mentioned at least four to five times more often than resilience and six times as often as preparedness and prevention. This is not unexpected as both response and recovery are essential reactions to disaster events, while resilience is largely a socially constructed and aspirational concept. Prevention and preparedness are clearly less central to the discourse suggesting that disaster management remains largely reactive. If the two sets of documents are treated separately, all of these terms except for response are used more frequently in the institutional framework documents than in the flood inquiry report.

The terms selected to explore the treatment of project management in the disaster management discourse were "project management", "program management", "risk

management", plus the terms "project" and "program". Clearly neither project management nor program management have any visibility or status in the disaster management discourse. Across all the documents, the term program management is not used at all and project management is only used four times and only in the institutional framework documents. Once it is used in an appendix to the State Planning Policy 1/03 in the context of risk management; two occurrences are in the Cairns District Disaster Management Plan in the context of provision of recovery support services specifically relating to repair of uninsured dwellings; and one occurrence is in the Rockhampton Local Disaster Management plan, again in the context of risk management. Project management does not appear at all in the 658 pages of the Queensland Flood Inquiry Report.

Risk management has the same level of importance in the disaster management discourse as prevention and preparedness and often in association with them. There is a clear presence at least in the institutional framework documents of a group of activities that together may be referred to as risk management that have a recognised place in and make a contribution to disaster management.

Taking the terms "project" and "program" separately, the term "program" is used slightly more often than "resilience", but most often not in any sense that is connected to projects and project management. The term "project" is used less than half as often as "program" and more often in the Queensland Flood Inquiry Report than in the institutional framework documents.

Detailed examination of the text in context indicates that while projects and programs are terms used to describe initiatives and actions that are undertaken as part of a disaster management process or in response to a disaster event, the concept of specific management approaches for projects and programs are not recognised within the discourse. By contrast, risk management as a set of processes and procedures is well understood and considered an important part of disaster management.

CONCLUSION

Although disaster management may be described as a form of public project management and therefore all phases of disaster management, from prediction and prevention, to response, recovery and development of resilience may benefit from a project management approach; this paper has revealed that project management has no visibility in the disaster management discourse.

Review of the literature revealed only a tenuous connection between project management and disaster management and analysis of the disaster management discourse via a case study confirmed this disconnect in practice. Risk management, however, appears to be well understood in the world of disaster management and features prominently in disaster management frameworks and practice.

Further research needs to be undertaken to understand why project management plays such a minor role in disaster resilience. One might speculate, however, that the current representation of project management in standards is seen as too bureaucratic and time consuming to be suited to a field in which response is the central concern. It is possible that project managers, in their attempts to define a profession, have erected barriers that isolate them from wider acceptance and engagement. This paper suggests the need for a rethink of project management approaches to meet the specific characteristics and needs of disaster events if project managers and the construction

industry wish to take an earlier and more influential role in building disaster resilience.

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STAKEHOLDERS' APPROACHES TOWARDS NATURAL DISASTERS IN BUILT ENVIRONMENT: A THEORETICAL FRAMEWORK

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Built environment is subject to many risks due to the unique features of construction tasks, such as long lead item procurement, complicated design processes, safety, quality and environment, financial intensity, dynamic organization structures and natural disasters. Natural disasters are becoming more frequent, expensive and devastating globally. They also jeopardize society, performance of economy, built environment, and other socio-economic and physical conditions. While natural disasters cannot be eliminated, successful construction projects are those where natural disasters are effectively managed by stakeholders. Little is known about stakeholders' responses towards natural disasters in construction projects and built environment. Furthermore, past theories on shaping stakeholders' approaches towards natural disasters have been shown to be inadequate in terms of their ability to represent real-life practice and measure the stakeholders' responses against disasters. Hence, the aim of this paper is to develop a theoretical framework on stakeholders' approaches towards natural disasters that integrates four theories, namely: (i) stakeholder theory; (ii) macroeconomic theory; (iii) disaster management theory and (iv) decision making theory. With disaster risk management theory providing the practical backbone of the theoretical framework, the other three theories are able to provide the additional explanation of various aspects of stakeholders' decision making process. Through disaster risk management theory, we are able to support the reactive or proactive approaches of stakeholders before, during and after natural disasters. Macroeconomic theory plays crucial role to choose the appropriate socio-economic variables in natural disaster management process. Decision making theory and stakeholder theory altogether pave the way to select the pivotal stakeholders and to manage their behavioural patterns against natural disasters. The paper concludes the anticipated benefits of proposed theoretical framework as (i) direct comparison of different stakeholders' approaches (reactive and proactive) against natural disasters in built environment; (ii) high-level disaster management planning decisions; (iii) contemplating disaster risk analysis and disaster risk response simultaneously.

Keywords: built environment, disaster management, stakeholder approaches, theoretical framework.

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Mojtahedi M.S.H and Oo B.L (2012) Stakeholders' approaches towards natural disasters in built environment: A theoretical framework *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 133-142.

INTRODUCTION

In devastating natural disasters not only local communities but also all people of a region or in some cases all people of a country are affected because of the fact that natural disasters have direct and indirect impacts on socio-economic and built environment conditions. Therefore, natural disaster management is highly recommended in built environment particularly from stakeholders' perspective. Although there are two approaches to tackle the natural disasters; reactive and proactive approaches, most studies have claimed that the stakeholders often resolve the predicaments arisen in natural disasters by reactive approaches (Bosher *et al.* 2009; Brilly and Polic, 2005; Loosemore and Hughes, 1998). An important matter for the natural disaster management team is to identify and analyse those stakeholders who can have an influence over natural disaster management phases. This paves the way for managing a process that maximizes stakeholder positive input and minimizes any adverse or negative consequences. The early definition of stakeholder's terminology comes back to 1980s. Freeman (1984) explained that stakeholder as an individual or group entity who can have an effect, or is influenced by, the goals and objectives of an institution. He also described that the purpose of stakeholder management was to devise methods to manage the myriad groups and relationships that resulted in a strategic fashion. Increasingly, Freeman (1984) developed the stakeholder management theory. Harrison *et al.* (2010) claimed that stakeholder theory should be considered the decision makers' roles, their decisions and who takes advantages of the outcomes of those decision. Therefore, for natural disaster management in built environment and construction projects, it is the responsibility of stakeholders to cope with devastating impact of natural disasters effectively. Built environment stakeholders are individual and institutions that are involved in the built environment life cycle or whose interests may be affected as a result of construction phase or built environment commissioning, operation and maintenance. The built environment decision making process requires a profound integrated understanding of how to avoid and mitigate the effects of risks and disasters (Bosher *et al.* 2009). In order to have a resilient built environment, stakeholders' approaches should be systematically considered in planning, execution and post-disaster reconstruction in natural disaster management process.

This paper aims to develop a theoretical framework for stakeholders' approaches towards natural disasters in built environment through a synthesis of four theories, namely: macroeconomic theory, disaster risk management theory, stakeholder theory, and decision making theory. As claimed by (e.g., Albala-Bertrand, 1993; Skidmore and Toya, 2002; Toya and Skidmore, 2007) macroeconomic theory supports the relationships between natural disaster impacts and socio-economic variables such as Gross Domestic Product (GDP), income level, population. Disaster risk management theory provides all necessary phases to mitigate the impacts of natural disasters (Bosher *et al.* 2009). Increasingly, the combination of decision making and stakeholder theories help to shape stakeholders' approaches towards natural disasters.

A FRAMEWORK FOR THE STAKEHOLDER APPROACHES AGAINST NATURAL DISASTERS IN BUILT ENVIRONMENT

An overview of literature related to natural disaster management in built environment and construction projects research works indicates that previous research efforts have dealt mainly with two research streams separately, including impact of natural disasters on socio-economic condition (e.g., Haque, 2003; Ibarrarán *et al.* 2007; Kahn *et al.* 2005) and impact of natural disasters on built environment (e.g., Hunt and Watkiss, 2010; Roberts, 2008; Wilby, 2007). Few studies have focused on stakeholders' roles and reaction behaviours against natural disasters in built environment with considering socio-economic condition (Roberts, 2008). Figure 1 shows the theoretical framework for stakeholders' approaches towards natural disasters. Moreover, Figure 1 illustrates the mainstream theories in italics, indicating their applicability for explanation and theoretical support.

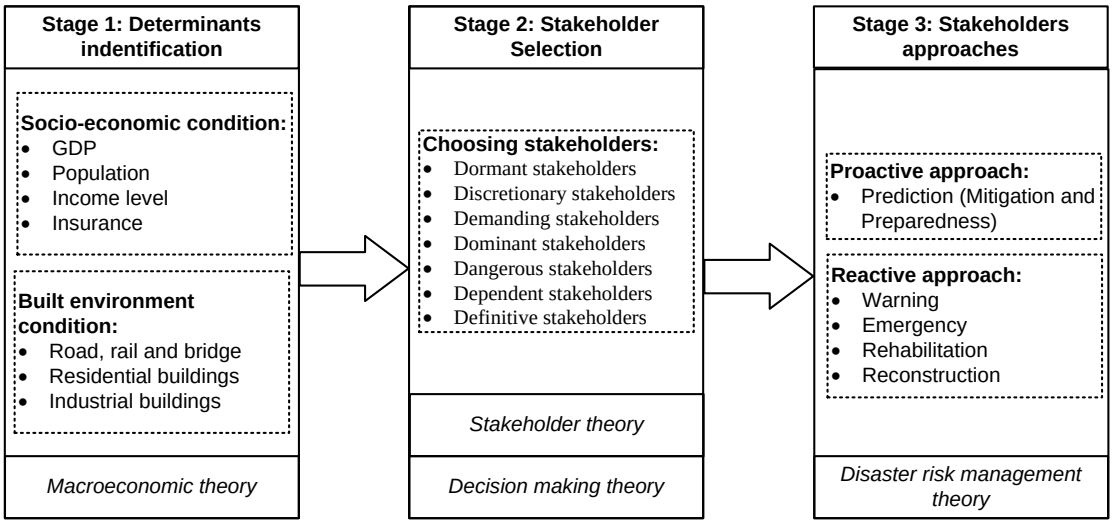

Figure 1: Stakeholders' approaches towards natural disasters

Socio-economic exposure and pertinent determinants

Understanding disaster threats requires comprehension of not only geophysical and biological processes and outcomes, but also the condition of population, economy and income levels, as well as other elements related to socio-economic condition (Haque, 2003). Natural disasters can have significant impacts on the overall economic performance of the society. Figure 1 depicts that natural disasters affect four main socio-economic related determinants, namely: GDP, population, income level, and insurance. Most of the time natural disasters have led to GDP fluctuation, economic loss, population loss, and insured loss among different income levels not only in developing countries but also in developed countries (Haque, 2003; Skidmore and Toya, 2002; Toya and Skidmore, 2007).

One of the most distinguished features of each natural disaster is population exposure. This exposure includes casualties (deaths and injuries). Many of the socio-economic and demographic variables are highly correlated with deaths and injuries associated with natural disasters (Haque, 2003). Population vulnerability describes the characteristics of individuals that make them more or less likely to be injured, killed, displaced, or to have their daily lives disrupted as the result of natural disasters

(Zahran *et al.* 2008. Hence, population vulnerability plays indispensable role in developing any disaster management indices.

Income distribution is a critical factor to determining death toll in natural disasters. Although statistical analysis shows that rich and poor countries are similarly susceptible to natural disasters (Kahn *et al.* 2005), the poor suffer higher mortality rates after natural disasters (Ibarrarán *et al.* 2007; Kahn *et al.* 2005; Pelling and Uitto, 2001).

Ibarrarán *et al.* (2007) claimed that limited access to credit markets, insurance facilities and government officials play critical role in exacerbating the impacts of natural disasters in society particularly in the poor communities. Minority and lower income people are less likely to hold earthquake and flood insurance instruments (Fothergill and Peek, 2004; Zahran *et al.* 2008). Many house owners in flood and earthquake-prone areas in USA were not insured against these dangers, although insurance was rather inexpensive and the government supported in most cases (Brilly and Polic, 2005).

There is no doubt that macroeconomic theory play essential role to not only determine socio-economic determinants but also to justify the relationship with other variables. Vulnerability is a changing feature of an economy, it can be affected by a change in the rate of economic growth due to socio-economic change. Reductions in the growth of GDP typically take place in the year that the natural disaster occurs, with the potential for sharp increases in subsequent years (Benson and Clay, 2004; Ibarrarán *et al.* 2007). Because of the fact that there is a significant impact on production, tourism industry, transportation, water supply, energy sectors, and export sectors (Albala-Bertrand, 1993; Ibarrarán *et al.* 2007; Thomalla *et al.* 2006). Considering the opposite side of the coin, Albala-Bertrand (1993) demonstrated positive impact of natural disaster on macroeconomic variables immediately after events. Interestingly, some scholars (e.g., Albala-Bertrand, 1993; Skidmore and Toya, 2002; Toya and Skidmore, 2007) have achieved an outcome from their empirical studies that GDP is generally found to increase in the periods immediately following a natural disaster. Skidmore and Toya (2002) believed that this phenomenon is owing to the fact that most of the damage caused by disasters is reflected in the loss of capital and durable goods; moreover, stocks of capital are not measured in the periods immediately after a natural disaster.

Built environment exposure

One of the earliest natural disaster impact studies on built environment and transport was conducted by the London Climate Change Partnership (LCCP) in 2002 (Wilby, 2007). Later, many scholars investigated the transportation network vulnerability against natural disasters (e.g., Hoshiya *et al.* 2004; Menoni, 2002; Sohn, 2006). Roads and bridges are most likely to be damaged by these hazards, may be of great importance as transportation hubs for post event disaster response and recovery efforts (Wood *et al.* 2002). Thus, there are a few studies scrutinizing the impact of the natural disasters on transportation networks, roads and bridges (Kim *et al.* 2002; Sohn, 2006). Sohn (2006) analysed the significance of highway network links in Maryland, USA in the case of flood damage. Ports and harbours are particularly vulnerable to natural disaster such as earthquakes, landslides, and tsunami inundation because of the fact that they are located in sea level areas (Wood *et al.* 2002). They also claimed that little attention has been given to developing hazard mitigation and preparedness strategies for ports and harbours as key community resources.

While the built environment is broad, extending from cottages to factories and airport terminals, the building sectors considered here are those that are both large in number and have high occupancy. Natural disasters like extreme weather, flooding, earthquake, bushfires, storms have devastating effects on building. Therefore, new buildings will have to be designed to cope with the effects of climate change and natural disasters. Wilby (2007) reviewed the most significant climate change impacts on the built environment. First, he found that there is an ongoing need to improve preparedness and forecasting of climate hazards. Second, there is clearly a need for improved representation of intra-urban flooding, at local, city and catchment scales. Finally, there is an urgent need to translate awareness of climate change impacts into tangible adaptation measures at all level of governance.

Selection of pivotal stakeholders

This section focuses on stakeholders who have a vested interest in built environment against natural disasters. Therefore, it is important to categorize stakeholders into different groups. Mitchell *et al.* (1997) classified stakeholders into seven main groups as following:

1. Dormant stakeholders
2. Discretionary stakeholders
3. Demanding stakeholders
4. Dominant stakeholders
5. Dangerous stakeholders
6. Dependent stakeholders
7. Definitive stakeholders

Although dormant stakeholders have little or no interaction with the firm the main criteria in dormant stakeholder is to possess power to impose their will on an organization. Discretionary stakeholders hold the attribute of legitimacy, but they have no enough power to affect a firm's decisions. Demanding stakeholders possess urgent claims but having neither power nor legitimacy. Dominant stakeholders have enough power and legitimacy to direct a firm's decision making process. Coercive behaviours making stakeholders dangerous to the firm (Mitchell *et al.* 1997).

The identification of stakeholders in built environment depend on the project life cycle from conceptual to closing phase. Furthermore, number of stakeholders increase when natural disasters affect built environment. A generic set of stakeholders in managing natural disasters in built environment would include local government, prime (general contractor), subcontractors, suppliers, emergency relief organizations, financial institutions, insurance companies and affected local community.

Altay and Green (2006) investigated a comprehensive review on operation research and decision making in disaster management. They found that most researchers have focused on mitigation, preparedness, and response and recovery phases of natural disasters. For flood disaster, Akter and Simonovic (2005) proposed a flood management decision making methodology to capture the views of multiple stakeholders using fuzzy set theory and fuzzy logic. Finally, decision making theory facilitates to select appropriate criteria to select ample stakeholders. The use of decision making techniques can be dated back to four decades. Since then, the theory and applications have been developed significantly (Shih, 2007).

Disaster risk management and its phases

Disaster Risk Management (DRM) is defined by the United Nations as: "The systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards" (United Nations International Strategy for Disaster Reduction (UNISDR), 2004: 17-18). It is important to note that there is a significant difference between crisis and disaster management. Booth (1993) explained that a crisis is a critical situation which individual, group and institution are unable to tackle the predicament by the use of normal routine activities. Kumar (2000) argued that the second phase of disaster events includes the emergency and crisis. Consequently, Moe and Pathranarakul (2006) concluded that crisis term might refer to the event when crisis arises whereas disaster management covers wider scope of prediction, warning, emergency, relief, rehabilitation, and reconstruction. Furthermore, there is a substantial difference between Natural Disaster Risk Management (NDRM) and Natural Disaster Management (NDM). Moe *et al.* (2007) argued that NDRM includes phases of prediction, warning, and emergency relief while NDM consists of prediction, warning, emergency, relief, rehabilitation, and reconstruction. According to UNISDR (2004), natural disaster management includes generic five phases, namely:

- Prediction (mitigation and preparedness)
- Warning
- Emergency relief
- Rehabilitation (short-term action)
- Reconstruction (long-term action)

Some scholars have divided disaster mitigation strategies into two main groups as following (e.g., Bosher *et al.* 2009; Pelling and Uitto, 2001):

1. Structural mitigation: some sort of activities associated with strengthening of buildings, and other infrastructure exposed to disasters.
2. Non-structural mitigation: to avoid building infrastructure in disaster prone area, relocating existing assets to safer zones, maintaining protective features of the natural environment.

Stakeholders' approaches towards natural disasters

Stakeholders who are involved in construction sector can play crucial role in structural mitigation strategies, while developers, planers, emergency institutions should be able to take non-structural mitigation approaches to cope with natural disasters (Bosher *et al.* 2009).

There are two different approaches to cope with the devastating impacts of natural disasters (Moe and Pathranarakul, 2006). First, tasks that are planned and conducted before the disaster impact with an aim to effectively minimize the adverse impacts of the disasters are called proactive approach. On the other hand, activities of responses and recovery are regarded as reactive approach.
Few studies exist on stakeholders' approaches towards natural disaster management in built environment. Loosemore and Hughes (1998) investigated reactive crisis management in construction management. Brilly and Polic (2005) studied a case in

Slovenia to provide an integrated flood mitigation decision making process with considering stakeholders' approaches. Moe *et al.* (2007) proposed a balanced scorecard technique with considering pro-active and reactive approaches to provide a continuous assessment of performance in each life-cycle phase in natural disaster management project. Bosher *et al.* (2009) claimed that there is a need to proactively address strategic weaknesses in maintaining the built environment from a range of disasters. They also emphasized that there is still insufficient evidence that key construction stakeholders are playing an active role in mitigating flood risk. They identified that the pre-construction phase of building's life cycle is the most critical stages when key stakeholders such as architects/designer, structural and civil engineers, urban planners, contractors and emergency/risk managers need to adopt natural disaster mitigation strategies. In their survey on the integration of disaster risk management into UK's built environment, they indicated that knowledge and awareness of integrated disaster risk management is poor and concluded by some key recommendations as following:

- Built environment stakeholders need to become more immersed in group decision making
- Professional training for stakeholders such as architect, planners, engineers, developers, etc pertinent to risk and hazard awareness should be systematically organized.
- Performance-based contracting, and product or service oriented procurement decision should be taken in order to make designers and contractors think about long-term implications and performance of buildings and structures they design and construct.

ANTICIPATED BENEFITS OF PROPOSED THEORITICAL FRAMEWORK

The development of the stakeholders' approaches towards natural disasters brings together a body of knowledge about their responses from a wide range of disciplines to provide three principal benefits. First, the proposed theoretical allows us to develop stakeholder disaster risk response index. By creating a composite index that combines all the pertinent factors, different stakeholders can be compared directly in built environment. Such a comparison could be useful for governments, public organization, and general contractors to choose appropriate contractors who have high response index against natural disasters.

Second, closer investigation of the disaggregated stakeholder disaster risk response index conveys information about the various factors that comprise the overall disaster risk response. One can focus on a single factor, and explore how the values of that factor vary among different stakeholders. Understanding the casual factors of stakeholder response constitute the first step in designing the most effective and efficiency strategies to mitigate the natural disaster risk. In a given built environment, those factors that are contributing most substantially to the risk will emerge as the most promising targets for mitigation efforts in that built environment by stakeholder.

Third, apart from stakeholders' disaster risk response, by excluding some factors (e.g., stakeholders' approaches) the theoretical framework can be easily changed to disaster risk assessment in relevant built environment. Therefore, by collecting same data we are able to take advantage of integrated stakeholders' approaches to elaborate the natural disaster risk in the built environment. While risk assessment studies have been

performed for many regions around the world, each study focuses on a single component of the risk.

CONCLUSIONS

This paper presents a theoretical framework of stakeholders' approaches towards natural disasters particularly in built environment. Theoretical framework developed through a synthesis of four theories. With disaster risk management theory providing the practical backbone of the theoretical framework, the other three theories are able to provide the additional explanation of various aspects of stakeholders' decision making process. Through disaster risk management theory, we are able to support the reactive or proactive approaches of stakeholders before, during and after natural disasters. Macroeconomic theory plays crucial role to choose the appropriate socio-economic variables in natural disaster management process. Decision making theory and stakeholder theory altogether pave the way to select the pivotal stakeholders and to manage their behavioural patterns against natural disasters. Empirical support for the proposed theoretical framework was obtained through a literature review providing a different perspective on socio-economic variables, built environment and stakeholder approaches towards natural disasters.

The limitation of this study is realised as the theoretical framework being based entirely on a literature review, particularly the deficiency of studies on stakeholders' approaches towards natural disasters. The next stage planned for this study involves validating the proposed theoretical framework with profound quantitative analysis by gathering relevant data from natural disaster management databases and in-depth interviews with built environment stakeholders.

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EDUCATION AND LEARNING

FRAMEWORK FOR FORMATIVE ASSESSMENT LEARNING STRATEGIES IN BUILT ENVIRONMENT HIGHER EDUCATION PROGRAMMES

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Formative assessment has begun to be recognized as a driving force for enhancing student learning. This paper addresses the context of Built Environment (BE) undergraduate programmes and the findings from a research project in the context of the changing Higher Education (HE) environment. The analysis of the literature on formative assessment shows that there is a common concern among the educational researchers about the function and position of assessment in HE today. The overall aim of this research is to contribute to an improvement in the quality of student learning in BE undergraduate education through the development of a theoretical framework for formative assessment. The application of a mixed methods approach and more particularly a constructivist stance to the research was adopted. A four-phase sequential approach has its key characteristic assessed and the advances in conducting and evaluating this design are presented. The results and analysis of all four phases of the research, which gives the views and preferences of senior academics, programme managers/leaders and lecturers/teachers in the BE in Ireland, are presented. From this ongoing research work a framework for a more scholarly approach to assessment in BE has been developed and piloted with selected student groups. The purpose of this framework is to provide an opportunity for undergraduate learners through their lecturers/teachers to change approaches to assessment practice so that their learning is enhanced to a level where they can become more self-regulatory and autonomous.

Keywords: assessment, formative, summative, higher education, built environment, mixed methods research, undergraduate.

INTRODUCTION

Assessment is recognized as being central to the education experience (Askham, 1997; Black & Wiliam, 1998; Stiggins, 2002; Biggs, 2007). Indeed recent research has emphasized the importance of assessment and feedback in the learning process, facilitating diagnostic self-monitoring, developing the ability to evaluate and make judgments and helping to foster learner self-regulation (Nicol & Macfarlane-Dick 2006; Sadler 2010). Rapid developments in networked, mobile and social technologies

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Scott L and Fortune C (2012) Framework for formative assessment learning strategies in built environment higher education programmes *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 145-154.

in the last decade have presented new opportunities to support assessment processes. When considered along with the expansion of further and higher education, technology has an important role in ensuring the sustainability of assessment practice (JISC 2010), be it summative or formative in nature. Common barriers to assessment change tend to be organisational, cultural and linked to the availability of resources, with existing codes of practice relating to assessment often misaligned with current and emerging practices.

Assessment is about measuring achievement and it usually involves giving feedback of some kind on the work being assessed. In examination terms that feedback is normally given as a mark or a grade. But what does the person being assessed learn from that? In HE, assessment practices and processes have been the topic of wide ranging conversations over the last fifteen years (Bryan & Clegg, 2006). Discourse about the current state of assessment often refers to unease as to its suitability for the twenty-first century and the need for it to be 'fit for purpose' (Brown, 2004). Knight (2002) posits the view of 'practices in disarray' where assessment has become a site of conflict, even a power struggle, founded on the unequal relationship between the two parties (student and institution). This disarray not only pertains to HE in Ireland and the UK; such discourse has also taken place in the US. It is argued that an in-built lack of clarity in the methods of assessment used to convey judgement on performance is an underlying factor. Assessment in the discipline of the BE, like in other disciplines, is required to fulfil a multiplicity of purposes and to play many different and often conflicting roles. The provision and embedding of opportunities for assessment to aid learners in more formative ways has been highlighted as currently failing students (Struyven, Dochy & Janssens, 2005).

This paper discusses the need for a project to research formative assessment in the context of the changing HE environment. A mixed methodology approach to research and a signpost of improvements in the quality of student learning in BE undergraduate programmes through the assessment process are proposed. This paper reports on the study so far, where seminal literature is explored in order to identify, inform and shape the assessment practices of academics. The results of the research are presented with an in-depth analysis of the findings of the already completed four phases (Scott & Fortune 2010, 2011). The emerging views and preferences of academics teaching on the identified undergraduate programmes are analysed, informing the development of a framework for formative assessment where the enhancement of student learning underpins the evaluative process. While this framework has been developed from research in the BE arena, it is applicable in other HE environments.

FORMATIVE ASSESSMENT AND LEARNING

Research into formative assessment techniques has pointed to feedback as being an essential mechanism in the learning process (Gibbs *et al.* 2004). Ramaprasad (1983) defined feedback as information about the gap between actual performance level and the reference level, which is subsequently used to alter that gap. Feedback, therefore, needs to be meaningful, understood and correctly acted upon. Lecturers/teachers not only need to undertake formative assessment, they also need to evaluate how effective any feedback has been in enhancing learning and more particularly in addressing the gaps in learning. In practice, formative assessment that allows students to receive meaningful feedback should make a difference in student learning (Black & Wiliam, 1998). However, Higgins *et al.* (2002) raise doubts as to what extent this is reality. They argue that students may recognise the central importance of formative feedback

for their educational development, but the ways in which they use that feedback are not clear.

Sadler's definition of formative assessment/feedback, 'to shape and improve the students' (Sadler, 1989:120) competence by short-circuiting the randomness and inefficiency of trial and error learning' is appropriate. Indeed, Sadler (1998) suggests that the role of the lecturer/teacher could broadly be described as 'working to reduce the rate of error production in trial and error learning and thereby to make learning more efficient'. In order to do this the lecturer/teacher needs to have an understanding of (a) subject and skill based knowledge and (b) the needs of the learner (Black & Wiliam, 1998). This study encompasses a key issue confronting lecturers/teachers in HE today i.e. how to bridge these two factors such that students can be given meaningful feedback to enhance their learning.

Summative assessment, usually undertaken at the end of a period of learning in order to generate a grade that reflects the student's performance, is not regarded as having any intrinsic learning value. The traditional unseen end of module examination is often presented as a typical form of summative assessment. Two important points arise from this differentiation. Firstly, there is no compelling reason why only summative assessment should be included in any formal grading of student performance. It is perfectly appropriate to have elements of formative assessment as part, or even all, of the final grade. Secondly, the distinction between formative and summative assessment may be a false one. Whilst some elements of assessment may generate a greater formative learning experience than others, it can be argued that all forms of assessment have some formative element. Students undertaking a degree course where assessment consists only of end of module unseen examinations will, over the period of the course, improve their examination technique. This formative learning experience was identified by some students during the preliminary research. It demonstrates a clear need for an appropriate level of discourse in BE education as to the position of formative assessment in regard to the learning experiences of students.

Assessment for learning acknowledges that assessment should occur as a regular part of teaching and learning and the information gained from assessment activities can be used to shape the teaching and learning processes. It can, most importantly, also be used by the learner to enhance learning and achievement. Gibbs and Simpson (2004), in their seminal work, have developed a model that promotes eleven conditions under which assessment supports learning, as outlined in table 1 below. Seven of the eleven conditions refer to feedback. The underlying principle and theory of this model forms the rationale for the survey of the lecturers on BE programmes.

Table 1 Gibbs and Simpson (2004) promoting 11 conditions under which assessment supports learning

Conditions where assessment supports learning	
1	Assessment should contribute positively to students' learning
2	Assessment is considered by academics and students as an integral component of the learning and teaching process
3	Tackling the assessed task engages the students in productive learning activity of an appropriate kind
4	Assessment communicates clear and high expectations
5	Sufficient feedback is provided, both often enough and with sufficient detail
6	The feedback focuses on students' performance, on their learning and on actions under the students' control, rather than on the students themselves and on their characteristics
7	The feedback is timely in that it is received by students while it still matters to them and in time for them to pay attention to further learning or receive further assistance
8	Feedback is appropriate to the purpose of the assignment and to its criteria for success
9	Feedback is appropriate to students' understanding of what they are supposed to be doing
10	Feedback is received and attended to
11	Feedback is acted upon by the student

The analysis of the literature on formative assessment shows that there is an agreed concern among the educational researchers around the function and position of assessment in HE today. This concern in regard to BE education is echoed by the researchers and hence the explorative research into how academics in BE education in Ireland view and engage with formative assessment practices.

METHODOLOGY AND ANALYSIS

This research reports on the overall investigation of the conceptions, attitudes and position of academics in BE in Ireland in regard to assessment practices. It involved four phases of research in which academics in the field of BE from the main providers of Architecture, Architectural Technology, Construction Management and Construction Economics (Quantity Surveying) programmes on the island of Ireland participated (see table 2). A mixed methods research typology resulted following the consideration of many other typologies, as well as several other dimensions. For example, the embedding of mixed-modal designs by mixing qualitative and quantitative approaches within and across the stages of research was a focus of the research enquiry. The mixed-methods design is based on the crossing of paradigm emphasis and time ordering of the quantitative and qualitative phases.

A primary justification for mixed methods is pragmatism and the identifiable fit in the educational research field. Pragmatism asserts no first or foundational principles and suggests that all human knowledge is empirical. To justify mixed methods, one must reject the incommensurability argument, i.e., the argument that the differences in epistemological theories cannot be overcome.

Table 2 The four phases of the research mapping the current approaches of BE academics in Ireland to assessment

Phases of the research	
Phase 1	Review of college regulations, programme documentation and student handbooks
Phase 2	Interviews with senior academics (management) (8)
Phase 3	Interviews with heads of dept./programme managers (20)
Phase 4	Online survey of BE lecturers/teachers

Phase 1

The first phase looked at finding out the current position and practices in the institutions chosen for the study. It was viewed as vital to review institutional documentation, school and programme documents, external examiner reports, student handbooks and any other resources that might allow a value judgement to be made as to the institutional, college, school, department or programme culture and approach to assessment in undergraduate education.

Phase 2

Semi–structured interviews were conducted with eight senior academics in management positions between September 2009 and March 2010 in Schools in the University/Institutes of Technology sector on the island of Ireland. There was evidence of what Rowntree (2003) refers to as the 'traditional' view of assessment. Within A and AT there appeared to be a more holistic approach to assessment in undergraduate programmes. In the areas of CM and QS there was evidence that a more traditional approach pertained, where assessment was viewed as a means of measuring learning and compliance with regulations was important. One senior academic made reference to the SA being the most important aspect of a learner's education. The quote below is his direct comment:

"we have to know what the students know. We have to know that and the question is how you find that out and that is the starting point Now, we also have to encourage students to learn and it seems to me that how do you do that is through forcing them into having to learn for an unseen paper - that traditional exam - and they will study that because assessment drives learning" Interviewee B

If a senior manager is of this mindset then it could be argued that innovative and more learner-centred methods of assessment will not be encouraged and learning, teaching and assessment will follow the traditional approach.

Phase 3

Interviews were conducted with some 20 heads of dept./programme managers across BE programmes in Ireland. The analyses of the interviews identified their views and conceptions around assessment. The emerging common themes included the purposes of assessment, learning and teaching, summative and formative assessment (Scott & Fortune 2010). One clear theme alluded to by all was a recognition of the importance of assessment in the educational process, with particular importance given to formative assessment in student learning. However, the mechanism on how this was to be achieved differed with each manager interviewed and was highly dependant on the particular conceptions on learning, teaching and assessment held by the programme team.

An identifiable emerging concept among the programme managers was the difference in philosophical position with respect to the assessment of student learning, i.e. the purpose of assessment. It was seen as multi faceted, examination orientated, part of a holistic approach, inclusive of both summative and formative assessment processes. The differing positions can be seen in the quotes below:

- ‘Assessment is about measuring what the student understands and can do’ Interviewee B
- ‘Assessment is about exams’ Interviewee E
- ‘If you want students to learn, they have to be assessed and I would see assessment as being more than just an end of term exam’Interviewee D

Phase 4

The online survey was circulated, having been piloted, reviewed and amended to some 130 academics from a survey population of those teaching on undergraduate programmes in A, AT, QS and CM. This reflected an overall response rate of 53% breaking down to 72.5% male and 27.5% female, reflecting the male/female proportions teaching on BE programmes. Thirty of the respondents came from the construction management discipline equating to 43% of the respondents. The level of lecturing experience varied among those participants with only three indicating they had less than three years’ experience.

One interesting point from the analysis of the function of assessment was that 86% of respondents agreed or strongly agreed that assessment should provide feedback to students on their learning, yet it would appear that, in practice, they seemed to focus on the measuring of learning rather than more formative approaches. A similar response rate relates to both questions on providing comment/direction to students about their learning and on encouraging students to apply and demonstrate their understanding. Academics worked with and wanted to work with their students and what was an issue was 'the need for more time' and/or the lack of educational theory as a foundation to their planning. When questioned about the issues around assessment the respondents identified the following as impacting negatively on their engagement with students:

Time management (more particularly time available); large classes, workload, student conceptions, academic regulations, academic research out put, plagiarism.

Issues in regard to providing feedback to students included; transparency, the time factor associated with marking, institutional policy, student engagement - the lack of student attendance and student attitudes. Many cited student indifference as a matter for concern.

Overall analysis and findings

Reflecting on the literature on assessment in HE and linking this to the views expressed by academics in the BE in Ireland, what was identifiable was that a conceptual framework for assessment should be based on the following key assumptions:

- Assessment should contribute positively to students’ learning
- It should focus on what is to be learned (learning outcomes) and how that learning might contribute to both the programme of study and beyond
- It must develop students' ability to make judgments about what constitutes good work

- It should be student centred and place the learner as ‘active’ in the learning process
- Assessment must engage students in the process of seeing themselves as people who will contribute to practice, whatever that practice might be (Scott & Fortune 2011)

Based on the analysis of the four phases the findings indicated there was a clear need for a framework that supports academics in their approach to aiding learners in today's complex constructivist environment. The expectations from all stakeholders indicate a desire for a framework that allows meaningful learning, teaching and assessment to take place. The framework as outlined in figure 4 below provides such a supportive structure. It was developed around the need to consider each course of study in a holistic way where the learner is considered with reference to their development through the programme of study. Significant support or scaffolding should be provided in the more formative years of study and as the student develops, more autonomy and peer support is advocated. Part of an approach such as this requires investment in the necessary early stage induction. The Formative Assessment Led Learning Strategies (FALLS) framework, as presented in figure 1, provides for a constructivist learner-centred approach to developing autonomous, self-reflective individuals.

DISCUSSION

Assessment is of central importance in HE and the more one researches the field the more there seems a ‘lack of commonality’ (Taras, 2005) across the disciplines within the BE. There is a growing interest in the quality of the student learning experience but how to enable change to take place requires a readiness to share the responsibility for the management of an assessment system in a way that allows learning to flourish.

An understanding of the perspectives and pedagogical positions of BE academics on the assessment of student learning is vital in any attempt to improve assessment practice. Firstly, it provides a firm starting point within the wide field of improving assessment practice. The areas where academics perceive that they have needs and experience problems can be targeted. Secondly, changing assessment practice does not merely involve the adoption of a set of new techniques leaving all other matters of pedagogy unaffected. Any significant change in assessment practice requires ‘seeing things differently’ (a conceptual change) alongside ‘doing things differently’ (a behavioural change) (Biggs 2007). The FALLS project has the potential to engage lecturers/teachers in doing formative assessment and so enable them to see formative assessment in more developed ways by actively engaging them in the processes of developing student feedback as part of authentic assessment tasks that provide the opportunity for significant learning.

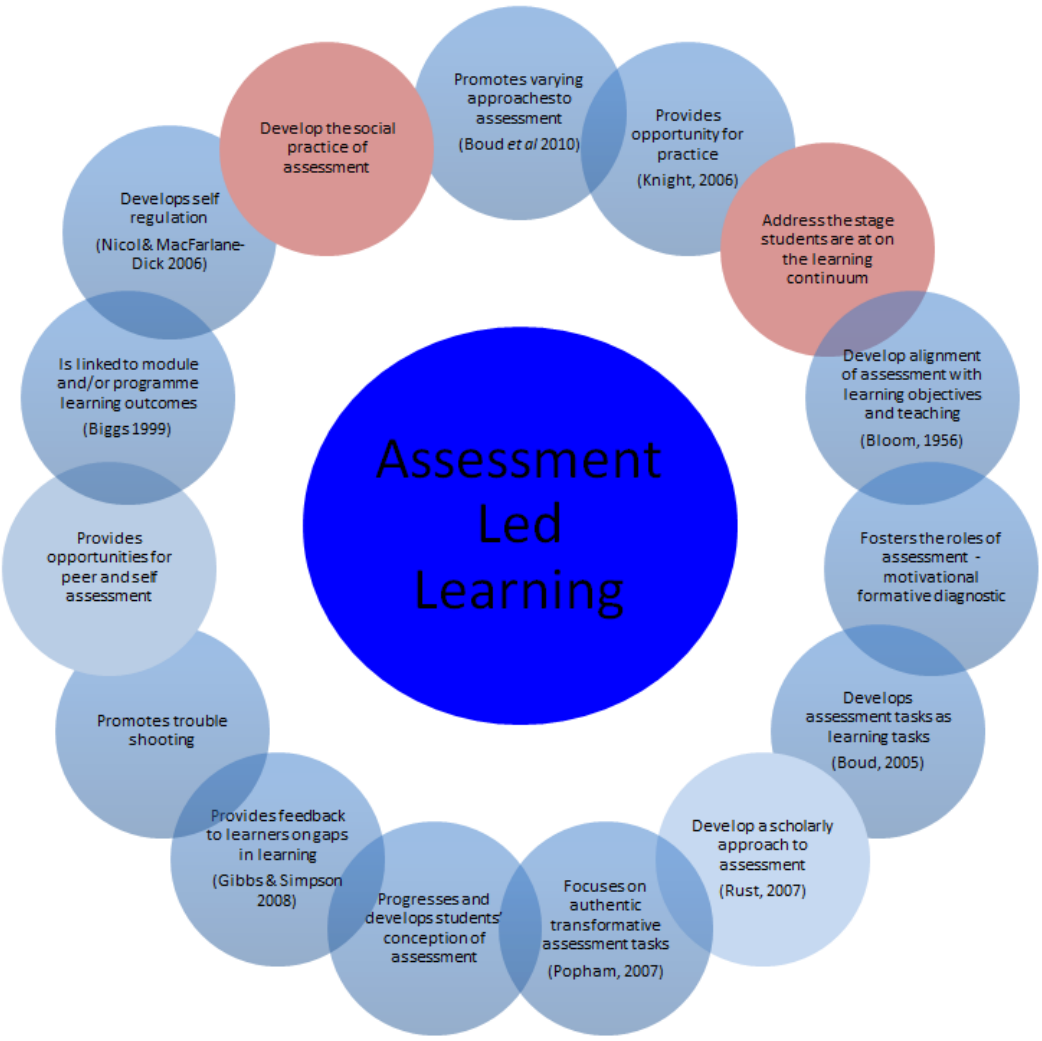

Figure 1: The FALLS framework addresses the four stages in an undergraduate programme of study

The FALLS project can provide the support and direction for developing lecturers'/teachers' views of assessment, especially formative assessment aspects. In the short pilot, one lecturer/teacher responded to say that many lecturers in his area, when asked, did not even know what formative assessment was. The ways in which some of the lecturers/teachers involved are now implementing formative assessment provide further demonstration. One example is the lecturer who has recognised the need for a formative assessment approach that promotes mastery of basic knowledge and competencies in first-year students. He allows students to take in-course tests up to four times until they demonstrate that they have reached the threshold mastery level.

For lecturers/teachers

Being aware of the influence of the department that you work in as well as the epistemology and practices of your discipline may help when attempting to introduce new or different methods of assessment, or when changing marking and feedback practices. Sometimes, it is only possible to exert change at the level of the course or programme for which you have direct responsibility, but taking a collaborative approach and 'getting colleagues on board' can begin to make assessment change happen, as can presenting *evidence* of any change initiatives. Such evidence may need to be presented at departmental meetings and as high in the institution committee

structure as you can get. It is also worth remembering that the student voice is part of the evidence base and can be a powerful trigger for change.

For students
Since assessment is such a fundamental and important part of a degree course, it is essential for candidates to understand as much as they can about the context of the programme of study, what it means to learn at third level and how the assessment system works in the course (both formative and summative). The process of students becoming independent learners, able eventually to judge the value of their own work takes time and so a high level of support and guidance should be concentrated in the first year of study, gradually lessening as the students grow in experience and confidence.

CONCLUSIONS

Academics must, as Boud (2010) proffers, 'build capacity for judgment' and move away from conservative approaches to assessing students. A move to developing and implementing assessment strategies that use the most appropriate means of producing reflexive learners is what is required. Formative assessment led learning strategies (FALLS) is important because it uses these elements to support learning. It is, therefore, at the heart of the learning and teaching cycle.

It is important that opportunities to include assessment led learning should be embedded in programmes and this learning should receive the necessary credit. Striking a better balance between assessment 'of' and 'for' learning is key to enhancing the learning experience of students at undergraduate level in the BE. The evidence indicates that there is a willingness to effect change in the approach to supporting student learning through sustainable and authentic assessment strategies.

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DEVELOPING AN UNDERSTANDING OF RESEARCH PRINCIPLES TO SUPPORT POST-GRADUATE EDUCATION IN THE BUILT ENVIRONMENT

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Most research universities require some combination of standardized classroom teaching and independent research as part of a post-graduate level plan of study. Increasingly construction management, construction technology, architecture, and related programmes that award degrees related to the built environment (BE) are awarding post-graduate degrees. Frequently these degrees, unlike traditional engineering degrees which test theory from a quantitative or positivist position, relate to issues that are more difficult to measure using strictly quantifiable metrics. Because the managerial issues faced by these graduates deal with human interaction and behaviour, research in the BE often resembles social science research to a greater degree than traditional scientific research. As post-graduate programmes in the BE expand, there is an increasing need for student support in the research fundamentals that are required to complete valid research on construction and design issues. Small programmes can rely on the individual mentorship of students, but as student populations grow a more formalized approach is needed to support varying research methodologies employed by post-graduate students as they complete their thesis or dissertation obligations. This paper is an examination of the research fundamentals approach to post-graduate education being used by construction related research programmes in a sample of universities in the US and the UK/Ireland. Emphasis was placed on understanding the current educational support for the understanding of research fundamentals critical to research in the built environment. The paper utilizes both a literature review and a survey instrument. Specific areas of examination include information detailing the educational unit(s) within the university with responsibility for teaching research fundamentals, research fundamentals courses available, the research philosophy or approach emphasized, and the text or other literature support utilized to advance valid research design by post-graduate students. As academic processes develop at post-graduate level there appears to be a consensus that the need for research principles courses is accepted. Where the position differs is at what level this course should be offered.

Keywords: graduate education, research, curriculum development, validity, methodology

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Scott L and Shaurette M (2012) Developing an understanding of research principles to support post-graduate education in the built environment *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 155-165.

INTRODUCTION

College level educational programmes covering material appropriate for the built environment (BE) have experienced a long evolutionary process. In the early 20th century professional education in engineering or architecture was the typical path taken by students preparing for work in the BE. By mid-century some universities began to recognize that over and above teaching engineering and design, there was a need to add management knowledge and skill as educational objectives for future construction professionals. To meet this emerging need, engineering and architecture programs created areas of specialization for students interested in management of construction.

In 1974 an industry group and a group of university faculty (lecturers) teaching construction management (CM) worked to form the American Council for Construction Education (ACCE) in the United States to promote and accredit construction education programs. In the years since the ACCE was organized by the American Institute of Constructors (AIC) and the Associated Schools of Construction (ASC), it has accredited undergraduate programs that provide CM education primarily for entry level construction management professionals that have been in high demand (ACCE, 2009). Since the advent of accreditation specific to the BE, well over 60 universities in the US have worked through the ACCE to accredit their programme while another dozen are candidates for accreditation. This growth in accredited baccalaureate degree programmes is a testament to the recent demand for college educated construction management personnel. In the UK and Ireland the development in post-graduate education has been driven by individual universities in an attempt to address the needs of both academia and industry. It should be noted that in the context of the US, graduate program refers to Masters and PhD level study while in the UK and Ireland it is referred to as post-graduate.

Historically construction industry hiring practices have not placed as high a priority on post-graduate level education in both the US and Europe. Some CM educators have advocated the need for post-graduate education programmes that are fully aligned with the construction industry. Rounds noted in 1997 that post-graduate level CM programs would advance the body of knowledge of the industry, provide professional construction educators with industry specific knowledge, and develop graduates with advanced skills appropriate for executive level careers in construction. In addition, the need for professional construction educators was addressed in a 2005 task force report to the Board of Directors of the ASC which examined the need for and the appropriate format of a PhD degree in Construction Management. Growing demand for construction educators in the US has encouraged the growth of post-graduate education specific to the BE. In 2007 the Associated General Contractors (AGC) of America, a US trade association comprised of more than 33,000 firms, expressed the organization's support for advancement of post-graduate CM programs. They stated "The need for senior executives to secure a masters (in construction management) is apparent from two perspectives. First, they will benefit from learning newly evolved construction techniques and management methods. Second, their experience is needed on campus as instructors" (Behling, Orczyk & Jenkins, 2007).

Gumport (1993) has traced the role of research in post-graduate education during the last century as part of a book titled The Research Foundations of Graduate Education: Germany, Britain, France, United States, Japan. Beginning in the late 1800s, research and post-graduate education became closely linked at major universities primarily

through the growth in the disciplines of science and engineering. The common practice of post-graduate student education in the US and Europe at that time consisted of a period of class-based study followed by research. Post-graduate education during this time period evolved to become a mentor based learning environment where students worked alongside professors on research projects. The benefit of this mentor-based process was that students would transition from consumers of research to producers of research. This process was accelerated in the post-World War II period where the economic expansion and cold war competition of the time period encouraged significant financial support for research. By the 1970s top tier universities had interwoven organized research and post-graduate education and lower tiered institutions strove to emulate this practice.

RESEARCH PROBLEM AND SIGNIFICANCE

Although some universities may offer non-thesis post-graduate options, research will continue to be a significant component of the post-graduate education provided by many construction management programmes. Some programmes consider research to be the most effective approach to the promotion of self-education or life-long-learning. Others see the need to maintain a research focus to support those who will become future educators of the BE. In some cases programmes may be given little choice within the university structure in which they operate. As post-graduate programmes grow many will face challenges in supporting the educational needs of their students. The potential for these challenges become more apparent as construction researchers expand the diversity of research philosophies and research methodologies considered appropriate for research in the BE. Those BE programmes that depend on the regular supervision of post-graduate students by mentors/ supervisors within the programme are limited by the capacity and number of mentors available. Programmes that look to the college or university in which they operated to provide courses in research methods are limited by the range of research methodologies provided at that level. Ultimately the question must be asked “what are the most appropriate ways to prepare post-graduate students for their research activities”? This paper attempts to provide the first step in that quest by exploring what post-graduate programmes in the BE are currently providing as research methods resources for their students.

EVOLVING CONSTRUCTION RESEARCH PHILOSOPHY

Quantitative or positivist views of construction research dominated early construction research published in academic literature. Possible explanations for this include the fact that many construction educators came from backgrounds in engineering where quantitative research is utilized both because of its ability to demonstrate scientific rigor and validity as well as the relative ease of relating engineering theories to mathematical analysis. During the last few decades an evolution in thinking about research philosophy in construction research has come about. In 1997 Seymour, Crook, and Rooke called for a debate on the role of theory in construction management research. Seymour *et al.* encouraged a dialogue about the need for a broader view of alternate research paradigms. They contended that the management components of construction require a more interpretive view of research that necessitated a reconsideration of what defined theory, rigour, and objectivity in construction research. Later that year Runeson responded to the call for debate by stating that positivist research is the best insurance against bad research. Although Runeson acknowledged that interpretive research has a place in normative research, he

asserted that it should not be taken as science. His arguments placed a clear demarcation between the value of qualitative and quantitative approaches.

The following year Wing, Raftery & Walker provided a less dichotomous response to the debate contending that the research philosophy or methodology chosen for construction research should be based on the nature of the problem being examined. In arguing against a single research approach they pointed out that behavioural scientists had been expressing dissatisfaction with 'scientific' methods since the 1960s. Wing *et al.* provided numerous references from a variety of disciplines to advocate for pluralism and diversity in construction research philosophy and methodology. They suggested the complementary use of quantitative and qualitative approaches. While this debate is not as public today, the authors suspect that the diversity of research approaches taught by various post-graduate programmes is not consistent. It is interesting to note that the qualitative vs. quantitative debate has been active in recent years among researchers in engineering education (Borrego, Streveler, Miller, & Smith, 2008; Borrego, Douglas, & Amelink, 2009).

In the construction management research community in the UK and Ireland discourse around methodological approaches have also begun to receive attention (Dainty, 2009). Knight and Ruddock assembled 14 chapters by various authors which each describe a different methodological approach that is applicable to the built environment. More than half of the approaches presented are not strictly from the positivist philosophy of research design. Nevertheless, Dainty in the opening chapter describes the recent history of research enquiry in the BE while advocating for a pluralistic approach toward research methodologies. He describes the relatively narrow range of methodologies employed for research published in a 2006 volume of "Construction Management and Economics". While his evidence is limited, he goes on to suggest that there is still a need for a paradigmatic change from the apparent dominance of a positivistic approach to research in the BE.

To advance this paradigm shift in BE research, Boyd (2011) gives several examples of ways to prepare post-graduate students for a less restrictive view of BE inquiry. In one instance he describes the use of systems education to help students become oriented to complex construction practice as well as the inherent complexity of research or problem solving in what has been described as construction's "loosely coupled systems" (Dubois & Gadde, 2002). Through the use of systems theory, and rich picture diagrams as a support tool to model multiple case examples (Sutrisna & Barrett, 2007), a deeper understanding of the problem complexity can be developed by the student (Boyd 2011). In a second presentation to BE educators Boyd describes a module where he encourages students to develop a personal construct theory by engaging in participant observation, ethnography and cooperative inquiry to develop their ability as critical thinking, learning practitioners (Boyd, 2012).

RESEARCH METHODOLOGIES APPROPRIATE FOR CONSTRUCTION RESEARCH

When a theory or hypothesis fits available data or realities of data acquisition, experimental approaches to construction research is preferable because of its ability to produce generalizable results. Frequently these experimental approaches require the researcher to separate naturally occurring phenomena into small components that facilitate data collection. Bernold and Lee (2010) describe five methods of experimental or quasi-experimental design commonly used for construction research. These five methods; pilot testing of devices and methods, passive observation,

controlled experiments, randomized experiments, and four group experiments may be favoured when measurement of well defined variables can be obtained. Unfortunately, conditions that allow such measurable evidence to be collected are often confounded by conditions beyond the researcher's control.

To overcome the challenges of experimental design, alternative philosophies and methodologies have been adapted from research more common to social science. A complete description of the range of research methods at the construction researcher's disposal is beyond the scope of this paper. However, a recent issue of the Journal of Construction Engineering and Management contains several articles describing both experimental and alternative approaches to construction research that can serve as useful reference material. Table 1 lists the range of methodologies and approaches described. While this list is by no means exhaustive it does show the breadth of research tools with which post-graduate students should be exposed in their education.

In addition to an introduction to multiple methodologies, students need to understand the limitations inherent in each particular case. Because validation of research results is necessary in order to obtain true meaning or application of the research, learning differing methods of validation is also important in preparation for the execution of scholarly work (Lucko & Rojas, 2010). For example multiple cycles of testing may be utilized to validate action research results (Shaurette, 2009).This approach is not necessarily appropriate or possible with other methods. Without implementation of sound and appropriate research procedures at every research step from conceptualization through data analysis and conclusions, theories and hypotheses cannot be reliably confirmed or denied (Abowitz & Toole, 2010).

Table 1: Research Methods in Journal of Construction Engineering and Management, January 2010

Method	Authors
Experimental Research	Bernold & Lee
Mixed Method Research	Abowitz & Toole
Observational Research	Leicht, Hunter, Saluja & Messner
Delphi Method	Hallowell & Gambatese
Ethnographic Theory-Building Research	Phelps & Horman
Action Research	Azhar, Ahmad & Sein
Charrettes as a Research Method	Gibson Jr. & Whittington

METHODOLOGY

The exploratory study described in this paper sought to identify what post-graduate programmes in the BE are currently providing as formal research methods educational resources. The scope of the inquiry was to examine course-based education in research methods based on the concept that students require a formal introduction to a diversity of research philosophies and methodologies appropriate for use in construction research. Although possible through one-on-one interaction with a research supervisor/mentor, growth in graduate enrolments make sole reliance on supervisory guidance for research fundamentals education increasingly difficult. The primary components of the inquiry were intended to disclose if programmes require

completion of a research methods course, if the research course is construction based or generic in nature, if a variety of philosophies and methodologies are included, and some indication of the assessment of student success in mastering research fundamentals. In addition, an opportunity was provided for respondents to describe other forms of support available to students.

The first phase of the study was conducted utilizing a short survey administered through an internet based survey tool and this was followed with by phone interviews utilising a standard set of 10 questions. The interviews were a convenience sample of four respondents from the online survey who answered a follow-up email with their availability and willingness to provide greater detail. University BE post-graduate programmes in the US, Ireland and the UK that require completion of a research thesis was the population of interest. A list of post-graduate coordinators or chairs and their email contact information was assembled by the authors based on previous knowledge and a search of descriptions available through programme websites. The membership of the Associated Schools of Construction (ASC) was used as a guide to avoid exclusion of US based programs. A review of the membership of ARCOM was used in the case of the UK and Ireland based research degrees. A total of 22 programmes were identified and all were sent a survey.

The survey was administered using Bristol Online Surveys. This allowed anonymous responses to be made by respondents, a major requirement for receiving exemption from full human subjects review by university Institutional Review Boards. The survey was completed over a two-week period with a reminder sent after one week to encourage those who had not yet responded to do so. A total of 16 responses were received for a 73% response rate.

SURVEY RESULTS

Data collected via an anonymous on-line survey of acadmeics involved in post-graduate research were mainly numerical with opportunities for respondents to include narrative data in response to a very limited number of open questions. The numerical data were analyzed mathematically by exporting the assembled data from the BOS survey software and are presented as tables of results. It was only necessary to do one cross tabulation.

The results of the survey indicate that in 81% of cases respondents require research students to take a research fundamentals/methods course as part of their research programme. There were 3 cases where there is no requirement on the part of the student to take any type of research fundamentals/methods course. Table 2 below sets out the breakdown of what level within the institution the research courses are taken.

Table 2: Level within the Institution the Research courses are taken

Level Where Research Course is Taught	Number of responses	% of Responses
University	4	31%
College	2	15%
School / Department	1	8%
Programme	6	46%
Supervisory and Other	0	0%

It is interesting to note that 54% of cases offer research fundamentals/methods courses at school, department or programme level. This would indicate that a focus on discipline-based courses prevails in those cases. This would appear to be a positive approach in that students are potentially exposed to research methodology principles that are discipline focused. However, this cannot be assumed as the research fundamentals experiences offered may be of a nature that might be narrowly focused based on the experience of those involved. One respondent made the following comment in regard to this area: "University wide Graduate School for the Social Sciences provides programme for CM doctorals. Research Engineers have their own credit-bearing courses in EngD programme".

Table 3 Titles Used for Research Fundamentals/Methods Courses

Course Title	Number of responses	% of Responses
Analysis of Research in Industry and Technology	1	8%
Research Methods in Construction	2	17%
Models of Disciplined Inquiry	1	8%
Research Approaches	1	8%
Research Methods	5	43%
Theory of Research in Construction Management	1	8%
Dissertation	1	8%

In 11 (73%) of the cases the research fundamentals/methods course is taken for credit. This would indicate that in the majority of cases 'learning' the rudiments of research are integrated into the research approach. This possibly offers the motivation for students, as judged by their supervisory team, to engage at a deep level to a course of study that may be viewed by them as unnecessary. The proportion of respondents with research fundamentals/methods classes at department or programme level indicates that the preferred option is for candidates to be prepared for this aspect of the research journey at a more local level. The titles of the research fundamentals/methods course offered in the institutions are shown in Table 3. The title Research Methods appears to be the preferred one. In only one case did a respondent name the title with the university coding.

Other forms of research support are provided by 100% of the respondents. The following list shows the forms of structured research supports available to research candidates:

Online training programmes
Data bases, online journals
SPSS training programmes
Library support, List of library references
Generic Research Skills programme also available to all students
PhD Conferences
Online resources/references library databases online journals module/course texts
Research Seminars - Presentations of active research within the department
Students can also take additional other research methods courses from other departments
PhD Forum

In terms of research course text, respondents specified different core texts. In three cases they specified social science research texts. The most common reply was “various texts specified”. Two respondents indicated that BE specific research texts were used. A cross tabulation between Q2 (level where research course was offered) and Q5 (title/author of text) indicated that the social research science texts referred to were the recommend texts of those taking university level research fundamentals courses.

It is interesting to note that only 70% of respondents indicated that candidates are required to submit thesis or research project minimum research requirement as part of the programme requirement. In 77% of cases no written/oral qualifying exam is necessary. In addition, 57% indicated that there is no formal approach to the assessment of students' research abilities. Further exploration is needed of specifically what is required of candidates as evidence of their ability to conduct sound research.

Interview Results

The data collected from the follow-up qualitative interviews offered a deeper understanding. More challenges than solutions were identified by the interviews and these included:

Student attitude and motivation a key to success - not clear at application stage
Candidates ability to write a limitation - differs by background
Limited support for those with weak writing skills

In all but one case some weakness in the research course or dissatisfaction with research preparation were identified. All those interviewed acknowledged a need to offer students a full range of research methods and that there are limitations to this at most institutions. Where university or college level modules are utilized, students may have difficulty applying the methodology to BE applications. Another key aspect recognised is that students have difficulty defining and limiting their research question. It was also noted that data analysis (statistics) is sometimes emphasized over methodology. The supervisor background was posed as problematic at times. For example, the assigned supervisor may not be active in research calling for training and a greater need for uniform research assessment procedures. Several of those interviewed acknowledgement they were "learning as we go" indicating the need for a community of practice among the construction management research active members.

DISCUSSION

As academic processes develop at the post-graduate level more institutions appear to be requiring research students to take a research fundamentals/methods course. The survey responses would support this. Responses also indicate that differing practices and configurations are in place by those institutions who are offering post-graduate research opportunities. A formalized approach to these courses is slowly developing and it will be interesting to observe how this emerges in the short term. There seems to be some inconsistency and diversity of opinion as to whether this is a positive direction and if research fundamental/methods courses should be held at programme, school/department or university level.

A goal of this paper is to increase the awareness of the role that research courses play in scholarly work by providing readers with alternate means to validate research based on sound research principles. The design of any research fundamentals curriculum should address learning, teaching and assessment approaches in line with best practice and validation. Validation of the research methodology and its results is a fundamental

element of the process of scholarly endeavour. Novice researchers need to be exposed to this discourse. Approaches used for BE research have included a variety of approaches. Some studies use more than one approach with emerging opportunities for research validation through collaborative efforts that utilize multiple research methodologies. Consequently, research courses should address multiple methods and related matters. The authors suspect that many faculty (lecturers) of research methods are not including adequate consideration of the pedagogical approach best suited to research courses. What is more, the scholarly literature contains few systematic discussions of curriculum design or teaching methods in research methods; nor is there a substantial research base to inform such discussions (Garner, Wagner, and Kawulich, 2009).

The specific issues raised by this study relate to similar positions across academic communities in both the US and Ireland/UK. The way that different BE communities deal with and manage the research of post-graduates requires a framework of best practice which can be built upon and improved over time. Included in that framework should be a contextual approach which has validity, reliability and direction as key underpinning principles.

CONCLUSIONS

As the post-graduate research community in the BE expands, the need for a focused research fundamentals/methods course will become more apparent. Whether or not it is at University, college, school/department or programme level is a matter for the programme of study committee to decide. It is the view of the authors that it is important for research candidates to have a sound understanding of a diversity of research methodologies and their underlying principles. Based on the output from this research study, it would appear that supervisory teams should advocate that research students be exposed to research fundamentals advancing from the generic to the specific. The student should experience and learn about the general overarching fundamentals of research and advance to the contextual and best practice approaches within the BE discipline.

As Wing (1998) *et al.* suggested, the way forward for the BE community should be "through methodological pluralism and paradigm diversity" for researchers to discover the rudiments of construction research through research fundamentals/methods. Post-graduate researchers need to understand fully the underpinning theory behind the methodologies that they choose to employ. The delivery of a discipline focused research fundamentals/methods course should take a comprehensive view and present diverse methodologies. This approach has the potential to provide a framework of structured thinking and activities to achieve discipline aligned research that does not limit the post-graduate researcher to a single paradigm.

Given the wide variety of issues still to be explored in the area of the education of researchers in research fundamentals/methods, discourse with respect to the best practice approach will be essential to future frameworks of post-graduate education. The authors have identified a clear need to investigate alternate research methods, this might be done by accessing some of the seminal literature sources and by collaborating across BE boundaries. The challenge is not to be "assumption free" but rather to be reflective and self-conscious of the assumptions upon which the underpinning principles operate. The BE research community, including those new to the discipline, needs to engage in the validation, justification and discourse around a

variety of research methods. While this research has evoked discourse among a small community of research active academics, there is a need to follow up with additional research and discussion.

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EFFECTIVENESS OF THE CONSTRUCTION MANAGEMENT COURSES

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This research assesses the effectiveness of current MSc. Construction Project Management programmes within the UK and Ireland. A review of published prospectuses is used to create questionnaires for universities, graduates and employers. Responses provide an insight into programme creation and their relative success in addressing the needs of industry and in achieving other educational objectives. Since the majority of learning institutions have attained professional accreditation, it is useful to review these awards and to assess their potential value to both graduates and industry alike. Interviews are conducted with representatives from the main professional accrediting bodies to understand their procedures and rigour in enforcing standards of education and training. The results show that project management education could be further enhanced by the inclusion of more practical learning and that current programmes place greater emphasis on hard skills at the expense of the softer human skills. There is clearly a need for a closer working relationship between academics and practitioners to tackle the perceived gap between theoretical learning and construction practice. Learning institutions can use the findings to improve their programmes and address the education deficiencies identified by the industry, by the professional institutions and by graduates.

Keywords: education, professional accreditation, project management.

INTRODUCTION

In an ever-developing industry such as that of the construction sector, demands are constantly changing, placing new requirements on education providers to create courses that adequately prepare graduates for the workplace. Variable factors such as the economy, technology and environmental awareness continue to dictate the direction of teaching. An investigation was conducted into the content of MSc Construction & Project Management programmes throughout the UK and Ireland, with a view to identifying critical success factors. Communication with industry, academics and graduates from these programmes has identified how these courses have been designed, and examined how reflective they are of the current skills and knowledge areas required for the workplace. The research reviewed the learning environments and accreditation from professional bodies. The need for further

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McArdle, K; Gunning, J.G and Spillane, J.P (2012) Effectiveness of the construction management courses *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 167-176.

education and training in construction and project management has been recognised by organisations and professionals globally. Several authors have claimed that the development of the professions deriving from traditional routes is becoming out-dated with the underlying theory of project management becoming obsolete (Koskela and Howell, 2002).

In recent years, greater emphasis has been placed on the quality (Akintoye, *et al.* 2000; Love, *et al.* 2000), value for money (Li, *et al.* 2007) and health & safety (Sawacha, *et al.* 1999; Edwards and Nickolas, 2002) of projects. This has required the establishment of a bespoke role to manage construction projects, leaving architects and engineers to focus on their own design specialisms. The discipline of construction project management has developed, along with recognition of the need for dedicated training in this area.

Postgraduate study has been a popular method of Continuing Professional Development (CPD) for those in the construction industry (Graham and Thomas, 2006). MSc level degrees are delivered as taught programmes or through research. A taught Master's typically includes lectures, coursework, examinations and assigned projects. Most Higher Education Institutions (HEIs) give the option of studying 1 year full-time or 2-3 years part-time, both of which comprise of 180 CATS credits (equivalent to 90 ECTS credits). Curriculum development is influenced by a number of stakeholders; government, construction industry, academia, professional bodies and associations. This research examined all 39 institutes in the UK and Ireland providing construction project management courses at postgraduate level. Each programme was examined to identify content similarities and 25 modules were highlighted. The relative similarity of modules across all the programmes reflects the development and growth of the profession. During the early progression of programmes, institutes tend to deliver a diverse range of modules with little correlation or similitude. This is reflective of a young academic discipline. The general uniformity in current curriculum content suggests that the skill set of a Project Manager has now been successfully characterised, resulting in a generalised programme design. The similarities between courses represent an academic consensus of the knowledge areas and skills required to be an effective project manager.

THE LINK BETWEEN ACADEMIA AND INDUSTRY

The construction industry relies heavily on third level institutes in providing an ample supply of competent construction project management graduates (Love, *et al.* 2003) with industry partners indicating that construction graduates should be proficient at undertaking skilled technical tasks from an early stage (McNamara, *et al.* 1997). However, Chan, *et al.* (2002) indicate that there is a mismatch between academia and the industry, particularly within the UK. Not only are soft skills important in the employability of graduates (McNamara, *et al.* 1997), but also their technical and practical ability. Chileshe and Haupt (2007) argue that there are both positive but also negative aspects associated with this relationship. One of the key findings concludes that academic education is not fulfilling the needs of the industry and thus a void is present between what academia provides and the needs of the industry. Esmi and Ennals (2009) aptly summarise by arguing that there is a core issue in relation to a perceived void between rhetoric and reality in the application of knowledge. It is of fundamental importance that the knowledge gap between what academics are delivering and what the industry requires is identified and corrected promptly. With such a void palpable and pronounced, it is essential, not only for the development of

the sector but for the future employability of UK construction and project management professionals, that this perceived gap between academia and the industry be removed, and that there are an increasingly closer links between the two sectors.

PROJECT MANAGEMENT ASSOCIATIONS

Over the years, various associations such as the Project Management Institute (PMI) have been formed, establishing and publishing their interpretation of project management best practice. These organisations are not strictly concerned with construction management; however, by examining these expert associations, the project management element of construction and project management programmes can be scrutinised. A synthesis of the various bodies of knowledge, codes of practice and other publications from these bodies suggests the following 11 knowledge/skill areas;

- Project Management & Integration - Ensuring proper coordination of all project elements.
- Monitoring & Control - Processes for timely completion of the project.
- Risk & Crisis Management - Highlighting potential risks and mitigating actions taken.
- Human Resource Management & People Skills - effective use of the people involved.
- Communications Management - Timely and appropriate generation, collection, dissemination, storage and ultimate disposition of project information.
- Quality Management - Ensuring that the project will satisfy its purpose(s).
- Information Technology – Implementing the latest in I.T. to aid project delivery.
- Teamwork and Motivation – Getting the most from the project team.
- Procurement – Acquire goods and services to attain project scope.
- Financial & Cost Management – Project completion within the approved budget.
- Scope Management – Ensuring that the project includes all the work required and only the work required to complete the project successfully.

Project management consists of a number of interlinked processes directed towards a particular result, namely the defining, planning, executing, controlling and delivering of a project (Schwalbe, 2009). The review of project management association literature has highlighted that these five process groups provide a framework for understanding project management in general and one that is applicable to any industry. HEIs generally ensure that their project management modules include most or all of the above areas in order to provide a holistic view of the discipline.

Professional Accreditation

Learning institutions aspire to provide courses which will prepare their students adequately for industry. To demonstrate their commitment to delivering programmes to the necessary standard, many education providers seek professional accreditation. Such accreditation tends to govern many university programmes, and these organisations establish their own standards upon which to judge education provision. Such accreditation is an important accolade and can be a powerful marketing tool for universities. Table 1 provides a summary of the core knowledge areas which have been established by the three primary professional bodies from which accreditation in

the discipline of project management is generally sought within the UK and Ireland. These are the accreditation requirements of CIOB (2010), RICS (2011) and APM (2011), from which organisations further information is available.

Table 1: Primary Knowledge Areas of the CIOB, RICS and APM

CIOB Educational Framework	RICS – APC Competencies	APM – BoK
Construction Technology	Conduct, Rules, Ethics and Professional Practice	Project/Programme/Portfolio Management
Construction Economics	Sustainability & Client Care	Project Success and Benefits Management
Construction Law and Dispute Resolution	Communication and Negotiation	Stakeholder Management
Risk Management	Risk & Health and Safety	Project Management Plan
Research Methods	Accounting Principles and Procedures	Project Risk Management
Health and Safety	Business Planning	Project Quality & Value Management
Professional Ethics	Conflict Avoidance, Management and Dispute Resolution Procedures	Health, Safety and Environmental Management Systems
Sustainability and the Environment	Data Management	Scope & Change Management
Project Management	Managing People & Team Working	Scheduling & Resource Management
Construction Contracts and Procurement	Contract Practice	Budgeting and Cost Management
Project Planning, Monitoring and Control	Procurement and Tendering	Earned Value Management
Cost & Quality Management	Programming and Planning	Information Management and Reporting
Construction Life Cycle	Construction Technology and Environmental Services	Issue Management
	Leadership & Project Administration	
	Project Process and Procedures	

Many similarities can be observed between their assessment criteria, which primarily incorporate report based assessments coupled with university visits and module review. Higher Education Institutes are faced with the decision of which accreditation path to take. Each accrediting body stipulates similar knowledge areas, making them more difficult to differentiate. The value associated with each award is dependent on the reputation of the awarding body; in this case the institutions are all internationally recognised and established, and so are attractive to potential MSc students.

RESEARCH METHODS

This particular investigation involved examining 1) the attitudes and responses of new graduates and people in industry regarding how effective current MSc. courses are in developing practical construction and project managers, 2) the approach taken by

academic accrediting bodies to ensure that learning institutions are delivering valuable and relevant programmes, and 3) assessing how HEI's are creating and developing their courses to suit the needs of industry.

In order to acquire the relevant information to assist in the deduction of a reasoned conclusion, it was essential to obtain information from industry professionals and graduates alike. In order to achieve this, a mixed methods approach was adopted in the form of both qualitative and quantitative data collection using a desk based literature review, semi-structured interviews and respondent specific questionnaire survey. This method of data collection was chosen due to the large number of respondents which were hoped to be surveyed from academics, industry and graduates. It was decided to conduct interviews with representatives of the three professional bodies to ascertain their viewpoints on the research topic. The interview process was semi-structured to ensure that the interviewee had the freedom to discuss the matter at hand while also providing the interviewer with a certain amount of control over proceedings, although not introducing a level of bias. Each interview was recorded and the resulting transcripts analysed using Cognitive (Mind) Mapping to ascertain and link the key points noted within each interview. Bespoke questionnaires were designed for each of these groups to elicit data to satisfy the research requirements and assessed accordingly. From the qualitative data collection, a number of key areas of consideration were included in the questionnaire; Bodies of Knowledge, renewal, accreditation and assessment. Questionnaires were circulated to 39 course directors, 180 industry practitioners and 120 graduates - with respectively 6, 25 and 31 questionnaires returned.

DATA ANALYSIS & FINDINGS

Academic Questionnaire

From the returned data it was clear that the HEIs take inconsistent approaches to course development, updating and assessment. Some universities take a very proactive approach in the identification of current issues to include in their curriculum, while others map in accordance with the learning outcomes outlined by accrediting bodies. The survey indicated that major internal reviews of curriculum content occur every 4 to 5 years. Academics indicated that they are mainly restricted by time in programme development. Other factors highlighted included;

- Modular delivery –broader teaching and collaboration is necessary; however modular design does not completely suit this approach
- Financing –postgraduate programmes are more expensive to run in comparison to undergraduate courses. Financial constraints limit the options available to course directors, with only 8 HEIs offering a wide range of optional modules
- Staffing –Lack of breadth of expertise impedes the development of modules in emerging subject areas

The majority of the institutions investigated do not require prior industrial experience of construction industry processes as a prerequisite for acceptance onto the programme. The research suggests that this limited practical experience needs to be acknowledged by HEIs and addressed accordingly. In many respects, the learning needs of experienced, mature students differ from those with limited exposure to industry practice, so programme design should try to incorporate means of satisfying these varying requirements within a single course.

Graduate Questionnaire
Out of the 31 respondents to questionnaires, 87% were male, and the average age was 26.5 years. The results revealed general dissatisfaction with programmes with common criticisms including;

- Majority of skills necessary for project managers are acquired in the workplace
- Insufficient practical assignments and the perceived limited industrial experience of many academic staff
- The academic process is too far removed from the construction industry, with too much emphasis placed on reports and research
- Students are not prepared to a level adequate for immediate employment, however knowledge gained may become of greater value as career develops

There was a general view from graduate respondents that they regarded MSc programmes as vocational training rather than as an educational experience for its own sake. If it is true, as Skinner (1984) suggests, that "education is what remains when what has been learnt has been forgotten", this focus on job training may be considered short-sighted. However, younger graduates would claim that they cannot afford a longer term view in the current recession. The respondents suggested that programmes could be improved through the inclusion of; regular field studies, site visits, industry professionals delivering lectures relevant to current practice and modules covering building information modelling and supply chain management. To supplement the findings, graduates were asked to rank a series of statements based on the Likert scale where 1-Strongly Disagree runs up to 5-Strongly Agree;

Table 2: Graduate questionnaire factors and results

Statement	Mean Score	Rank
Placement or industrial practice alongside academic teaching would be more beneficial	4.581	1
Courses providing optional modules to facilitate specialisation would be advantageous	4.029	2
Masters programmes have been developed which use a single common project as a reference for all modules; this would be a beneficial teaching method	3.677	3
More emphasis should be put on the development of soft skills	3.516	4
Dissertation/thesis production and topic selection can prove greatly beneficial to a student's future career	3.355	5
Online MSc's and distance learning programmes have been created that allow project managers to remain in employment and mobile, this is a good innovation	2.968	6
International fieldtrips should be made compulsory on programmes	2.170	7
Education providers are offering what is necessary to deal with construction projects in today's environment	2.581	8

Industry Questionnaire
Industry respondents revealed that graduates are insufficiently trained in the areas of programme management, competent use of CAD, "real world" knowledge and experience, business acumen (in so far as this can be taught), people skills, communication and negotiation skills, on-site methods and construction processes,

and current building regulations. The respondents stressed the importance of placements and actual industry experience. It is suggested that graduates, by definition, are knowledgeable in the theory of their subject area; however, they often lack the confidence to apply that knowledge to real life situations. This may only be developed over time, as they gain experience. Employers want experienced graduates. This raises the issue of whether or not students should be allowed onto MSc courses without post graduate industrial experience. If employers are unwilling to take on inexperienced employees due to training costs, why do learning institutions still continue to supply this type of postgraduate-qualified person to the industry?

The industrialist and graduate respondents were both asked to rate on a 5-Point Likert Scale, the identified modules from all institutions in order of their current importance and relevance. This provides HEIs with the opportunity to assess and highlight the inclusion and importance weighting of the various modules are perceived by both construction industry employers and graduates;

Based on factor analysis of these results, a correlation coefficient of 0.78 emerges, indicating that there is a very high positive correlation between the order of importance and relevance attributed by both employers and graduates (the closer the figure to 1, the higher the correlation – results in excess of 0.7 indicate very high correlation). The survey clearly demonstrates which modules are most applicable in today's industry. They give an indication of the knowledge areas necessary to operate in the workplace. Less popular topics could make room for the deficient areas which have been previously identified.

The low rating by employers of the subject of Construction Law is rather surprising, and the high importance of Value Management to employers but not to graduates is particularly striking. Perhaps the most unexpected outcome was the positioning of International Construction at the very bottom of the priorities of both groups. Teixera, *et al.* (2006) have highlighted the importance of knowledge of international markets and practices in an economic recession, so this outcome reflects an inappropriately parochial viewpoint.

Interviews

CIOB – The education framework, which is central to CIOB accreditation, is created by academics and practitioners, who form a Review Group to monitor the framework and convene to update and amend its content. Online technology permits regular tweaks opposed to the long-term overhauls, previously associated with traditional hard copy format. A concerning issue is that major amendments to the framework will only be implemented in accredited programmes when reassessment is due after 5 years of the initial award. Thus, it is suggested that annual reviews would maintain standards and should be employed.

APM – APM accreditation has been described as an exercise of alignment with the breadth and depth aspects of the APM Five Dimensions of Professionalism. It is the APM BoK which influences curriculum design; this document is updated more frequently than any other accrediting body's guidance material (every two years). In theory this ensures that learning institutes are delivering the latest in industry practice, helping to reduce the gap between academia and industry.

RICS – The RICS accrediting procedure appears on the surface to be the most meticulous of the three awards. Five quality principles are used to assess student selection, innovation, teaching quality, curriculum and graduate output. The Assessment of Professional Competence pathways are devised by the RICS Project

Management Professional Group; details of changes are available 24/7 on the RICS website. However, RICS appear to have accredited some programmes without completion of their first cohorts. The partnerships between RICS and many HEIs might be viewed as cosy relationships which do not encourage serious criticism but promote easy acceptance/re-accreditation processes.

Table 3: Employer & graduate module review - results in order of importance and relevance

Module	Rank Employee	Rank Graduate
Project Planning and Scope Management	5	1
Time Management	2	2
Risk Management	4	3
Procurement and Contract Administration	7	4
Estimating, Purchasing and Cost Control	3	5
Construction Technology	1	6
Construction Law	18	7
Quality Management	9	8
Sustainable Construction	8	9
Safety Management	10	10
Resource Management	14	11
ICT for Construction Management	13	12
Group Project	15	13
Communication Management	11	14
Management Theory and Management Practice	19	15
Human Resource Management	24	16
Construction Economics	17	17
Computer Aided Architectural Visualisation	12	18
Facilities Management	20	19
Design Management	16	20
Value Management	6	21
Corporate Strategy Management	23	22
Research Methods	22	23
Innovation & Entrepreneurship	21	24
International Construction	25	25

CONCLUSIONS

This research was conducted to identify how effective current construction project management courses are in preparing students for industry. The investigation found that programmes in the UK and Ireland are somewhat lacking, with significant gaps between the education provided and the requirements of the construction industry. Project management education should instil a set of skills that can be applied anywhere, contextualized, conveyed via proficient soft skills and that can prepare

students to be life-long learners. These skills must include skills in research – which are required for all true learning to take place. This study concludes that the majority of institutions overlook soft skills, possibly because they are very difficult to measure and to teach. Some people instinctively have soft skills and others learn and develop these through experience. Thirty nine programmes were investigated in the study, all delivering relatively similar curriculum options. The research found that accreditation is the key driver behind course content, with the majority of universities attaining such awards. CIOB and RICS awards are considered to have more inherent value to students than APM, due to their closer links with the construction industry.

It is accepted that the sample size of respondents was limited, but the responses were consistent enough to provide a reliable indication of the views of MSc graduates and industry employers in UK and Ireland. In the ongoing debate about whether HEIs should be providing education or training, (as in CNBR in 2010), this survey verdict was that the two are not incompatible, and that "learning by doing" on practical construction industry-linked assignments is the way forward for project management education. Jimenez, *et al.* (2011) have strongly advocated the inclusion of relevant case studies in teaching and learning of construction practice.

The professional project manager's capacity to function effectively and efficiently within today's dynamic complex projects requires certain skills including; adaptive leadership, reflective learning, a proactive mindset, superior communication and relationship management skills. Education also needs to prepare students for the dynamic nature of real life projects and environments that project managers, clients, contractors and others have to deal with on a routine basis. This cannot be taught solely within a classroom environment. The need for more practical learning has been highlighted in previous studies, and by graduates and employers. Entrants to MSc programmes without practical experience or thorough understanding of construction activities are unlikely to develop these fully within the traditional confines of a university programme.

Construction projects are fundamentally different from what they were 20 years ago, but not very much beyond IT-related processes has changed in what young project managers are being taught. Current project management education is considered by many employers and graduates alike to be composed of specific, circumscribed, learning packages aimed primarily at gaining and maintaining professional accreditation. In order to avoid what Veblen (1899) has referred to as the "conspicuous uselessness of education", many MSc programmes need to be more industry-based, with practical learning at the core to aid with application and understanding. It is those in the industry who are best placed to determine the knowledge requirements of a project manager, so they should have a greater role in the shaping of education and in the setting of course content and learning approach.

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COMMUNICATION MODES AND PERFORMANCE OF VIRTUAL DESIGN TEAMS IN AN UNDERGRADUATE BUILDING PROJECT

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Effective communication between parties in distributed design teams is essential for successful construction projects. However, there is little consensus and understanding on the factors influencing the distanced communication between these multidisciplinary parties. Many effective practices that are applicable to traditional collocated teams may no longer be relevant and require a thorough examination. This paper reports an on-going research project that aims to investigate the factors influencing the communication effectiveness of virtual design teams in a case project undertaken by final-year undergraduate students in two institutions in Canada and the UK. The empirical work involved a questionnaire survey of 69 students, comprising 32 UK (civil/structural engineering) and 37 Canadian (architectural) students. The findings suggest that there is tendency for different communication modes used by the two professions, with architects preferring visual and kinesthetic modes, and civil/structural engineers preferring aural and read/write modes, although this was not statistically significant (p=0.286). Higher levels of trust could be sustained by providing evidence of consistent performance over the course of the project. The architectural students and female participants are more likely to exhibit higher levels of trust to their counterparts and higher levels of satisfaction with team working. The findings reveal the potential influence of disciplinary training on the preferred communication modes and the development of effective virtual collaboration. Additionally, the research provides material for further reflection and may serve as a useful consideration for future development of a guiding framework for effective training of built environment professionals.

Keywords: communication, design, education, virtual teams.

INTRODUCTION

Construction works, by their very nature, are multi-disciplinary activities to achieve a common project objective. Although the diverse disciplines are believed to bring

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Soetanto R.; Poh P.; Austin S.; Hao J. and Katsanis C. (2012) Communication modes and performance of virtual design teams in an undergraduate building project *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 177-187.

innovative ideas in the products and processes (Horwitz and Horwitz 2007), the parties involved require effective information exchange protocol if the project is going to progress and achieve its intended objective. In reality this is difficult because these parties may have different interests on a project, as an outcome of interacting influences in their social, business, legal and educational environments. One of the notable influences is the educational background and training of individual parties in their earlier years of engagement with the built environment sectors.

It is recognised that many causes of poor performance in construction emanate from communication problems between parties during the course of a project (Dainty *et al.* 2006). Often the problems remain hidden until the construction plan and design are implemented on site. Communication between parties in the design process should not be overlooked as the process has significant impacts on the downstream activities, and on the creation of added value to the construction facilities. Advance developments in information and communication technologies (ICTs) have made possible real time, distanced communication between parties in different locations (Gaudes *et al.* 2007). However, the 'interface' problems which may have existed between these parties could be further exacerbated by the need to communicate over distance within a time constraint in an increasingly interconnected and globalised construction sector. Many effective practices that are applicable to traditional collocated teams may no longer be relevant and require a thorough examination.

Developing a better communication practice in the industry requires fundamental rethinking of the education content and process of the future built environment professionals. Multi-disciplinary working presents a significant conceptual challenge for the students as this requires a comprehensive understanding of the interests and orientation of the other subject disciplines, and fit them in the 'jigsaw' of knowledge to produce the constructed facility. This understanding may get better as individuals obtain more experience from their exposure in the workplace practice. Further, there are attitudinal requirements that will facilitate successful multi-disciplinary working, for example, a willingness to accept other ideas, level of trust, preference to working in teams, the ease to establish relationships with others in the team, which are very much related to the culture at functional, organisational and national levels. These all should be better acquired through experiential learning, rather than infused through the process of knowledge transmission during lecture session. This issue presents a complex and intricate problem for construction educators, whose main responsibility is to prepare the future professionals for the industry. A project, sponsored by Hewlett Packard (HP), has been initiated to address this challenge by creating an authentic, multi-disciplinary, distanced collaborative working environment, designed to mimic a real industry practice. A greater understanding of individual's preferred communication modes and significant factors influencing the performance of virtual teams will contribute to addressing this challenge. This paper reports the initial findings of the investigation of a simulated virtual team project of final year undergraduate built environment students in two institutions in Canada and the UK. A questionnaire survey of 69 students comprising of 32 UK (civil/structural engineering) and 37 Canadian (architectural) students was undertaken. The data were analysed using descriptive statistics and chi-square tests. The following sections describe the definition of virtual teams and factors influencing effective virtual teams focusing on the development of trust and team diversity, a method to identify individual preferred communication modes, group work process/ research design and methods, before the presentation and discussion of the findings. Conclusions are drawn to illustrate what

the findings may mean for the construction education and industry professional practices, and to describe future research.

TRUST AND PERFORMANCE IN VIRTUAL TEAMWORK

In this research, virtual teams comprise geographically distributed members who may have diverse expertise and responsibilities, but have to work together as a team to achieve a common project objective. Geographical separation of team members prevents frequent face-to-face communication and physical interactions for decision making, which has brought challenges to managing virtual teamwork. That is, it would be inappropriate to assume that factors influencing collocated teams effectiveness are valid for virtual teams (Potter and Balthazard 2002 c.f. Kirkman *et al.* 2004). Extensive research has been conducted to understand how and why teams achieve desired outcomes, however relatively little is known about the elements that determine and influence virtual team performance (Lee-Kelley and Sankey 2008, Algesheimer *et al.* 2011). Gaudes *et al.* (2007) compiled a comprehensive list of factors that contribute towards the effectiveness of virtual teams, but there is no pointer of which factors are the most appropriate for a certain context, and the same list could also be applicable for traditional collocated teams. Given the limitation of resources, it would be impractical to consider all factors, but the research identified trust-related factors inherent within individual members, that may influence the effectiveness of a virtual team.

Team development describes a progression of a team from merely a collective group to a performing team that capitalises the effort of each member into synchronised actions for a common objective. A team is built on trust. Traditionally, trust is nurtured through personal interactions between members over time. Teams develop higher levels of trust when they involved on more social interaction (Jarvenpaa and Leidner 1999 c.f. Gaudes *et al.* 2007). When team members are separated, they are less likely to establish one-to-one relationships (Chinowsky and Rojas 2003). Shortage of time due to commercial pressure further prevents the development of trust in teams. Several other factors that may contribute to the lack of (the development of) trust in this project are different disciplines involved, different working practices (i.e. building standards, regulations, legal framework), and different culture at functional, institutional and national levels (Zolin *et al.* 2004). In addition to project-based nature of construction, working in a virtual team does not enable the anticipation of future association which promotes trust and cooperation. Collocation allows teams to foster shared values, expectation, cohesion and increase commitment to objective (Daim *et al.* 2012). The absence of frequent face-to-face interaction, aligned expectation and team cohesion may increase the propensity of conflicts between team members (Kankanhalli et at. 2007).

In virtual collaboration, the word ‘trust’ is interpreted as perceptions of trustworthiness (Hardin 2000; c.f. Zolin ibid.). Mayer *et al.* (1995) and Zolin (ibid.) recommended three dimensions underlying perceived trustworthiness: benevolence, ability, and integrity. As defined in Zolin (ibid.), benevolence is the positive perception of the trustee towards the trustor (Mayer ibid.). Benevolence can be the outcome of parties having successfully aligned interests and goals in the project (Hardin 2000, Das and Teng 1998). Ability is the perception that the trustee has the skills and resources needed to perform the task for the project. Zolin (ibid.) distinguished between the skills and effort in that high level of effort (i.e. diligence) does not guarantee success if the party does not have the required skills to undertake

the task. In this case, levels of trust may suffer. Integrity refers to the trustee's honesty and moral character as perceived by the trustor. Trustee having integrity is seen to be more likely to behave in honourable ways and not deceive their co-workers about their intention to meet commitments and expectations (Zolin ibid.).

DIVERSITY IN VIRTUAL TEAMS

Past research on the relationships between team diversity/ composition and team performance has been inconclusive (Kankanhalli et at. 2007). Some scholars argue that diverse members will bring benefits to the team in terms of new perspectives to problem solving and innovative ideas (Staples *et al.* 2005 c.f. Gaudes *et al.* 2007), others found heterogeneous teams can experience significant difficulties resulting from tension and conflict (Horwitz and Horwitz 2007, Kankanhalli et at. 2007). In an evaluation of virtual team performance, Lee-Kelley and Sankey (2008) found that time zone and cultural differences affected communication and relations more than collocated team. In this research, team diversity has been manifested in bio-demographic/social and functional diversity (Kankanhalli et at. 2007). Bio-demographic/social diversity includes individual characteristics such as age, gender, race/ethniticy (Horwitz and Horwitz 2007). For the purposes of this research, only 'gender' was included. 'Age' is fairly uniform due to the students being in the same year. Many of the participating students are from overseas, and one would expect diversity of race and ethnicity in the groups. However, for ethical reasons, 'race/ethnicity' was not included in the research. Functional diversity arises from differences in educational background, working experience, and functional expertise among team members (Kankanhalli et at. 2007). The variables included in this research were working experience in the industry, experience in distanced collaboration, and educational background (civil/structural engineering and architecture).

IDENTIFYING PREFERRED COMMUNICATION MODES

Individuals have preferences on the way they work. Due to external factors such as economic pressure, organisational procedures, (domineering) colleagues, the preferences may not align well with the work they actually do. The mismatches can act as an indicator of possible role stress (Lee-Kelley 2006). In the context of the project, work type preference or skills or psychological mismatches in any areas of schedules, priorities, manpower sourcing, technology, administrative procedures, personality and cost, can cause a project to disintegrate (Thamhain and Wilemon 1975). The same information can be presented in different ways; the choice is made by individuals based on their cognitive process of sense making. The mismatches between preferred and actual communication modes may lead to less effective exchanges of information, misunderstanding, disputes and stresses. In educational context, the VARK (Visual, Aural, Read/write, Kinesthetic) questionnaire was developed by Neil D. Fleming in 1987 as a means to identify an individual's preferred communication modes (Marcy 2001). Fleming and Mills (1992) found that many students attributed their learning difficulties to the form in which course material was presented. That is, some students found they had difficulties learning in situations where the course material was only presented orally, while others reported similar difficulties when the material was primarily in written form. In comparison to other learning style questionnaires (e.g. Kolb's experiential learning style), VARK has a particular focus on identifying the preference of individuals to take-into and give-out information from their mind. The VARK questionnaire helps users to understand their

preferred communication modes, and allows them to reflect, and then facilitate their subsequent learning. Since it was created, VARK questionnaires have been widely adopted not only in education context, but also in businesses. Through online surveys since 2001, a large database has been collected (with around 2 million responses in 2011 alone) and analysed according to demographic and occupational backgrounds of the respondents. Self-evaluation of the results of the questionnaire produced a reasonable degree of accuracy, as was explained in Fleming (2012).

GROUP WORK PROCESS

During the course of the project, students worked in groups based on a project brief. A project scenario was developed based on a real academic building, which would be built in the future to replace the existing building. The comprehensive project brief included (i) description of purposes of building, requirements of facilities (e.g. rooms, area, environmental aspects), site location and constraints (relationships with the existing building and facilities in the surrounding area), requirements on group formation and work process (meetings, roles of individual student), assessment of tasks with detailed requirements for each project phases, and peer assessment using Web-PA system (see Wilkinson and Lamb 2010 for description of Web-PA). In addition to these, design guidance of building standards, structural design codes, poster and presentations were also provided.

Local groups of four students were formed in the participating universities. The UK students studied civil/structural engineering, whereas the Canadian students studied architecture. Each group was asked to produce one A2-sized poster which advertised the skills in the team. The teams reviewed the different team posters with a view to negotiating and agreeing with a counterpart team for the formation of a company. The teams conducted weekly meetings, and appointed a company leader and secretary that were rotated every four or five weeks, thus enabling each member of the team to carry out each role. The company leaders chaired the weekly project meeting, monitored and co-ordinated the work of the group, ensured that submission dates were met and generally oversaw the day-to-day running of the project team. The company secretary took the meeting minutes, noting any important points discussed, and deputised for the group leader in the event of their absence. The marking scheme combined individual and group marks for each task. The individual marks were derived from the assessment of the task that the individual was responsible for. The group mark was peer-assessed using Web-PA system. The system provides a control mechanism to discourage students being ‘passengers’ in the team. Further pedagogical benefits from peer assessment to the skills formation in a group work is explained in Wilkinson and Lamb (2010).

RESEARCH METHODS

A programme of data collection was developed to capture and monitor a number of important aspects of team collaboration (e.g. conflicts, trust, performance) throughout the project duration (one academic year). This included a series of interviews, questionnaire surveys, personal reflections, grades and tutor assessment feedback at different points with both students participating in the team activity and students on the same module who had opted to work collocated with students from the same institution (‘non-participating’ students). The questionnaire survey, reported in this paper, sought (i) background information (including course, gender, working experience, experience of distance collaboration), (ii) aspects of distance collaboration/team working (such as trust, quality of work, risk, perception on other

team members, communication, face-to-face meeting, satisfaction), (iii) VARK questionnaire, which comprises 16 questions (explaining 16 different situations), each with four different answers, that reflect different ways of taking and giving information for the same situation. For questions related to distance collaboration, the respondents were asked to express their level of agreement against a four-point scale from 1 to 4 where 1 indicates 'strongly disagree'; 2 'disagree'; 3 'agree'; and 4 'strongly agree'. Neutral middle point ('neither agree nor disagree') was not included to make respondents more discriminating in their responses, and this makes respondents more thoughtful and leads to more precise responses (Busch 1993, Garland 1991, Reid 1990). Therefore, the engagement with and accuracy of the scale used by the research may be improved through the use of a four-point scale. The responses to the VARK questionnaire were coded according to corresponding preferred modes (V, A, R or K). The respondents were allowed to choose multiple answers to each question. The responses corresponding to V, A, R, and K were then summarised. The highest score indicates the preferred mode. If there is a tie between two or more modal preferences, the result is considered a double or triple tied preference (Fleming 2012).

The questionnaires were distributed to all participating students before the project commenced. They were given around 15 minutes to complete this short questionnaire (three pages in total), and their responses were collected by the tutors during the session. This process yielded 69 responses, including 32 UK (civil/structural engineering) and 37 Canadian (architectural). Only very few did not hand-in their responses (2 students). The responses were analysed using descriptive statistics and chi-square tests obtained from SPSS software. Using students as the participants brought several advantages, notably higher response rate to the data collection exercises and importantly, higher degree of control over the tasks required in this 'experiment' (in terms of e.g. comparability across the groups). Although the use of students as respondents aligns well with the research focus on early education of built environment professionals, generalisation to the industry professionals should be drawn with caution, as they would have acquired more experience and other influences in the workplace. The results are presented in the following section.

RESULTS AND DISCUSSIONS

From a total of 69 responses, male students represent 66% and female 34%. Two-thirds (66%) had no work experience in the construction industry. Very few (2 students) had experience in distance collaborative before this project. Apart from experience in distance collaboration categories, the relatively even distribution of responses allow comparison between categories (e.g. comparison of responses between UK and Canada, male and female) to explore the relationship between categories and the other variables.

The analysis of 11 factors influencing distance collaboration revealed that the need to check progress and quality of other team members scored the two highest, honesty of other members was the third highest score. This confirms the need for conformance with individual expectations, and that trust will need to be confirmed by evidence of performance. Table 1 presents significant relationships between (institution and gender) categories and other variables in the questionnaire. The analysis revealed some evidence of a relationship between institutions and three perceptions of distance collaboration, namely (i) checking progress and (ii) quality of work, and (iii) honesty of other members. However, the relationships would not appear too strong (p-value of

0.094, 0.098 and 0.058, respectively). This indicates that higher levels of trust (in terms of 'integrity') could be sustained by providing evidence of consistent performance over the course of the project. An observation of data suggests that a higher degree of trust between team members is more likely to be found between students at the Canadian university (i.e. more students chose 'strongly agree', p=0.058). An explanation for this may be found in the fact that architecture students are required to spend more of their time working with their colleagues in the studio, which allows higher level of face-to-face interactions, which in turn, facilitates the development of trust. This is further supported by the significant relationship between gender and four perceptions of distance collaboration: (i) competence of team members (p=0.020), (ii) honesty of other members (p=0.027), (iii) other member completing work commitment on time (p=0.069), and (iv) individual satisfaction with working in a team (p=0.034). This confirms that higher degree of trust (in terms of 'integrity') between team members is more likely to be found between female students, who were mostly from the Canadian university. They are also more likely to derive higher levels of satisfaction from working in teams.

The results of the VARK questionnaire in relation to institution categories (i.e. UK and Canadian institutions) are presented in a histogram in Figure 1. It can be seen that UK students tend to prefer aural and read/write modes, whereas Canadian students tend to prefer visual and kinesthetic modes. The same tendency was also found in the gender categories. However, the relationships were not significant (with p-value of 0.286 and 0.294 respectively). The VARK website, which has been online since 2001, can provide a comparison of this finding with the general student population. Based on online responses from around 80,000 students from different levels (including universities, colleges and high schools), Fleming (2012) found significant differences (based on chi-square analysis) between males and females in their preferred communication modes with men have more kinesthetic responses and women more read/write responses. If the responses in this research should demonstrate the same tendency, the finding of our research suggests that training in the subject disciplines can influence the preferred communication mode of the students. In this case, there is tendency for different communication modes by the two professions, with architects preferring visual and kinesthetic modes, and civil/structural engineers preferring aural and read/write modes. There is no relationship between industry experience and VARK categories (p=0.603). However, there is a tendency for those who have had industry experience to prefer a kinesthetic mode of communication.

Table 1: Significant relationships between categories and other variables

Category versus Variable	Probability value
Institution vs. the need to check progress	0.094
Institution vs. the need to check quality	0.098
Institution vs. honesty of other members	0.058
Gender vs. team member competence	0.020
Gender vs. team member honesty	0.027
Gender vs. complete work commitment on time	0.069
Gender vs. satisfaction with teamworking	0.034
Institution vs. VARK	0.286
Gender vs. VARK	0.294

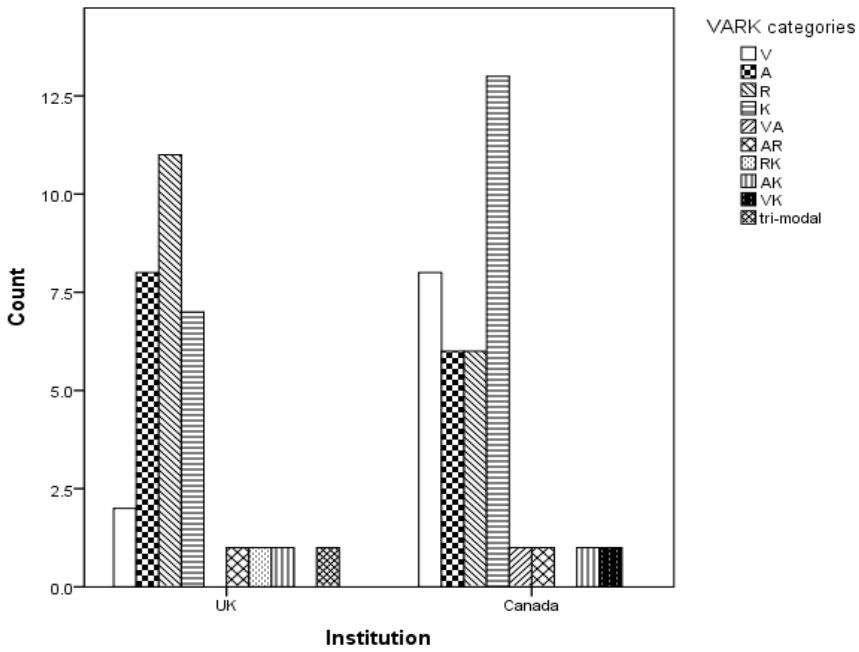

Figure 1: VARK profile for institution categories

CONCLUSIONS

Advances in ICT and changes of social, economic and legal requirements of the modern globalised world have redefined the way the parties in construction work together and communicate. Distributed team work across geographical boundaries has become more common and naturally unavoidable in modern construction. This represents a significant challenge to the industry as many effective practices that are applicable to traditional collocated teams may no longer be relevant and require a thorough examination. This research has considered factors that may influence the effectiveness of virtual team working through an investigation of authentic simulated learning environment where students work on a case study project. The investigation examines the factors during the training of the built environment students, who will

bring the skills and knowledge to their workplace after the completion of the study. One can expect that understanding of the factors during this training would allow appropriate adaptations to be made in the programme (i.e. curricula) so that the students would be better prepared to meet the requirements of virtual collaborative practice.

The findings suggest that different disciplines in this project tend to prefer different communication modes with UK students (civil/structural engineers, male majority) preferring aural and read/write modes, whereas Canadian students (architects, female majority) preferring visual and kinesthetic modes. A comparison of this finding with the general student population, as demonstrated by Fleming (2012), reveals the potential impact of disciplinary training to the students' preferred communication modes. Further evidence indicates that higher levels of 'integrity' trust could be sustained by providing evidence of consistent performance over the course of the project, and higher degrees of 'integrity' trust between team members is more likely to be found between female students, who were mostly from the Canadian university (architects). They are also more likely to derive higher levels of satisfaction from working in teams. If the 'integrity' trust is regarded as an essential foundation for an effective teamwork, the disciplinary training may have an influence on the development of effective virtual collaboration. It could be argued that architectural students are required to spend more of their time working with their colleagues in a studio, which allows higher levels of face-to-face interactions. This 'collegiate' training may facilitate the development of 'integrity' trust. However, in a virtual collaborative environment, this 'integrity' trust would need to be nurtured by consistent demonstrated performance (e.g. meeting deadlines and expectations of other members). This reciprocal relationship is further emphasised by individual satisfaction (as one measure of performance of teamwork) which was found to be derived from the performance of the other members.

The findings have implications on education and industry practices that can cut across national boundaries. The findings can be considered as a pointer to the possibility that construction educators may have not sufficiently addressed the grand idea of 'integration' between the disciplines/professions in the built environment, despite all the rhetoric and efforts that have been expended. Radical changes would not happen overnight, but multi-disciplinary collaborative working over distance should be made a fundamental element of the curricula. Currently, this skill is still considered high added value for employability, however in the future, this will be an essential part of built environment education. The research presented here has several limitations. Firstly, a small data set would have denied stronger results of the statistical tests. Secondly, other performance measures (such as assessments from tutors and industry practitioners, team cohesion) would need to be examined and incorporated in the research to investigate their relationships with the factors. Thirdly, generalisation to the general (practitioners) population should be drawn with caution, as practitioners would have acquired more experience and other influences in the workplace. These limitations suggest future research areas.

ACKNOWLEDGEMENTS

The authors wish to thank Hewlett Packard (HP) through the Office of Global Social Innovation for funding this research, International Society for Technology in Education (ISTE) and Global Collaboratory Consortium for facilitating the project. Thanks are due to all staff involved.

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THE INTEGRATION OF DIPLOMATS AND GRADUATES INTO THE CONSTRUCTION INDUSTRY: A PILOT SOUTH AFRICAN STUDY

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Tertiary construction management programmes are challenged in terms of producing diplomates, and graduates that are deemed suitable by employers and the built environment in general. However, employers and the built environment are also challenged as they have a complementary role to play. Tertiary education transfers knowledge and develops skills to a degree. Experiential training, internship, and the education of diplomates and graduates further develop skills. Consequently, employers fulfil a critical role and need to mentor, and integrate students, diplomates, and graduates into their organisations and the overall built environment. A study currently being conducted among members of a regional employer association to determine perceptions, and to provide feedback relative to diplomates and graduates, provides the basis for the paper. The following are reported on: the importance of competencies relative to subject streams and the rating of diplomates and graduates relative thereto; the importance of competencies relative to the nine functions in an organisation and the rating of diplomates and graduates relative thereto; and the importance of competencies relative to the functions of management work and the rating of diplomates and graduates relative thereto.

Keywords: **construction management, diplomates**, employers, graduates, **South Africa**

BACKGROUND

The Confederation of British Industry (CBI) (2008) states that when considering graduates for employment, employers seek a positive attitude, and wider employability skills needed in the workplace. The report reveals that executives rank positive attitude and employability skills at the top of their demands. These employability skills, *inter-alia*, include:

- Self-management - readiness to accept responsibility and improve performance, flexibility, time management;

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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*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 189-199.

- Team working - respecting others, co-operating, persuading, and contributing to discussions;
- Business and customer awareness – a basic understanding of the key drivers for business success and the need to satisfy the customer, and
- Problem solving – analysing facts, issues, and applying creative thinking to develop appropriate solutions.

This report therefore reinforced the significance of surface competencies in the form of knowledge and skills with respect to the practice of construction management. Smallwood (2006) contends that subject areas in the construction management domain reflect the focus at three respective levels of management: top, which is the management of the business of construction; middle, which is the management of a number of projects, and operational, which is the management of specific projects. As a result, tertiary construction management programmes are tailored to produce diplomates and graduates that are deemed suitable by employers and the built environment in general.

However, the education of students has continued to challenge both academia and the industry. The need to address aspects of these challenges in the South African context forms the basis of this paper. More so, Scott and Fortune (2009) reveal that there is a growing interest in the quality of students' learning experience, as there appears to be willingness to effect changes to current approaches. The overall objective of this study was therefore to ascertain the perceptions related to the performance of diplomates and graduates that are produced by a South African university for the benefit of the industry locally, and beyond. The initiative was embarked upon in order to secure responses to the following questions:

- Why diplomates are more highly regarded than graduates by employers?
- How long employers have worked with diplomates and graduates?
- What are the employers' defining experiences when working with diplomates and graduates?
- Is the balance between education / training of diplomates and graduates a key factor responsible for their performance in the work place?

Skills Required for the Practice of Construction Management

Given that the environment within which construction management is practiced is not stagnant, the debate about the content of construction management programmes and employers' expectations of construction graduates' performance has been ongoing for a while. In 1999, Davies, Csete and Poon (1999) published the findings of an empirical study conducted among construction graduates of The Hong Kong Polytechnic University and their employers. The empirical study was quantitative in nature because the use of a questionnaire described the development and testing of a paired graduate and employers' satisfaction in order to determine the development of general skills by graduates from professionally accredited construction degree programmes.

The survey revealed that graduates and employers from the population surveyed largely agreed on the importance of a set of general skills required by graduates. Such skills include computer literacy, collect and interpret information, lead others effectively, accept responsibility, recognise and respond to environmental concerns, exercise professional judgement, possess professional knowledge, and cope with

changing work environment, among others (Davies *et al.* 1999). However, comments from the employers and graduates indicated the need for additional skills in the form of problem solving skills, specialist technical skills, and the ability to conduct 'hands-on' training.

Furthermore, a survey conducted among graduates of the civil engineering programme at the Zagreb University, Croatia, between 1955 and 1985, determined the most important knowledge and skills for a construction manager (Katavic, Matic and Ceric, 2005). These include: command of technical knowledge and professional skills; responsibility towards the employees and the organisation; ability to organise and coordinate work; ability to establish good interpersonal relations; ability to contract work; ability to ensure quality control; ability to forecast; knowledge of economic business analyses; ability to manage employees; and ability to control cost (Katavic *et al.* 2005).

The nine recognised functions in an organisation thus provide further insight with respect to the knowledge and skills required by construction managers. According to Smallwood (2006), the nine functions may not be limited to general management; production; procurement; marketing; financial; human resources; public relations; legal, and administration as well as information technology. Because the organisational structures of contracting firms and related entities depend on these functions, it can be argued that successful management of the business of construction, which is not unrelated to the management of projects, is dependent upon the effective integration of these functions (Smallwood, 2006).

Also important in terms of the practice of construction management is the ability to execute projects using the functions of management work. The functions of management work in the form of planning, organising, leading, and controlling are vital for the ability to develop forecasting, programming and scheduling competencies, ability to delegate and develop relationships, communication and decision making abilities; and performance evaluation competencies (Allen, 1973 cited in Smallwood, 2006).

A Brief History of Construction Management Education in South Africa

In South Africa, degree courses in building management commenced in 1962 following the efforts of far sighted construction industry personalities. Foreseeing the future demands that the South African construction industry would be subjected as a result of increasing complexities pertaining to technology and business practices, the National Development Fund for the building industry was established in order to facilitate the start-up of degree programmes in South Africa. Administered by the Building Industries Federation South Africa (BIFSA), the fund assisted in establishing construction management university degree courses and also provided bursaries for students. Today, Chartered Institute of Building (CIOB) accredited BSc construction management programmes are offered at the University of Cape Town, the Nelson Mandela Metropolitan University, University of Pretoria, University of the Free State, and the University of the Witwatersrand.

RESEARCH METHOD

The sample stratum was purposively compiled. Purposive sampling refers to a non probabilistic or random selection of respondents for a study (Springer, 2010). The general contractors (GCs) surveyed were members of a regional employer association – East Cape Master Builders Association (ECMBA). The ECMBA was chosen as the

sampling population because of the role the association played when the programmes commenced at the then Port Elizabeth Technikon and the University of Port Elizabeth, but now collectively the Nelson Mandela Metropolitan University. As the primary employer association in the region, the association has continued to play important advisory roles pertaining to module development and other aspects at the department in Port Elizabeth.

The GCs that were contacted had employed construction management diplomates, and / or graduates at one time or the other. Given the relative small size of the city, only nine (9) GCs were eligible to take part in the pilot study. The GCs were surveyed per e-mail using a structured questionnaire consisting of seven principal questions and a number of sub-questions. The seven questions were close ended. Six of the seven close ended questions were five-point Likert scale type questions, which also included an 'unsure' as well as a 'not applicable' response option. The 9 responses were included in the analysis of the data using MS Excel to compute descriptive statistics, namely a measure of central tendency in the form of a mean score (MS).

The aforementioned explanations suggest that although the research design was qualitative, the primary data was collected quantitatively. This was in line with the intent of the pilot study, which was to reveal perceptions relative to diplomates and graduates produced by a particular university for the benefit of the members of a regional employer association. In effect, the findings of this preliminary study can be considered to be limited by the sample size and the number of respondents.

RESULTS

Respondents that took part in the study indicate that 6 firms have employed, while 2 firms are currently employing National Diploma Building diplomates from the university. 5 of the GCs also affirmed their willingness to employ diplomates from the institution. However, none of the firms were willing to employ BSc (Construction Studies) graduates from the university. Perhaps, this is because none of the GC firms has a BSc graduate in its employ, or because only 2 firms have employed them in the past.

It can also be observed that 4 respondents were willing to employ BTech Construction Management graduates from the university, while 3 of the firms had employed such graduates in the past, although only 1 firm is currently employing a BTech graduate from the university. It is notable that only 1 of the GCs had previously employed a BSc (Hons) Construction Management graduate from the university, while none of them is either currently or willing to employ BSc (Hons) graduates in their firms.

When asked to rate how important subject streams / subjects such as construction business environment, construction economics, construction law, construction science, construction technology, management practices, among others are for diplomates and graduates of the programmes listed in Table 2 based on a 5 point Likert scale, the respondents generally indicate 'a more than important' level for the subjects. Given that the scale ranged from 1 (not important); 2 (less than important); 3 (important); 4 (more than important), to 5 (very important), mean scores were computed for each subject stream / subject.

Concerning the National Diploma Building programme, the respondents rated the importance of construction technology as well as management principles, theories and practices more important than the other listed subject streams. The respondents also rated construction technology, management principles, theories, and practices,

construction science and construction law, to be more than important or very important for the BTech Construction Management programme. With the exception of research methodology, the ratings of subject streams indicated by the GCs concerning the BSc programmes seem to be more than important / very important. Furthermore, it is notable that with the exception of construction science, construction technology, and research methodology, the mean scores relative to the BSc programmes are higher than those for the Diploma / BTech programmes.

Table 1: Diplomates and Graduates in the employ of the respondents

Programme	Response (No.)								
	Has			Currently			Willing		
	Unsure	No	Yes	Unsure	No	Yes	Unsure	No	Yes
Diploma / BTech programmes:									
ND (Building)	0	2	6	0	5	2	1	2	5
BTech (Constr Man)	0	3	3	0	5	1	0	2	4
BSc programmes:									
BSc (Constr Studies)	0	3	2	0	5	0	1	4	0
BSc (Hons) (Constr Man)	0	4	1	0	5	0	1	4	0

Table 2 Respondents' ratings of the importance of subject streams / subjects

Programme	Subject stream / Subject (Mean score)							
	Construction business environment	Construction economics	Construction law	Construction science	Construction technology	Management principles & practices	Project management	Research methodology
Diploma / BTech programmes:								
ND (Building)	3.63	3.28	3.13	3.88	4.60	4.00	3.88	2.29
BTech (Constr Man)	3.83	3.71	4.14	4.43	4.71	4.57	3.86	2.67
BSc programmes:								
BSc (Constr Studies)	4.25	4.50	4.50	5.00	5.00	4.75	3.75	3.25
BSc (Hons) (Constr Man)	5.00	5.00	5.00	4.00	4.00	5.00	4.75	3.25

The GCs were then requested to rate the adequacy of diplomates and graduates from the programmes in terms of the adequacy of their preparation by tertiary education relative to the listed subject streams. The GCs were asked to make use of a scale of: 1 (most inadequate); 2 (inadequate); 3 (near adequate); 4 (adequate), and 5 (most

adequate). They were equally given the option of selecting an 'unsure' or 'not applicable'. N/R in the table indicates a 'no response.'

In this context, Table 3 shows that only construction technology, construction science and research methodology were perceived to be near adequate or adequate by the GCs concerning the National Diploma Building programme. However, in the BTech programme, the GCs were of the opinion that construction technology, research methodology, management principles, theories and practice, construction science, construction law, and project management can be considered to be near adequate or adequate. It is notable that majority of the GCs failed to indicate their perceptions concerning the adequacy of BSc programmes.

Perhaps, this may be as a result of the fact that they do not have such graduates in their employ as indicated in Table 1. However, the few GCs that expressed their opinions indicate that construction technology and construction science may be deemed adequate. The importance of required knowledge and skills to the accomplishment of both project and business objectives for GCs cannot be overemphasised. Therefore, the GCs were requested to rate 'how important' competencies related to knowledge and skills are, in terms of functions in a contracting organisation for construction management diplomates and graduates. The scale used in the questioned ranged from: 1 (not important); 2 (less than important); 3 (important); 4 (more than important), and 5 (very important). The 'unsure and not applicable' options were provided in the scale of measurement.

Table 3 Respondents' ratings of the adequacy of diplomates and graduates relative to subject streams / subjects

Programme	Subject stream / Subject (Mean score)							
	Construction business environment	Construction economics	Construction law	Construction science	Construction technology	Management principles & practices	Project management	Research methodology
Diploma / BTech programmes:								
ND (Bdg)	2.67	2.86	2.29	3.00	3.29	2.71	3.17	3.00
BTech (Constr Man)	2.33	2.75	3.50	3.67	4.00	3.75	3.25	4.00
BSc programmes:								
BSc (Constr Studies)	2.00	3.50	4.00	4.00	4.00	3.50	3.50	N/R
BSc (Hons) (Constr Man)	N/R	4.00	4.00	N/R	4.00	4.00	N/R	N/R

In Table 4 it can be observed that the GCs opined that production, purchasing and general management constitute the functions that can be deemed to be either important or more than important for Building diplomates; while all the functions, apart from marketing and public relations were perceived to be important for BTech graduates. In the BSc programmes, the GCs ratings ranged from important to very important for both programmes.

Using a scale of: 1 (very poor); 2 (poor); 3 (average); 4 (good), and 5 (excellent), the GCs were then asked to rate diplomates and graduates of the construction management programmes in terms of their competencies (knowledge and skills) when engaged in contracting organisational functions (Table 5).

Table 4 Respondents' ratings of the importance of organisational functions

Programme	Function (Mean score)								
	General management	Administration and IT	Financial	Human resources	Legal	Marketing	Production	Public relations	Purchasing
Diploma / BTech programmes:									
ND (Building)	4.00	3.67	3.56	3.33	3.33	2.33	4.44	3.33	4.11
BTech (Constr Man)	4.29	4.00	4.14	4.14	4.14	3.14	4.29	3.86	4.43
BSc programmes:									
BSc (Constr Studies)	4.40	4.40	4.40	4.20	4.40	3.80	4.20	4.40	4.60
BSc (Hons) (Constr Man)	4.60	4.80	4.80	4.40	4.80	4.40	4.00	4.80	4.60

'Unsure' and 'not applicable' options were also provided in this instance. The GCs rated the competencies of the diplomates when fulfilling organisational functions lower than that of graduates. In particular, their rating of the competencies of BSc programme graduates was between average and good for the honours programme and average for the BSc (Construction Studies) programme. The GCs' rating apportioned to the general management competency of BTech graduates predominated among the ratings related to the diploma and BTech programmes.

Table 5 Ratings of the competencies of diplomates and graduates relative to organisational functions

Programme	Organisation function (Mean score)								
	General management	Administration and IT	Financial	Human resources	Legal	Marketing	Production	Public relations	Purchasing
Diploma / BTech programmes:									
ND (Bdg)	2.71	3.00	2.43	2.50	2.43	2.14	3.14	3.00	2.71
BTech (Constr Man)	3.50	3.00	3.00	3.00	2.75	2.25	3.25	2.75	2.75
BSc programmes:									
BSc (Constr Studies)	4.00	3.50	3.50	3.50	3.50	3.00	3.50	3.00	4.00
BSc (Hons) (Constr Man)	4.00	3.00	4.00	4.00	4.00	4.00	4.00	N/R	3.00

In addition, using a scale of: 1 (not important); 2 (less than important); 3 (important); 4 (more than important), and 5 (very important), the GCs were asked to rate 'how important' skills relative to the five functions of management work (planning, organising, leading, controlling and coordinating) are in terms of the overall management of standard resources in construction in the form of finance, information, labour, materials, plant and equipment, and subcontractors for diplomates and graduates of the construction management programmes. As indicated in Table 6, the GCs were of the opinion that the principal functions of management work in the form of planning, organising, leading, controlling and coordinating are either more than important or very important to the programmes. It is notable that the BSc programmes did not record a MS less than 4.20, which indicate s a more than important / very important rating. However, the ratings of skills of diplomates and BTech graduates did not mirror the importance levels attached to these functions as indicated in Table 7. Table 7 indicates how the GCs rated diplomates and graduates of the construction management programmes in terms of their skills relative to the respective functions of management work concerning their overall management of standard resources in construction. The ratings, which are based on a scale of: 1 (very poor); 2 (poor); 3 (average); 4 (good), and 5 (excellent), suggest that the skills of graduates of BSc programmes were perceived to be either average or good, while that of diploma / BTech programmes were perceived to be either average or poor.

Table 6 Ratings of the importance of the functions of management work

Programme	Function of management work (Mean score)				
	Planning	Organising	Leading	Controlling	Coordinating
Diploma / BTech programmes:					
ND (Building)	4.44	4.22	4.33	4.44	4.11
BTech (Constr Man)	4.71	4.57	4.11	4.43	4.57
BSc programmes:					
BSc (Constr Studies)	5.00	4.83	4.83	4.83	4.67
BSc (Hons) (Constr Man)	5.00	4.83	4.83	4.83	4.67

Table 7 Ratings of skills relative to the respective functions of management work

Programme	Function of management work (Mean score)				
	Planning	Organising	Leading	Controlling	Coordinating
Diploma / BTech programmes:					
ND (Building)	2.86	3.00	3.00	3.14	2.57
BTech (Constr Man)	3.00	2.75	3.00	3.00	3.25
BSc programmes:					
BSc (Constr Studies)	3.50	3.50	3.50	3.50	4.00
BSc (Hons) (Constr Man)	4.00	4.00	4.00	4.00	4.00

DISCUSSION

It can be observed that the 9 GCs have employed diplomates, while only 3 of them employed BSc graduates from the university in the past. In addition, while none of the GCs are currently employing or willing to employ BSc graduates, all of the GCs were willing to employ diplomates from the university. Clearly, it can be argued that the perceptions of the respondents related to diplomates can be regarded as credible, while those pertaining to graduates may be less credible. In this context, the findings amplify the importance of certain subject streams in construction management education concerning diplomates. It can be observed that the respondents' ratings revolved around subject streams that include construction technology, construction

science, and management principles, theories, and practice. However, there appears to be a noticeable gap between the importance and the adequacy expressed by the GCs.

It is vital to address this perceived gap, since the industry opinion is that the performance of construction management graduates is inadequate in almost every learning outcome in comparison to the importance thereof (Rawlins and Marasini, 2011). The gap analysis between importance and performance of learning outcomes includes, *inter-alia*: demonstrate a critical approach to project and site management; knowledge and skills relating to construction technology; knowledge of the importance of key issues in construction; and knowledge of key concepts and theory, show that communication, management of relationships (people skills), leadership, evaluative judgements (problem solving), and team work, are the areas with the biggest gap. Even in the Alaskan construction industry in the United States of America (USA), the top construction management skills required pertain to oral and written communication; planning and scheduling; estimating; project administration and management; and decision making abilities in terms of alternatives, cost / benefit ratio, return on investment and net present value (Gunderson, Ra, Schroeder and Holland, 2002).

Therefore, it can be argued that the findings of the study pertaining to diplomates are not at variance with the findings of the study conducted in the UK by Rawlins and Marasini (2011). In effect, it would seem that the performance of construction management diplomates is not satisfactory to industry stakeholders in terms of knowledge and skills. As indicated in Table 4 and Table 5, there is a manifest gap between importance and performance of diplomates in terms of the ability to make use of learning outcomes in fulfilling functions in a contracting organisation. The human resources, legal, marketing, and public relations functions have the biggest gap. Because skills such as negotiation, leadership, teamwork, business writing and communication remain a prority among employers in the local and global contexts (Souder and Dennis, 2006), it is pertinent for the university to address the abovementioned gaps.

CONCLUSIONS

Because tertiary construction management programmes are challenged in terms of producing diplomates, and graduates that are deemed suitable by employers and the built environment in general, this study was initiated in order to determine perceptions, and to provide feedback relative to the performance of diplomates and graduates of a South African university in the work place.

Although the GCs that were purposively surveyed indicated that subject streams / subjects that constitute part of the construction management curricula in the four programmes offered at the university are important for diplomates and graduates, they however differ on the adequacy of the subjects. In particular, the GCs were of the opinion that there is major scope for improving the competencies of diploma and BTech programme graduates with respect to the ability to carry out the function of a contracting organisation. The GCs also observed that the skills of diploma and BTech graduates in terms of the planning, organising, leading, controlling, and coordinating functions of management work should be improved. Perhaps, their perceptions were focused on the diplomates because the surveyed GCs can be said to have not interacted with graduates of the BSc programmes from the university. Essentially, the

findings of the study can be regarded as a starting point for an in-depth study that should include a detailed list of employers of the construction management graduates from the university nationally and internationally.

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CURRICULUM INNOVATION IN TRANSNATIONAL TEACHING: A PILOT STUDY

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Students are increasingly operating in a globalised world. Off shore education is challenging for students and teachers, as both need to make connections between local and culturally located knowledge and discipline. The relevant literature indicates that the transnational classroom has a number of challenges. Skills and knowledge of off shore and on shore teachers to enhance the quality of off shore learning and teaching are limited and unrealised. Off shore students experience culturally dislocated and disconnected pedagogies which impede student learning, engagement, program cohesion, and graduate outcomes. Yet, the transnational classroom also offers opportunities. Not just from an economic perspective, it offers Universities an opening to build and maintain a global presence and has the potential to offer scholarship benefits to staff and students alike. This paper presents the results of one of RMIT University's Learning and Teaching Investment Funded applied research project. The aim of this project, trialled as a pilot was to improve student learning experiences, outcomes and employment opportunities by developing and implementing a transnational educational partnership comprising; on and off shore teachers, students, and local industry stakeholders. This partnership used focus groups, interviews and surveys to develop and deliver three interactive workshops designed to integrate international and local contexts and enhance student's learning and work. The results show that the partnership between on and off shore teachers introduced a change in teaching practice developed through a partnership with their local and off shore teachers, each other and local industry. In addition to enhanced student learning outcomes, opportunities for professional development for teachers were also realised. The success of this pilot has led to changes in the Bachelor of Applied Science Construction Management curriculum and teaching practices at RMIT University.

Keywords: construction management, curriculum development, teaching and learning, transnational education.

INTRODUCTION

Since the start of the new millennium, transnational education has made a slow and steady progress from few offerings to mainstream education (Bohm 2000; Cuthbert,

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Iyer-Raniga U and Wingrove D (2012) Curriculum innovation in transnational teaching: A pilot study *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 201-211.

Smith and Boey 2008). There is currently no accepted definition of transnational education. It can include off shore teaching to cross cultural teaching (Dashwood *et al.* 2008). For most universities in Australia, however, transnational education generally refers to formal educational qualifications by Australian universities outside their country (Ziguras 2007). Most universities in Australia now consider global education, in terms of content and presence, as part of their strategic vision. For transnational education to be successful however, there are many facets that need to be considered. True transnational education should reflect exchange of ideas or knowledge, of students and faculty (Altbach 2000). To do this, it is essential to examine and identify the culture based assumptions that impact on transnational program delivery.

Student experiences are central to any educational program. Traditional modes of education typically result in greater levels of satisfaction among students. Although typically, transnational education has been lagging slightly behind, students' experiences indicate satisfaction with the overall experience of transnational education (Archer and Brett 2009). With specific reference to Singapore, Dunn and Wallace (2004) report that Singapore students prefer to be given opportunities for deep learning, but the teaching, learning and assessment styles for Australian students do not produce the same interactions with Singaporean students. Singaporean students find the student centred pedagogical approach that characterises Australian higher education for teaching, learning and assessment to be confronting. In a subsequent paper, the same authors (Dunn and Wallace 2006) reported that there is an untapped potential in using the expertise of the local tutors and partner organisations in ensuring effective learning in the transnational classroom.

From a teachers' perspective, transnational education can provide fulfilling professional development opportunities (Smith 2009). Leask (2004) argues that transnational programs provide an opportunity for institutions to achieve internationalisation goals if academic staff can be assisted to transform their teaching through active engagement in other cultures.

To achieve good practice for transnational education (Baird and Gordon 2009) a number of factors need to be considered. Among this is the role of transnational pedagogy, considered in terms of both development of the pedagogy itself and a process for developing this pedagogy (Dashwood *et al.* 2008). A challenge is to determine how teachers recognise and apply good practice principles of transnational teaching and learning; and to understand the extent to which students derive benefits from the application of different pedagogies. Goodfellow *et al.* (2001) discuss intercultural issues with e-learning and transnational education, and suggest that communities of practice and a learning approach would be appropriate.

Central to transnational program design and delivery is the need to consider cultural differences right at the outset (Hoare 2006). Hoare showed that for a transnational program to be effective, one objective must be the 'recognition of, adaptation to and valorisation of, cultural difference' (Hoare 2006: 243). She suggests greater face to face student contact hours and longer periods between intensive teaching sessions, rather than focusing on teacher availability.

From a curriculum development perspective, epistemological awareness and attendant pedagogical questions need to be considered. Curricula cannot be simply transplanted without acknowledging cultural and social contexts. For Singaporean students in particular, Hoare (2006) recommends small groups as effective pedagogical practice, linked directly to assessment, wherever possible. Leask (2009, 2008) describes that

curriculum innovation in the transnational classroom will need to consider relationships between individuals, institutions and nations, and relationships between culture and knowledge. An internationalised curriculum will engage students with internationally informed research and, cultural and linguistic diversity. Local content and knowledge also has a place in the curriculum (McBurnie 2000). Strategies for professional development need to be developed, along with attendant changes in the curriculum design, teaching, learning and assessment methods.

In this paper, curriculum is referred to mean both teaching and pedagogy. This includes content, learning outcomes, and learning activities and assessment to meet required learning outcomes. The process of teaching and learning, interaction of the students amongst themselves, interaction of students with teachers, and competencies developed are all considered. As this paper focuses on curricula, only those elements directly related to curriculum development have been considered. Staff professional development and interactions, cross and inter cultural learning for example, have not been considered.

THE CONTEXT AND AIM

RMIT University's vision includes transnational education as a fundamental role in realising the University's mission to embed itself as a quality provider of further education and training in local and global contexts, reflected in RMIT's Strategic Plan 2010-15. The School of Property, Construction and Project Management (PCPM) has been offering the Bachelor of Applied Science (Construction Management) Program as a joint degree with SIM University since 1995. To date, over two thousand students have graduated from the program. Currently, students are enrolled for the 33rd Intake of the program.

The degree is identical to that awarded to a full time student studying in Australia. The program is taught over 2.5 years, as face-face part time, with classes over weekday evenings and Saturdays. Students enrolled in the program usually have a Polytechnic Diploma and most of them work full time, which is part of the attraction for the Program. There are 12 courses to be completed over 5 semesters, and these are taught by Singapore local lecturers (off shore, mostly appointed as sessional staff) and Melbourne lecturers (on shore teachers).

The aim of this applied research project was to develop a framework for curriculum innovation by fostering students' capacity and awareness of the role local and international culture plays in shaping professional practice. With limited resources, the obvious place to trial the partnership was in the transnational classroom, by developing and implementing an innovative transnational learning and teaching partnership model. The underlying approach in this paper uses the work of Dunn and Wallace (2006) to bridge gaps between Australian approaches to teaching and Singaporean students' abilities to learn. This model was piloted in in the Bachelor of Applied Science Construction Management Program- Research Project: BUIL 1222, from June-December 2010.

There were many challenges associated with the existing framework. Until 2010, BUIL 1222 consisted of a teamwork effort of 4-5 students per group, working on a predefined topic. There were difficulties with this approach; including, lack of ongoing engagement with the research groups by the RMIT lecturers leading to modest learning outcomes for this part of the curriculum. Due to cultural issues, timetabling and resources, the students often did not come prepared to the teacher-

student meetings. Follow up was conducted using email, however, due to language and cultural barriers, it was difficult for teachers to direct students appropriately, leading to only partial realisation of this engagement. From the student perspective, lack of confidence and language barriers dissuaded them from making the best use of available resources. It must be noted that although the common language in Singapore is English, official languages are English, Chinese, Malay and Tamil. Due to Singapore policies, increasing numbers of migrants are attracted to Singapore to service the building and construction sector.

The innovative approach comprised not just a change in the content of the curriculum, but also how the change was put into effect. The project team worked on a framework for curriculum change where on shore and off shore teachers were able to work together in the transnational classroom. A theme was selected to provide the framework for curriculum development and change. This theme was "Living in Singapore in 2020". The new course design for BUIL 1222 incorporated interactive student workshops involving teachers, industry and students at the start of the semester, where the focus was on discussion and debate and both, processes and content were explored. The number of students in this cohort was 65. The total number of teachers teaching this course was 7, comprising 3 on shore and 4 off shore teachers. These teachers were involved in the workshops.

The students presented their research work in the form of a written piece of work: 'research report' and a Poster. The posters were presented and assessed at the 'Industry Night', where RMIT and SIM University teachers and external industry experts were invited to view and assess student work. The rationale underlying this was two-fold: to give students the opportunity to showcase their work, and for the on shore and off shore teachers and industry experts to view and assess student work.

RESEARCH APPROACH

The theoretical framework underpinning the curriculum innovation was drawn from constructivist theory, recognizing the subjective nature of human experience. In addition, the project also used the self-learning and reflective practice model, as developed by Schon (1983). Reflective practice is linked closely to double loop learning as also espoused by Argyris (1990). The project team adopted a case study approach because this offered the most viable means of capturing rich experiential data, both qualitative and quantitative. Analysis of data captured through the roll out of the project informed the development of the transnational partnership model. A range of research instruments were used: focus groups, interviews and surveys.

A focus group was conducted with teachers involved in the course (total 7) prior to the roll out of the project to support collaboration and seek engagement of off shore teaching staff. This was conducted in Singapore and enabled the project team to determine if there were common goals in overall learning outcomes between on shore and off shore teachers as well as shared concerns in the learning outcomes of students. The focus group also enabled the project team to determine the themes for the course workshops and determine the industry participants to be invited to the workshop. Interviews with three selected on shore teachers provided the historical context and the background leading to the current course learning outcomes, and whether the framework for the proposed curriculum innovation would work in Singapore. Student pre and post course surveys were designed to capture student learning goals, preferences and outcomes, and overall project impact of the curriculum innovation. Pre and post course teacher surveys, administered to both on and off shore teachers

were also undertaken, designed to capture professional learning aims, research and industry interests needs and project impact.

All students were provided with paper copies of a survey and asked to complete these in the class at the commencement of the course. The pre survey was undertaken at the information session provided to the Final year students, and the post survey was undertaken at the Industry Night. Pre and post course surveys were compiled in Excel to allow data to be analysed. In addition to this, pre and post course survey responses were entered into a secure online survey using Survey Monkey for the purposes of data analysis. Pre and post course teacher surveys were completed online using Survey Monkey making it easier for data analysis. As the sample sizes were small, it was easier to use Excel rather than coding into more sophisticated packages such as NVivo.

Data from the student and teacher surveys and teacher interviews were analysed to determine themes and patterns. Data was further evaluated in light of current and recent research as discussed in the literature. Where possible variables of gender and years in industry were used to establish patterns within the data. Summary notes of all interviews sessions were taken and sent back to the contributing participants for review and approval before being considered as research outcomes. For qualitative analysis, all captured data was analysed using qualitative data coding techniques to identify main themes. Patterns and themes arising from the data informed the research project's findings, including recommendations for the future development and implementation of a potential transnational teaching partnership in the future.

All data was numerically coded in the project report. No person was attributed to any response; it was reported anonymously and patterns rather than specific responses were sought for the curriculum innovation component of the research project. Participation in the partnership model and the project's research was voluntary for both students and teachers. Prior discussions with the teachers both, on shore and off shore indicated a willingness to work collaboratively on the research project, hence there was an implicit commitment to improving their teaching. Likewise, for Singapore students, participation in the project's research was also voluntary.

There are limitations to this study. As the research was conducted for the Bachelor of Applied Science Construction Management between RMIT and SIM Universities, the findings cannot be generalised for all construction management curricula. The application of the pilot model in other off shore courses and programs delivered across RMIT is likewise, limited. This also applies to wider findings across international partnerships among other universities. Nevertheless, this study does provide an insight to effective teaching and learning as a cycle of continuous improvement. Observations were made by one of the Project Leaders during the Industry Night, and informal discussions with teachers and students were also held to ensure that the findings of the study are consistent with the data obtained. This was done mainly for validating the findings, rather than as a means for gathering additional data.

CURRICULUM INNOVATION

As this paper focuses on curriculum innovation the finding and discussions are restricted to these aspects of the research project only. The curriculum innovation focused on one course. Prior to the commencement of the semester, focus group undertaken with staff assisted in developing the content for the workshops for the course and gather baseline data. Likewise, the student preparatory workshop was used

to explain proposed changes and gather baseline data from students as per the research plan. Although the original intention was to run four, only three industry workshops were undertaken due to time constraints. It was decided to run the workshops during the time the RMIT teachers were teaching in Singapore due to resource constraints. Workshops were undertaken from July-September 2010 to coincide teaching times of RMIT teachers. The workshop themes were: Sustainability; Property and Construction, and Economic and Social Contexts of the construction industry as determined through the focus groups and discussions with the on shore and off shore teachers. Each workshop was led by an RMIT teacher and supported by off shore teachers. Where possible, industry mentors were also invited to the workshops. The workshop assessment contributed to 30% total of the overall score, with each workshop assessment being 10% of the total. The remaining 70% assessment comprised of 30% for the poster presentation and viva at the Industry Night and 40% for a written paper- the ‘research report’.

The workshop worked as a 'constructionarium', where students worked on tasks for a short period of time. The focus was on high level response, not detailed information. Each workshop comprised three hours duration. The first hour involved a presentation by the lecturers on the theme of that particular workshop. Thus, a partnership between on shore and off shore teachers were realised during the workshops. Prior reading materials were provided to students, so they came prepared to the transnational classroom. The second hour included student engagement in their pre allocated groups, with the lecturers/guest lecturers working with the students. The third hour involved students presenting to the class their responses and in class assessments by the off shore and on shore teachers.

Each workshop addressed five questions. The students critically engaged with these questions in their groups and presented the responses to the class in the third hour. Prior reading materials provided to the students was undertaken in consultation with on shore and off shore teachers. Students submitted their responses as a record to their lecturers via an online learning hub on a standard template. The questions for the workshop were:

1. What is living in Singapore going to be like in 2020 from a sustainability perspective; from a property and construction perspective and from economic and social perspectives?
2. What needs to be done to maximise benefits?
3. What areas need to be prioritised in each sector?
4. Suggest at least two ways in which changes can be facilitated.
5. How can these changes give a competitive edge for Singapore companies?

An Industry Night was held at the end of the semester where students presented their work. The Industry Night was well attended by staff of SIM and RMIT Universities, and other members from the industry such as student employers.

FINDINGS AND DISCUSSION

This section presents the findings and attendant discussion. As the sample size of the teacher group is small, the resulting data cannot be considered statistically significant or extrapolated to a wider group. The Construction Management Program was taught by 8 local teachers from Singapore and 4 teachers from Australia, so this represented the sample size of the teachers. The sample size of the student group is considerably larger in comparison, with 65 students participating in the course and accompanying research. As the focus of this paper is on curriculum development, this paper focuses

on student responses to the curriculum innovation. Some elements of the teacher survey considered noteworthy and general observations by the Project Leader have also been presented.

Pre course student survey

As already indicated, students were surveyed before and after the course. Of the 65 students who participated in this study, the gender split was female 37 and male 27 with 53 indicating they were currently working in the construction industry on a full time basis. Of these 70% (38) had been employed for between one-five years and 18.5% (10) for between five-ten years in the industry with the remaining 11.5 % (6) having been in the industry for over ten years. The respondents were aged between 20 and 45 years of age; 45 respondents were aged 26-35 and 22 were aged 20-25. Only 2 respondents were aged 36-45.

A question in the survey related to why students were enrolled in the Program. The most frequent responses to the question was a combination of 'improving employment prospects; career development; and personal satisfaction' comprising of 18 responses, closely followed by 'career development' with 16 responses.

Open and close ended responses were sought as to whether student learning so far in the Program supported their professional practice. In response to the close ended part of the question, 53 (80%) of 66 respondents agreed that the BCM program has supported their professional practice. Seven respondents (11%) agreed and disagreed with the questions, while just 6 (9%) disagreed with the question. In response to the open ended part of the question about learning outcomes students perceived the program had fostered: industry knowledge, technical knowledge, career development, capacity as a learner, knowledge building, confidence, discipline knowledge, broadening of understanding of other fields related to construction. In addition, fitting learning into cultural experience and geography dominated the responses.

Students were also asked to identify their preferred learning styles. Most students preferred to work in groups directed by the teacher or face to face interaction as directed by the teacher. Working in groups with a mentor or working individually with a mentor did not score highly in comparison. When students were asked to identify their expectations of BUIL 1222, 45 (85%) of 53 respondents agreed that BUIL 1222 would 'deliver useful and relevant learning.' Two respondents (4%) indicated that the course would not deliver useful learning, while six respondents (11%) indicated both.

Post-course student survey

After the students completed and submitted their Posters at the Industry Night, students were asked to rank the list of outcomes and aptitudes arising from the new teaching partnership. Students strongly agreed 'understanding of current /emerging issues in the local construction industry context' was the primary outcome, closely followed by 'ability to work in teams'.

Most students agreed that 'ability to think globally and consider construction management issues from local and international perspectives' and 'ability to source research material from a variety of sources' were the most important outcomes. This was closely followed by agreement on 'ability to evaluate diverse views to take an informed position on differing viewpoints', 'ability to evaluate research material from a variety of sources', and 'ability to make ethical decisions about the impact of the construction industry in Singapore'.

These findings demonstrate that the pilot curriculum intervention has, from the student perspective delivered successful results. The new learning model improved student's capability development. When analysed according to gender, it was found that women were overall 21% more likely to choose 'neutral' as a response to these statements than men. Nearly 7.5% of men and 27% of women chose 'neutral' to the statement 'ability to make ethical decisions in the workplace'; 7.4% of men and 27% of women chose 'neutral' to the statement 'ability to make ethical decisions about the impact of the construction industry in Singapore'. In all but one of these statements a higher proportion of men responded 'strongly agree'. 'Working in teams' was the only statement where a higher proportion of women responded 'strongly agree'.

When asked about their overall experience of the course, there was a strong agreement expressed by majority of students that the BUIL 1222 course would benefit their career, that they would recommend the course to their peers, with the partnership perceived by the majority as having improved their learning.

Discussion

As identified in the literature and reported in the first section of this paper, there are significant challenges in engaging off shore students in the transnational classroom, and in fostering quality learning and graduate outcomes. Eliciting genuine critical feedback and encouraging critical engagement with content and delivery with Singapore students is challenging as on shore teachers are seen as experts and are held in higher esteem than the local teaching staff (Dunn and Wallace 2006, Gribble and Ziguras 2003).

In its endeavour to address this challenge, the project team incorporated student briefings in the project design to make explicit to students the purpose of the project, and the significance of their learning and teaching experiences for the Program and the future of the Program. As a large proportion of students (80%) were working either full time or part time in the building and construction industry, the students had the nous to comment on the Program outcomes and related aptitudes. It also provides the underlying reasons as to why students indicated 'career development' and 'improving employment prospects' as being primary reasons for enrolling in the Program. Eighty percent of the students indicated that the Program supported their professional practice. This also highlighted that they considered professional practice capability as core to the learning outcomes of the Program. In addition, students also identified dispositional factors such as self-confidence as learning outcomes they had developed prior to the teaching partnership approach to the final year Research Project.

The curriculum intervention involved a mixture of student to student, and student to teacher interactions. Understanding student's learning preferences served to illuminate the degree to which the pedagogy enacted through the teacher partnership aligned with students preferred learning styles. This contributed useful knowledge about the cohort and about how to in the future, bridge the disjuncture between Westernised and non-Westernised pedagogies. Understanding the degree to which the partnership aligned with student's preferences also contributes to knowledge of culturally located ways of knowing for local Singaporean students. Using the local teachers and the industry as a resource assisted this process.

In the pre course survey, students were confident that the course would deliver useful learning. This was confirmed in the post course student survey. Broadly, the majority of students strongly agreed or agreed that they had developed a suite of capabilities to

enhance professional practice. There were strong agreements on a number of key outcomes and attitudes, including understanding key issues in the local construction industry context and team work. Students agreed that they were able to think globally and consider construction management issues from local and international perspectives. They were also able to source material from a variety of sources, which equipped them with useful professional attributes.

In summary, the curriculum innovation enhanced the quality of learning and teaching in BUIL 1222, and supported the development of student's professional practice capabilities skills and expertise, and improved learning outcomes. From the teachers perspective, intercultural learning and understandings were facilitated between off shore teachers and their students, and between on and off shore teachers. The ‘us’ and ‘them’ mentality that existed to date between the on shore and off shore teachers was diluted through the new partnership model used as the foundation of this research.

There are clear limitations as already identified. The project was trialled over one semester, with only a small group of teachers and one student cohort. A longitudinal study would greatly benefit in providing greater richness and validity to the findings of this pilot project. Tracking the impacts of the pedagogical developments would greatly benefit content, approach and student learning outcomes of the Program and related aptitudes of students. So too, would expanding this model across the Program.

The curriculum intervention introduced in the course BUIL 1222 has the potential to be applicable to diverse disciplines, both on and off shore. Modest innovative changes as shown with this project design model has the potential to be adopted for application across wider RMIT off shore programs, with a professional development teaching partnership applicable to a breadth of program delivery.

CONCLUSIONS AND RECOMMENDATIONS

The aim of the project was to develop a framework for curriculum innovation. This was done by developing and implementing an innovative transnational learning and teaching partnership model. This model was piloted in an off shore Program offered by RMIT University in Singapore. The results from this pilot show that it is possible to implement and evaluate a model of intercultural learning to identify and develop best practice in transnational education. The curriculum innovation analysed has the potential to enhance transnational learning experience and graduate outcomes by engaging students in local and internationalised learning facilitated by off shore and on shore teachers, including local industry experts. As this paper has explored, it is possible to create a forum for the exchange of intercultural teaching skills, knowledge and expertise, and to actively foster student’s preparation for professional practice. In tandem, there are unrealised opportunities to create an evidence base for future professional development for on shore and off shore staff. The project enhanced student learning and fostered student's pride in their work through formal recognition and rewards, culminated in a presentation at the Industry Night.

It is recommended transnational programs consider how international and local knowledge can enhance student learning outcomes by planning, designing and implementing a teaching approach comprising local knowledge as part of the curriculum. Creating partnerships with on shore and off shore staff in the transnational classroom can provide opportunities for professional development for staff, while enhancing learning experience for students and teaching experience for staff.

ACKNOWLEDGEMENTS

The authors thank RMIT University for the LTIF grant, on shore and off shore teachers and staff, and off shore students involved in the project. In particular, the authors thank Kathryn Robson and Guillermo Aranda-Mena.

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WORKSHOPS AS EMBYRONIC BOUNDARY OBJECTS FOR COLLABORATIVE UNIVERSITY-INDUSTRY INNOVATION IN CONSTRUCTION

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The authors participated in different capacities in a project originally conceived for the transfer of knowledge from university-based research to the engineering-construction industry. The project's original aim was 'to collect knowledge from across the [...] portfolio' of a university research centre and re-package this knowledge to meet the business needs' of the member companies of an engineering-construction industry association. We took the opportunity the project created of exploring whether and how the social worlds of construction academics and engineering-construction industry practitioners might cooperate to create the conditions for collaborative innovation in spite of differences of a kind often deemed to be barriers to university-industry collaboration. Through an analysis of the project's unfolding between construction-industry and academic parties, we first reveal some of the apparent differences between them and then consider the possibility that boundary objects might facilitate cooperation for innovation without eliminating the differences. We pay particular attention to workshops as boundary objects.

Keywords: innovation, knowledge transfer, technology transfer, university-industry links.

INTRODUCTION

There is widespread agreement these days that knowledge produced by research is essential to much innovation and thus to sustainable economic growth. That agreement does not extend, however, to the ways in which knowledge should be produced. For the consensus about research governance that characterized the decades following the second world war, in which scientists were entrusted with the safekeeping of science, and politics was excluded from it (so that science could speak truth to power), is long dead. Policy researchers have collectively torn up the linear model of innovation now regarded as having underlain the post-war consensus and with it the usually unspoken assumption that basic science could be relied upon to keep society's larder stocked with the knowledge required for the innovations that would secure continued economic growth.

In its place, numerous conceptions of the proper place for research in society currently vie with one another. Mode 2 (Gibbons *et al.* 1994) is perhaps the best known and

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Stokes, C; Carrillo, P and Dainty, A (2012) Workshops as embyronic boundary objects for collaborative university-industry innovation in construction *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 213-222.

most widely admired. It has many adherents in the policy making community. Academic promoters are to be found in numerous disciplines, notably research policy and mainstream organization and management studies (OMS) in Europe. Others have stronger followings in the US, such as engaged scholarship (Van de Ven, 2007). The so-called co-production of knowledge is another close relative flourishing in Europe. After it won support in mainstream organization and management studies in the UK in recent years (see e.g. Knight and Pettigrew, 2008), several construction management researchers have recommended it as an approach to doing research in construction management (Stokes and Dainty, 2011). While they hedge their advocacy by endorsing co-production as a complement to, not a replacement for, other approaches, they nevertheless say that 'one thing is for sure' – that the CM research community needs more research in the co-production mould (Green, Kao and Larsen, 2010: 126).

In theory, the direct participation of potential beneficiaries (and possibly other stakeholders) in the co-production or mode-2 production of knowledge assures its exploitation. Nevertheless, whatever the merits of heterodox ways of organizing research, we presume that traditional forms of knowledge transfer will continue to thrive. Imagine a future landscape in which many more problems are solved through mode-2 and similar forms of knowledge production than at present. Leave aside whatever knowledge emerges from more orthodox endeavours. For the new knowledge produced in these problem-solving efforts would there not in general be more potential beneficiaries and/or stakeholders than could typically be accommodated as research participants? These will need to be served by knowledge transfer or variants of it.

We use the term ‘knowledge transfer’ here to refer to practices intended to bridge knowledge production and exploitation by transferring knowledge (or technology) once it has been produced from its producers to potential beneficiaries for subsequent exploitation. (This usage, usually associated with innovation, is different from the common and more generic usage in knowledge management, where 'knowledge transfer' usually refers to the movement of knowledge within a business or an industry and not necessarily for innovation.) Traditionally, knowledge-transfer practices were conceived of as working one-way like this. Their intent was dissemination, a word still frequently used unselfconsciously by academics. In recent years these practices have been joined by others promoted as surpassing or at least complementing unidirectional technology and knowledge transfer – for example knowledge exchange, knowledge brokerage (Meyer, 2010), knowledge mobilization (Levin, 2008) and K* (UNU-INWEH, 2012).

The idea that knowledge production and exploitation need bridging by knowledge transfer or to be more intimately interwoven in new modes of knowledge production underlines their separation in the thinking and practice of researchers, policy makers and lay observers. One way this manifests itself is in explanations for why innovation systems are not more effective. Bruneel *et al.*'s (2010) categorization of barriers to university-industry collaboration is typical in seeking to attribute limitations of the innovation system to differences (actual and perceived) between what we might call, after the symbolic interactionists, 'social worlds'. This perspective usually neglects however the possibility of cooperation without consensus – without, that is, complete alignment of practices and elimination of differences. This is, of course, a possibility that Star and Griesemer (1989) reckon may be realized through systems of what they call 'boundary objects' combined with associated work practices such as methods standardization.Our aim is to assess the possibility that boundary objects might be

fashioned to coordinate the efforts of university-based construction researchers and engineering-construction industry practitioners to generate knowledge-based innovation and thus avoid the necessity of eliminating the differences. We pay particular attention to workshops as embryonic boundary objects.

As the knowledge-transfer project and the reflexive research we have been conducting on the back of that project are yet to be completed, this paper can make only a limited contribution. What we have been able to demonstrate on a practical level is the messy complexity that knowledge transfer can take on even in circumstances that on their surface may lead one to expect simple efficiency and even when we confine our attention, as we do here, to the early stages of collaborative university-industry innovation, that is the facilitation of tie formation between potential innovation partners. Theoretically, we are consider the shaping of objects that may in time become boundary objects. We do this in particular by treating workshops which we organized, participated in and observed directly in our knowledge-transfer project as boundary objects in the making. The boundary object (Star and Griesemer, 1989) has become an extremely popular concept with all manner of social scientists and humanists. Frequently, however, researchers have neglected certain dimensions of the concept that Star regarded as important (Star, 2010). We have been careful to take full account these dimensions.

METHOD

Our study is based on the involvement in different roles of all three authors in the knowledge-transfer project whose unfolding we outline in the following section. Stokes, employed as a research associate, has the role of facilitator. Carrillo is the principal investigator, that is the academic who leads the project, controls the money in its budget and is responsible for its final report. She took over as principal investigator from another academic three months into the project when he retired; for the first three months, she was formally a co-investigator. Dainty is a co-investigator, that is an academic who is participating in the project alongside the principal investigator but without budgetary control and without ultimate responsibility for final reporting.

In the original proposal, the project is defined as a knowledge-transfer project and makes no provision for research. At the outset, however, the first principal investigator encouraged Stokes to regard it additionally as an opportunity for research. At first, the investigators and Stokes expected the topic that the project would offer the best chance to research would be communities of practice because of the importance the original proposal gave to communities of practice. As our account of the research below indicates, this expectation dwindled rapidly in the first months of work as negotiations between ITA and those engaged in the knowledge-transfer project at Erewhon led to a new focus on the use of existing ITA activities – in particular, workshops and ITA's annual conference – as the vehicles that would be used for knowledge transfer. The research element of the project is a case study of the knowledge-transfer project. Data was collected mainly by Stokes in a participant-observer capacity. Stokes and Carrillo had access too to a large amount of documentary data that had been accumulated by the research centre, ARC (see below). Their access was greatly facilitated by the research centre's coordinator, who knew his way around the structure of the data directories in which the data had been stored, so to speak. We have used pseudonyms for many of the actors involved in the project for reasons of confidentiality.

THE CASE

ARC and ITA

ARC was a research centre at Erewhon University funded for the ten-year period 1999–2009 by a research council. The researchers who held ARC grants came from several academic departments. Those in the construction department, more than half in construction management, received the second largest departmental share of ARC research funds. With it, they conducted more than 30 substantive research projects.

ITA is an international engineering-construction industry association. Mostly project-based businesses, members range from large multinational corporations to SMEs. They include clients, contractors and consultants. Its mission is the continual improvement of members' performance, for which it runs three main activities – an annual programme of events, including a conference and a series of one-day workshops; a set of communities of practice focused on different aspects of the engineering construction business, some formed to address a single issue then disbanded, others, formed long ago, focusing on an indefinite sequence of issues; and a publishing programme, which produces guides, training manuals and reports.

COPIER

A year before ARC was due to close, an academic in Erewhon's construction department obtained funding from the university for a knowledge-transfer project that aimed ‘to transfer the knowledge created by [ARC] to the engineering construction sector through the creation of a [c]ommunity of [p]ractice (CoP) between [ARC] and [ITA]’. We shall refer to the project as COPIER. The funding came from a fund the university had won from the same research council that had funded ARC for its ten-year lifetime. One of several held by UK universities, it is specifically for work that overcomes the obstacles standing between the research the research council normally funds and its better exploitation.

The academic who wrote the proposal for COPIER left Erewhon unexpectedly before it started. COPIER consequently began several months late and with a substitute academic at its helm. Two important knock-on effects followed. First, by the time it began, the project had to be completed in one year, not the 18 months first planned. Secondly, a project coordinator was recruited three months after COPIER started on a six-month fixed-term contract to provide marketing and other support to the project leader and the research associate.

In spite of substantial existing links between Erewhon and ITA, the first weeks of the project saw not only its fundamental shape but its very existence threatened. ITA’s officers, it transpired, could recall only barely, if at all, having heard of the project or the knowledge-transfer idea behind it. Without their cooperation, COPIER could not proceed. The director of ARC, academic leader of COPIER for its first three months (until retirement), responded by holding discussions with ITA managers and, with two of the authors (Stokes and Carrillo), re-worked the proposal, written for internal university use only, into a form in which it could be respectably presented to a forthcoming ITA board meeting.

The resulting document retained the original proposal’s knowledge-transfer aim, a list of the ARC projects likely to be of most interest to ITA members and a list, slightly modified from the original, of the activities by which the aim was to be realized. The main ones were: 1) a web-based repository of the knowledge produced by ARC repackaged for easy search and assimilation by practitioners; 2) masterclasses, which

the COPIER team hoped would appeal to ITA members, used as they were to masterclasses ITA had long been running for them; 3) contributions to ordinary workshops in ITA's annual workshop programme and its annual conference; and 4) one-to-one knowledge packages, comprising an expert diagnosis of the knowledge needs of a member company followed by advice on how to realize them.

Towards the end of COPIER's first month, the ITA board meeting took place. In presenting the revised proposal, the COPIER team, anxious to win the board's approval and so avoid the closure of the project, emphasized that the set of knowledge-transfer activities it outlined was open to negotiation. They welcomed ITA and its members to propose modifications to them or indeed additional activities – activities with which they might be more comfortable.

In a bid to give some momentum to the process – fundamental to this knowledge-transfer project but now behind schedule – of identifying interests shared by ARC academics and ITA members, the team also presented a one-page summary of a single ARC research project – a project the team judged likely to be one of the most amenable to industrial application. Written in plain language, it was divided into sections – abstract, start and end dates, background, approach, results, stage of development, application domains and intellectual property – and ended with a table with contact details for the lead researcher, a list of collaborators and a list of related ARC projects. If acceptable to ITA, the team suggested, the format could be used for summaries of all 30-odd construction-related ARC projects.

The ITA board responded positively to the proposal. They were receptive to the project summary too but requested a set of briefer summaries for the ARC construction research projects in the first instance to save time. The COPIER team produced the summaries in tabular form and ITA sent a copy to each of their communities of practice with a request for an initial indication of the projects of most interest to them. When this drew no useful response, ITA sent the project summaries to the ITA contact at each of its members. After this too failed to get a response, ITA and the COPIER team met to decide how to keep the project alive.

At this meeting the decision was made in a straightforward manner. The ITA managers leafed through a printed copy of the project summaries, picked out projects they thought most likely to interest their members, and invited the COPIER team to organize the next regular ITA workshops with themes derived from their selection of ARC projects. The invitation to run ITA workshops surprised the COPIER team but with three and a half months of the project already behind them they accepted. In what follows, we focus on the organization of the workshops that stemmed from this decision, which came to be central to COPIER. We touch on other parallel COPIER activities only in so far as they help in our analysis of workshop organization.

WORKSHOPS

If, as the ITA managers hoped, the roughly monthly frequency of ITA's workshops was not to be disrupted, the first ARC-ITA workshop would need to take place in two month's time. The discussions and negotiations that took place between the COPIER team and the ITA managers over the next few weeks as the former tried hurriedly to organize that first workshop turned up several differences that challenged their agreement. The innocuous label 'workshop', it emerged, held different meanings for the COPIER team and the ITA managers. For academics, workshops are primarily occasions, staged towards the end of a research project, for what they often still term

'dissemination' (in spite of its one-way knowledge-transfer connotation) of their research findings. ITA workshops, as the COPIER team learned from attending two in the weeks following their agreement, were occasions for construction-industry professionals to hear from industry peers how they or their company had handled a particular problem or implemented a new process and what the results had been. The following are some of the differences that most struck the COPIER team.

1. The ITA managers believed that the COPIER team would be able and willing to enlist the speakers for their workshops from construction businesses that had collaborated in ARC research. The lead COPIER researcher had later to make clear that this would likely not happen because researchers are rarely comfortable risking their relationship with collaborators by asking favours of this magnitude of them.
2. Their annual subscription fee entitles member companies to send delegates to ITA workshops free of charge. Non-members must pay a substantial fee. The COPIER team argued, however, that it would be wrong to charge ARC-ITA workshop delegates because the research findings to be disseminated came from publicly-funded research. ITA made concessions for Erewhon construction academic delegates but insisted on charging others as normal. Otherwise, they feared, ITA members would think they were subsidizing non-members.
3. The COPIER team proposed to hold the first workshop at a conference centre on Erewhon's campus, which they had used before and rated highly. The ITA managers were not in favour. They usually choose hotels at or near airports for workshop venues. As an international body, they need to make their events accessible to delegates outside the UK. They worried too that a university venue might deter some by creating the impression that the workshop would be academic.
4. A researcher who showed interest in leading an ARC-ITA workshop was one of the few ARC researchers who had worked with ITA in the past. He suggested the workshop comprise short presentations from six to eight industry speakers. Accepting the task of enlisting one from a blue-chip engineering construction company, he suggested ITA would enlist the others through their industry contacts. The ITA managers were not sympathetic, because they had passed organization of the workshops to the COPIER team and expected them to enlist the speakers and because the proposed format deviated too far from the model they were accustomed to, with three or four speakers in the morning and breakout group exercises in the afternoon.

These were not the only differences COPIER encountered. Some of the ARC researchers were unenthusiastic about participating in COPIER at all. Several, for example, had completed their ARC-funded research some time ago. One explained that he had already disseminated the findings of his research in events he organized for industry towards the ends of his projects and if he now presented those findings in new workshops, some in the audience might ask why he was re-presenting old research findings.

BARRIERS AND BOUNDARY OBJECTS

At the time of writing (the ninth month of COPIER), one ARC-ITA workshop has been held, another is to be held next week and for the one other, due in month 12, speakers have been engaged and a venue provisionally booked. To the best of our

knowledge, no strong new innovation-oriented connexions between ARC researchers and ITA members have arisen (yet) as a result. One might respond by looking for evidence that barriers to innovation through university-industry linkages are getting in the way. Are there not signs in the ARC-ITA differences described above, for example, of a cross-boundary 'mutual lack of understanding about expectations and working practices', one of the barriers defined by Bruneel *et al.* (2010: 862). On the other hand, the differences that surfaced in the organization of the workshops has not (yet) led to their abandonment, even though the differences have not been uniformly eliminated. What then of the possibility suggested by the notion of the boundary object that the cooperation can flourish without consensus between cooperating social worlds? Might ARC and ITA cooperatively produce innovation without first restricting their collaboration to work for which they can find a consensus?

Susan Leigh Star coined the term 'boundary object' for an object (not necessarily a material one) through which the work of more than one social world is coordinated (Star, 1989; Star and Griesemer, 1989) in the crafting and working out of what for at least one of those social worlds is a 'coherent problem-solving enterprise' (Star and Griesemer, 1989: 392). It has, of course, been taken up by many since and spread from science and technology studies to many other fields. (See Trompette and Vinck (2009) for an overview.) Organization and management studies (OMS) has been among the most receptive, and, as Zeiss and Groenewegen (2009) point out, those in OMS who make use of the concept, like researchers in other fields, frequently turn to one particular passage in Star and Griesemer's paper for their definition of the boundary object: '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.' (Star and Griesemer, 1989: 393)

In a recent paper, Star clarified some matters that were not very clear in that 1989 paper. Defining the boundary object now as having three dimensions, she hinted that very often other researchers who have used the term had recognized only one. This is the boundary object's interpretive flexibility, something she thought the boundary object had become 'almost synonymous with' (Star, 2010: 602). Of the overlooked two, one has to do with the 'material/organizational structure of different type sof boundary objects'. Boundary objects are – or, one might say, bring in train – a set of working arrangements, which vary from one to another. As such, the concept is most useful in studies at the organizational scale (Star, 2010: 612–613).

The third dimension follows from the plastic-yet-robust aspect of boundary objects. Between social worlds, a boundary object is 'ill structured' (Star, 2010: 604), which is to say it has no single clear, precise meaning or use or significance. Within each of those social worlds, however, it has a more specific use and is 'therefore useful for work that is NOT interdisciplinary' (Star, 2010: 605; emphasis in the original). So members of the cooperating social worlds switch – Star says 'tack' – continually between the ill-structured interdisciplinary and customized discipinary forms of the object.

Acknowledging Star's point that when boundary objects facilitate cooperation, they usually do so in sets or systems rather than alone (Star, 2010: 602), we now consider whether the ARC-ITA workshops can properly be likened to boundary objects. First we look at the framing of the cooperation and the set of boundary objects involved. Then we look at the three aspects Star attributes to boundary objects in turn.

Of the multiple ways in which we might frame cooperation between Erewhon's construction department and ARC on the one hand and ITA and its members on the other, we choose one in which innovation is the coherent problem-solving enterprise on which these different social worlds work together. We prefer innovation here to knowledge transfer. The latter smacks too much of the academic perspective; on the whole, ITA members, for example, do not, we suppose, concern themselves with anything they call 'knowledge transfer'. They do, however, do innovation, for example by improving existing or creating new products or services. So too do construction academics. They seek to publish original (i.e. innovative) work and increasingly to engage users and other stakeholders, often industrial, in that work's exploitation. Recall the aim of the fund awarded to Erewhon by the funding council that funded ARC. This fund, the source of the COPIER grant, was to overcome the obstacles between the research funded by the research council and its better exploitation.

The workshops are the object in which we are primarily interested, but they operate in concert with other objects we might tentatively identify as boundary objects (without examining them here in the same details as workshops). Here are two examples. There is what the revised COPIER proposal called a 'web-based knowledge repository of the new knowledge created by [ARC]', a collection of COPIER-developed 'snapshots' rendering ARC findings 'readily searched, understood and assimilated by [ITA] members'. This includes the brief summaries of the 30-odd construction-related ARC projects prepared by the COPIER team and sent by ITA to its communities of practice and its members. Repositories are one of the classes of boundary object listed by Star and Griesemer (1989: 410). Another boundary object in the COPIER collaboration is innovation itself, which appears to fit the ideal type class of boundary objects also listed by Star and Griesemer (1989: 410).

Of Star's (2010) three aspects of boundary objects, we can quickly dispense with interpretive flexibility. Workshops clearly exhibit interpretive flexiblity. For many construction academics, workshops are, among other things, a means of disseminating a research project's findings to groups of stakeholders towards the end of the project. Events labelled 'workshops' have been a normal feature of the annual programme of events ITA organizes for its members since 2010. In that year, ITA substituted workshops for the masterclasses they had been running for several years. They saw in workshops the possibility of a more egalitarian activity. Usually one-day affairs, they are events of two halves. In the morning, a handful of experienced engineering-construction industry practitioners give presentations on a practical construction-management topic, each followed by time for questions from the delegates. In the afternoon, delegates do exercises related to the topic in small groups. These are designed to stimulate peer-to-peer learning. This is a key element of the rationale and the characteristic that not only distinguishes ITA workshops from their (discontinued) masterclasses (and from academic dissemination workshops) but also constitutes an important selling point. ITA managers believe it attracts new delegates – delegates they feared were being put off in the past by the master-pupil impression conveyed by the term 'masterclass' and by their one-presenter format.

The second of Star's three aspects – their material and organizational structure and the work practices they entail are less easy to make out in the not-yet-routinized relationship still developing between the COPIER team and ITA. We can nevertheless discern some of their lineaments. The plain-language summaries of ARC projects and their compilation mentioned above are an obvious example. As COPIER proceeded,

other tasks the COPIER team performed in organizing ARC-ITA workshops (and similar events, such as a session at the annual ITA conference and a one-day seminar for a learned institution not connected with ITA), recurred often enough to appear liable to become a regular requirement. A notable example was the compiling of thumbnail biographies of ARC researchers (and non-ARC speakers where appropriate). These were included in the flyers used to publicize the workshops and attract delegates. They often made a point of stressing the researchers' connections with industry, identifying companies they had collaborated with in their research and any companies they had worked for in the course of their careers. The COPIER team drafted them where possible from biographical material the ARC researchers had on their university web pages, but they took pains to remove from them elements they thought unlikely to appeal to industry practitioners as opposed to fellow academics.

We think it important to point out that neither of these tasks (and the resulting summaries and biographies) should be taken at present to have stabilized. They are still open to re-negotiation, to revision, refinement and even abandonment in the light of feedback from workshop delegates or second thoughts on the part of the COPIER team. So they point to the ongoing development of what might turn out in time to be boundary objects.The third aspect – the tacking back and forth between between the ill-structured interdisciplinary and customized discipinary forms of the object – raises some evocative difficulties. It requires, in Star's formulation, that the disciplinary forms of the object have uses that are not interdisciplinary. For example, in Star and Griesemer (1989), the standardized forms that amateurs completed and submitted to the Museum of Vertebrate Zoology along with the animal specimens they obtained served a purpose within their own social world that did not depend on the scientific use to which they were put by the museum's director. Star and Griesemer do not say what this use was but we might surmise that they conferred kudos on the collectors among their fellows much as reports that amateur birdwatchers nowadays submit to county recorders do.

For most objects identified as boundary objects, the object is used in its different social worlds largely out of site of the others and this no doubt helps in avoiding the necessity there otherwise might for endless negotiation between social worlds. Because workshops like the ARC-ITA workshops involve the co-location in time and space of members of the different social worlds involved in the common problem-solving enterprise, they have not enjoyed what we might call the privacy of more run-of-the-mill boundary objects. In other words, much of what ARC researchers might do in or to a workshop as a part of their disciplinary customization of the form will inevitably be visible to industry practitioners attending as delegates and to ITA managers who are present. Where such practices do not agree with their conception of a proper ITA workshop, they may prompt new negotiations over the form of ARC-ITA workshops.

With only one ARC-ITA workshop held so far, it would be premature to pronounce on whether this renders workshops strictly inadmissible as full-blown boundary objects in accordance with Star's (2010) definition. We imagine that the impressive openness of the workshop form in general means that it may well accommodate arrangements that minimize the visibility of social-world-specific features of the disciplinary uses of boundary objects and thus enable them to work as boundary objects nevertheless. We shall be observing developments in this regard very closely in the remaining months of the COPIER project.

CONCLUSIONS

'Each social world has partial juisdiction over the resources represented by that object, and mismatches caused by the overlap become problems for negotiation' (S&G, 1989:412)

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A STUDY ON NEW CONSTRUCTION TECHNIQUES AND SKILLS TRAINING WITH FOCUS ON THE PLASTERING SUBCONTRACTOR IN JAPAN

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The purpose of this study was to establish the contents and methods of a vocational education program for modern, advanced-level plasterers. The interview survey confirmed that there is a serious shortage of vocational education resources available for advanced-level plasterers. The first questionnaire survey for seminar attendants during September 2005 and November 2007, conducted in ten regional blocks nationwide, clarified the basic attributes of plasterers. The results of analysis, by multivariate statistical method (Hayashi's Quantification III) and cluster analysis, allowed plasterers to be grouped into eight types, and clarified the characteristics of each plasterer type as well as their relationships with each other when separated into the 10 regional blocks. In the follow-up survey in August 2008, a questionnaire completed by plastering site supervisors was analyzed. This analysis facilitated a thorough understanding of the current work responsibilities of plastering site supervisors, and the types of vocational education that will be needed by advanced-level plasterers in the future. Regarding the training methods necessary for the vocational education of advanced-level plasterers, training types were broadly divided into on-the-job training and off-the-job training, and then further sub-classified into 15 training types. Detailed vocational education contents were proposed for each sub-classification. Vocational education for plastering site supervisors trained through off-the-job training was implemented through a collaboration of the Japan Plasterers' Association and a university architecture department. The contents were described using a relational diagram. The results of the study were divided into the eight national types of plasterer mentioned above in order to facilitate vocational education for plastering site supervisors and advanced-level plasterers in accordance with the construction industry policy outline. In addition, the research results were used to establish and propose vocational education contents and methods based on the type of training required for each plasterer type.

Keywords: plastering site supervisor, architectural skills education, management education, Hayashi's Quantification Ⅲ, multivariate analysis, cluster analysis

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Mihara, H; Yoshida, T; Suzuki, K and Hojo, T (2012) A study on new construction techniques and skills training with focus on the plastering subcontractor in Japan *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 223-233

INTRODUCTION

In the Heian Era (794-1192 AD) of JAPAN, when wood and earth were the primary materials used to construct buildings and plasterers, together with carpenters, assumed the leading roles during building construction. Conventional technical education has been implemented within an apprenticeship system; however, the framework to support this system is now collapsing. However, in Japan, the training of technicians has been left to subcontractors; this has resulted in a lack of consistency, and this approach is now in a state of neglect. The modern building industry is characterized by major advances in construction technology and the challenge of new building technologies. In view of this, there is a need to train top-class plasterers who are capable of adapting to a constantly changing work environment. The work description of an advanced-level plasterer is to perform plastering work requiring advanced skills (that is, work that only a skilled craftsman or supervisor can handle), to work with clients and engineers to propose technical solutions and coordinate work processes, and to train, instruct, and guide young and subordinate workers. In order to perform these activities, advanced-level plasterers must have the management skills to provide appropriate and timely instruction, guidance, and proposals on-site. Advanced-level technicians who are skilled craftsmen, or who are supervisors and also have management skills, have come to be regarded as “supervisors” for the construction industry. Consequently, the Ministry of Land, Infrastructure and Transport has officially recognized advanced-level supervisors who pass a test implemented by a specialist construction industry body as “supervisors.”

Details concerning work-site vocational education at various plastering sites throughout Japan are unknown because this education has been implemented independently in each regional block. So far, regional differences in plastering skills and plastering education have not been analyzed.

This study is to present a classification of the plasterers being surveyed as the foundation of various discussions about technical education for plasterers and also to explain the types of senior plasterers in each region in order to show regional differences. The purpose of this study was to establish the contents and methods of a vocational education program for modern, advanced-level plasterers.

OUTLINE OF QUESTIONNAIRE SURVEY

The Japan Plasterers' Association conducted a questionnaire survey of all 618 trainees who attended the 1st through 10th training courses certifying Plastering site supervisor in 10 blocks throughout the nation (hereinafter, training courses) held from September 2005 to November 2007. The survey was titled "Questionnaire Concerning the Work of Plastering site supervisor on Construction Sites". As Table 1 shows, the questionnaire survey in each regional block was conducted on the last day of the training course. The questionnaire recovery rate was 100%. The Japan Plasterers' Association planned the questionnaire survey and requested Mihara Laboratory, MONOTSUKURI UNIV. Institute of Technology, to cooperate in the survey. Mihara Laboratory prepared the questionnaire and also collected and analyzed the data.

Training	Term	Trainees	Average Age (Years)	Place
1st: Kanto Block	2005: Sep. 20 (Tue) - 22 (Thu)	91	42	Shizuoka: Fuji Education Training Center
2nd: Tohoku Block	2006: Aug. 10 (Thu) - 12 (Sat)	41	42	Miyagi: SME University
3rd: Kinki Block	2006: Sep. 16 (Sat) - 18 (Mon: Holiday)	80	41	Osaka: Cosmo Square Hotel and Congress
4th: Hokkaido Block	2007: Mar. 5 (Mon) - 7 (Wed)	64	44	Hokkaido: JR Training Center
5th: Koshin-etsu Block	2007: Apr. 13 (Fri) - 15 (Sun)	59	42.7	Nagano: Village Azumino
6th: Hokuriku Block	2007: Apr. 20 (Fri) - 22 (Sun)	55	41.6	Ishikawa: Saigawaso
7th: Shikoku Block	2007: Jun. 22 (Fri) - 24 (Sun)	38	47.1	Kochi: Kochi Sunrise Hotel
8th: Chugoku Block	2007: Jul. 14 (Sat) - 16 (Mon)	53	43	Hiroshima: Hiroshima Seishonen Bunka Center
9th: Tokai Block	2007: Oct. 28 (Sun) - 30 (Tue)	53	41.2	Aichi: Sanparea Seto
10th: Kyushu Block	2007: Nov. 27 (Tue) - 29 (Thu)	84	44	Fukuoka: Qkamura, Shigamura
Total		618	42.9	

Table 1. Outline of questionnaire survey.

METHODS

Questionnaire data on the basic attributes of senior plasterers was compiled. Using multivariate analysis, plasterers from all the regional blocks were classified and the types of senior plasterers were presented. Then the regional differences of senior and general plasterers were analyzed. More specifically, the survey participants were classified by several attributes and the grouping of the senior plasterers in Japan was analyzed by performing a factor analysis using Hayashi's Quantification Method Type III. A cluster analysis was performed on the basis of the factor scores obtained using Hayashi's Method Type Quantification III. The purpose of the cluster analysis was to identify multiple similar factors and classify senior plasterers into clusters corresponding to a plasterer type. To show the regional differences of plasterers in Japan, the distribution of senior plasterers across clusters were compared between the 10 regional blocks.

RESULTS

Results of Questionnaire Survey

To confirm the basic attributes of senior plasterers with the questionnaire results, basic information was compiled from seven questions: (1) Age, (2) Experience as a plasterer (years), (3) Experience as a plastering site supervisor (years), (4) Employment position, (5) National qualification, (6) Doubling as a chief engineer, and (7) Position within the model work system. A total of 618 plasterers participated in the survey. Four participants returned invalid responses, resulting in a total of 614 valid responses being available for analysis. A significant difference test was performed on the results of the questionnaire survey The incidence rate was assumed to be 50%, the range of difference to be 5%, and the confidence level to be 95%. When these values were used in Formula 1, the result was greater than or equal to 384 participants. There were 618 participants in the survey. Because this was enough to identify statistically significant differences, we concluded that analysis was possible.

Formula 1: $$n \geqq \left(\frac{Z_{\alpha/2}}{x}\right)^2 \pi(1-\pi)$$

n = (1.96/0.05) × 2 × 0.5 × 0.5 ≈ 384 ($\alpha = 0.05$, $Z_{\alpha/2} = Z_{0.025} \approx 1.96$),

Table 2. Selected questions and response numbers by category.

Question	Category	No. of Replies
① Age	29 years-old or younger	28
	30 to 49 years-old	394
	50 years-old or older	192
② Experience as a plasterer	Less than 10 years	56
	11 to 20 years	244
	21 to 30 years	137
	40 years or more	177
③ Experience as a plastering site supervisor	None	35
	9 years or less	368
	10 to 19 years	140
	20 years or more	70
④ Employment position	Company employee	330
	Regular employee	65
	Daily or temporary employee	19
	Business owner	182
⑤ National qualification	First-class or second-class plasterer	583
	First-class or second-class construction management engineer	114
	First-class, second-class, or wooden building architect	30
	Vocational trainer (plastering)	265
⑥ Doubling as a chief engineer	Doubling as chief engineer	373
⑦ Position within the model work system	Full-fledged (skilled worker or work chief)	127
	Experienced plasterer (supervisor or senior supervisor)	327
	Subcontractor management engineer (construction leader)	67
	Vocational trainer or part-time college lecturer	40
	Advanced-level plasterer (master or expert)	14

Factor Analysis using Hayashi's Quantification Method Type III

A factor analysis was performed based on the questionnaire responses as described below. As shown in Figure 1, Factor 1 scores were larger for categories indicating more experience (e.g., "Experience as a plastering site supervisor: 20 years or more", "Experience as a plasterer: 31 years or more", and "Age: 50 years-old or older"). Factor 1 was designated the "Empirical factor" because it depended on the degree of experience as a plasterer. As shown in Figure 2, Factor 2 scores were larger for occupations in which plastering skills could be used (e.g., "Daily or temporary employee", "Full-fledged", and "Advanced-level plasterer"). The scores were smaller for those in organizational and managerial occupations (e.g., "Subcontractor management engineer" and "Business owner"). Therefore, Factor 2 was designated the "On-site occupation work factor". As shown in Figure 3, the Factor 3 scores were larger for those with higher levels of technical certification (e.g., "Vocational trainer or part-time college lecturer", "First-class, second-class, or wooden building architect", and "Advanced-level plasterer"). Therefore, Factor 3 was designated "Expertise factor". As shown in Figure 4, the Factor 4 scores were larger for those

with lower levels of field experience (e.g., "Experience as a plasterer: Up to 10 years", "Age: 29 years-old younger", and "Vocational trainer or part-time college lecturer") or more experience away from construction sites. The scores were smaller for those with more field experience, excluding on-site management (e.g., "Advanced-level plasterer", "Daily or temporary employee", and "Experience as a plastering site supervisor: None"). Therefore, Factor 4 was designated the "Field experience factor" .As shown in Figure 5, the Factor 5 scores were larger for those with higher levels independence as business owners or master plasterers (e.g., "Advanced-level plasterer," "Experience as a plastering site supervisor: None", "Daily or temporary employee", "Vocational trainer or part-time lecturer", and "Business owner"). Therefore, Factor 5 was designated the "Independence factor".

	Category	Factor 1
11	Experience as a plastering site supervisor: 20 years or more	2.6407
7	Experience as a plasterer: 31 years or more	2.1272
3	Age: 50s or older	2.0672
10	Experience as a plastering site supervisor: 10 to 19 years	1.1292
15	Business owner	0.9709
24	Vocational trainer or part-time college lecturer	0.9007
14	Daily or temporary employee	0.8054
25	Advanced-level plasterer (master or expert)	0.7511
8	Experience as a plastering site supervisor: None	0.6235
19	Vocational trainer (plastering)	0.5736
17	First-class or second-class construction management engineer	0.1005
22	Experienced plasterer (supervisor or senior supervisor)	0.0833
23	Subcontractor management engineer (construction leader)	0.0764
13	Regular employee	0.0638
6	Experience as a plasterer: 21 to 30 years	0.0572
20	Doubling as a chief engineer	0.0378
16	First-class or second-class plasterer	−0.0079
18	First-class, second-class, or wooden building architect	−0.5763
12	Company employee	−0.6866
2	Age: 30s or 40s	−0.9013
21	Full-fledged (skilled worker or work chief)	−0.9895
9	Experience as a plastering site supervisor: Less than 10 years	−1.0584
5	Experience as a plasterer: 11 to 20 years	−1.3133
4	Experience as a plasterer: 10 years or less	−1.6215
1	Age: 29 years-old or younger	−2.4538

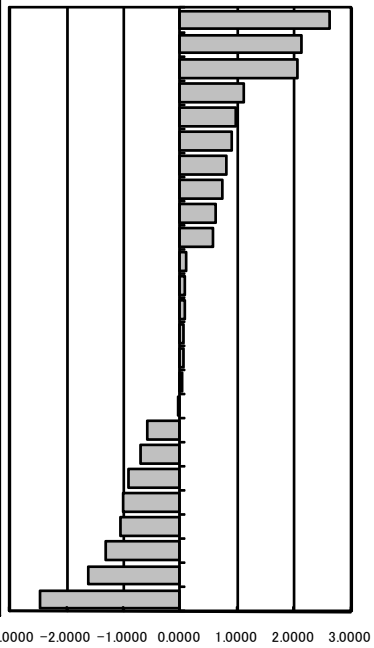


Figure 1. Factor 1 scores: Empirical factor.

	Category	Factor 2
1	Age: 29 years-old or younger	5.4855
4	Experience as a plasterer: 10 years or less	2.4984
14	Daily or temporary employee	2.4745
21	Full-fledged (skilled worker or work chief)	1.8220
25	Advanced-level plasterer (master or expert)	1.6260
11	Experience as a plastering site supervisor: 20 years or more	1.4235
7	Experience as a plasterer: 31 years or more	1.2347
3	Age: 50 years-old or older	0.9745
13	Regular employee	0.6702
8	Experience as a plastering site supervisor: None	0.5120
12	Company employee	0.4578
9	Experience as a plastering site supervisor: 10 years or less	0.2127
16	First-class or second-class plasterer	0.1515
5	Experience as a plasterer: 11 to 20 years	−0.0144
22	Experienced plasterer (supervisor or senior supervisor)	−0.1296
19	Vocational trainer (plastering)	−0.1753
20	Doubling as a chief engineer	−0.2095
2	Age: 30 to 49 years-old	−0.7300
15	Business owner	−1.0141
10	Experience as a plastering site supervisor: 10 to 19 years	−1.0300
24	Vocational trainer or part-time college lecturer	−1.1014
17	First-class or second-class construction management engineer	−1.3657
18	First-class, second-class, or wooden building architect	−1.7732
23	Subcontractor management engineer (construction leader)	−2.0522
6	Experience as a plasterer: 21 to 30 years	−2.2032

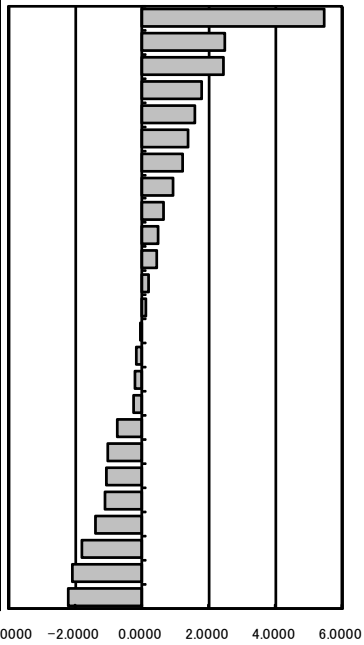


Figure 2. Factor 2 scores: On-site work factor.

	Category	Factor 3
24	Vocational trainer or part-time college lecturer	2.7208
18	First-class, second-class, or wooden building architect	2.2557
8	Experience as a plastering site supervisor: None	2.0332
11	Experience as a plastering site supervisor: 20 years or more	1.9019
25	Advanced-level plasterer (master or expert)	1.5780
23	Subcontractor management engineer (construction leader)	1.5208
15	Business owner	1.2221
17	First-class or second-class construction management engineer	0.8536
5	Experience as a plasterer: 11 to 20 years	0.7578
19	Vocational trainer (plastering)	0.4909
12	Company employee	0.2317
9	Experience as a plastering site supervisor: Less than 10 years	0.1816
21	Full-fledged (skilled worker or work chief)	0.1656
7	Experience as a plasterer: 31 years or more	0.0880
3	Age: 50s or older	−0.0329
20	Doubling as a chief engineer	−0.0391
2	Age: 31 to 49 years-old	−0.0522
4	Experience as a plasterer: 10 years or less	−0.0844
16	First-class or second-class plasterer	−0.1245
1	Age: 29 years-old or younger	−0.2644
22	Experienced plasterer (supervisor or senior supervisor)	−0.9745
6	Experience as a plasterer: 21 to 30 years	−1.6792
10	Experience as plastering site supervisor: 10 to 19 years	−2.1892
14	Daily or temporary employee	−3.5444
13	Regular employee	−4.1644

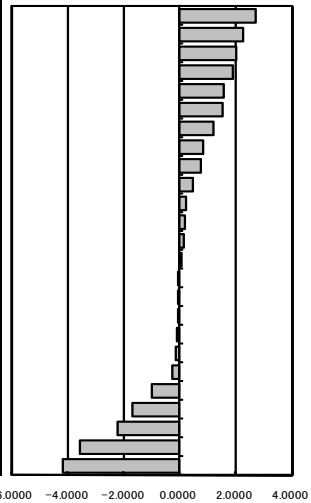


Figure 3. Factor 3 scores: Expertise factor.

	Category	Factor 4
4	Experience as a plasterer: 10 years or less	4.0921
1	Age: 29 years-old or younger	3.5532
24	Vocational trainer or part-time college lecturer	2.2022
13	Regular employee	1.7138
17	First-class or second-class construction management engineer	1.5958
21	Full-fledged (skilled worker or work chief)	1.1802
6	Experience as a plasterer: 21 to 30 years	1.0167
23	Subcontractor management engineer (construction leader)	0.9818
15	Business owner	0.8247
10	Experience as a plastering site supervisor: 10 to 19 years	0.4804
18	First-class, second-class, or wooden building architect	0.2581
19	Vocational trainer (plastering)	0.2243
11	Experience as a plastering site supervisor: 20 years or more	0.2024
3	Age: 50 years-old or older	−0.0709
20	Doubling as a chief engineer	−0.1101
9	Experience as a plastering site supervisor: Less than 10 years	−0.1188
16	First-class or second-class plasterer	−0.1299
2	Age: 31 to 49 years-old	−0.2885
7	Experience as a plasterer: 31 years or more	−0.3374
12	Company employee	−0.5255
22	Experienced plasterer (supervisor or senior supervisor)	−0.8325
5	Experience as a plasterer: 11 to 20 years	−1.3791
8	Experience as a plastering site supervisor: None	−1.8333
25	Advanced-level plasterer (master or expert)	−4.6804
14	Daily or temporary employee	−5.4942

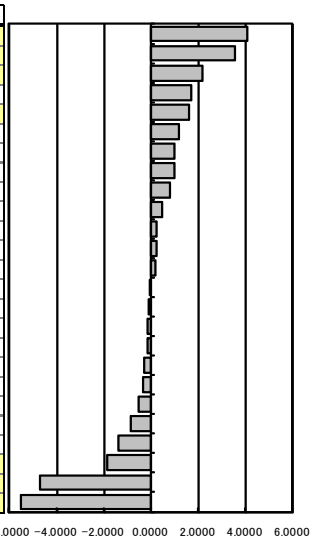


Figure 4. Factor 4 scores: Field experience factor.

	Category	Factor 5
25	Advanced-level plasterer (master or expert)	6.8206
8	Experience as a plastering site supervisor: None	5.6087
14	Daily or temporary employee	4.2683
24	Vocational trainer or part-time college lecturer	2.5092
4	Experience as plasterer: 10 years or less	2.1254
1	Age: 29 years-old or younger	1.2466
6	Experience as a plasterer: 21 to 30 years	1.2396
15	Business owner	0.9709
19	Vocational trainer (plastering)	0.7962
10	Experience as a plastering site supervisor: 10 to 19 years	0.1606
2	Age: 31 49 years old	0.1461
16	First-class or second-class plasterer	0.0421
22	Experienced plasterer (supervisor or senior supervisor)	−0.1332
21	Full-fledged (skilled worker or work chief)	−0.1644
9	Experience as plastering site supervisor: Less than 10 years	−0.2443
20	Doubling as a chief engineer	−0.2618
17	First-class or second-class construction management engineer	−0.4892
3	Age: 50 years-old or older	−0.5400
12	Company employee	−0.6199
7	Experience as a plasterer: 31 years or more	−0.6600
18	First-class, second-class, or wooden building architect	−0.7486
5	Experience as a plasterer: 11 to 20 years	−0.7510
13	Regular employee	−0.9628
11	Experience as a plastering site supervisor: 20 years or more	−1.9772
23	Subcontractor management engineer (construction leader)	−2.2355

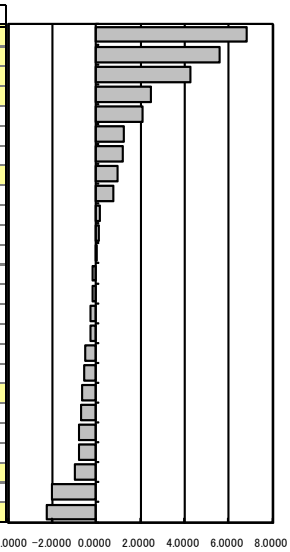


Figure 5. Factor 5 scores: Independence factor.

CLUSTER ANALYSIS

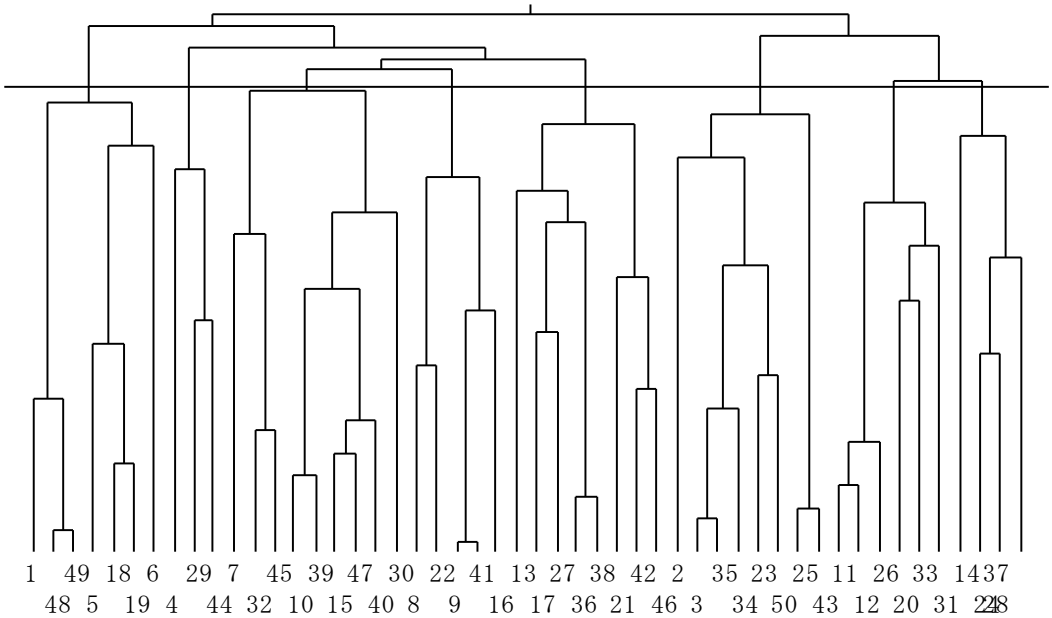


Figure 6. Dendrogram illustrating the results of the cluster analysis

The category scores obtained using Hayashi's Quantification Method Type III to generate factors from the 614 participants returning valid responses were entered into statistical analysis software and analyzed using non-hierarchical cluster analysis (the k-means method). The purpose of the cluster analysis was to identify similarities among factors among the included 614 participants by distance. Euclid's algorithm was used to calculate the original distances, and Ward's method was used to calculate the distances after merges. Participants were classified into groups with similar characteristics. Figure 6 is a dendrogram illustrating the results of the cluster analysis.

In this dendrogram, the lower the grouping, the higher the level of detail used in the cluster analysis. Clusters at the bottom have all factors independent. Figure 6 classifies participants into 50 clusters. In the cluster analysis, the characteristics of each cluster were read from top to bottom from the dendrogram. Because characteristics could be clearly distinguished for the 8 cluster case, 8 was adopted as the number of plasterer types. We conducted a cross-tabulation with each question to determine the characteristics of each cluster. The results are given by cluster. We named the plaster type of each cluster according to the resulting characteristics. The type names and characteristics are given as (1) to (8) below. (*N* represents the number of participants.)

1. Middle-standing plasterer type (Number of participants = 139)

This cluster consists mainly of middle-standing plasterers in their thirties with 10 years or more of experience as plasterers. These plasterers play the core role among plasterers. Plasterers in this cluster can be further separated into those brushing up on their skills to become "Chiefs of organization" (64.2%) and those planning futures as "Advanced-level plasterers (master or expert)" (32.8%).

2. Middle-standing experienced field worker type (Number of participants = 102)

This cluster consists of plasterers in their forties with 20 years or more of experience as plasterers. Among them, the percentage of experienced plasterers (supervisors and senior supervisors) is particularly large, 84.4%. In the plastering industry, they have positions as work-site managers. Plasterers in this cluster prefer the status quo and

wish to maintain a stable living by keeping their positions as master or supervisor. They do not have much expectation of promotion or independence.

3. Middle-standing leader type (Number of participants = 83)

This cluster consists mainly of middle-standing plasterers in their forties but also includes ones in their thirties with 10 to 20 year of experience as plasterers. Plasterers in this cluster are business owners, vocational trainers, and part-time college lecturers who strongly desire to be independent plasterers or instructors. Their aim is not to join the management of their organizations but rather to develop their own unique styles of plastering.

4. Older, experienced supervisor type (Number of participants = 73)

This cluster consists of older plasterers, mainly plasterers in their fifties, with 31 years or more of experience as plasterers. This cluster includes many plasterers who entered this industry in the high-growth period. They have careers as experienced plasterers but have not yet established positions as business owners or other specialists. Despite their long careers, their salaries are not very different from those of younger plasterers and they are uncertain about their future plans.

5. Older, experienced master type (Number of participants = 58)

This cluster consists mainly of plasterers in their sixties. Of the plasterers, 62.9% own businesses and have established positions. Plasterers in this cluster are mostly successful independent business owners. They became plasterers because they appreciated the profession and the contents of the work (e.g., "Yearned for plastering skills", "No work more attractive than plastering"). Their current degree of satisfaction is high.

6. Skill-pursuing independent type (Number of participants = 57)

This cluster includes a wide range of ages and careers. Participates identifying themselves as "Daily or temporary employee" made up 33.3% of this cluster, and few had experience as plastering site supervisors. Many plasterers in this cluster did not belong to any organization and typically worked alone. They reported that they were very concerned about low income and unstable employment. They were originally positive about plastering (e.g., "Yearned for plastering skills", "Expected higher income") but now are uncertain about what to do.

7. Construction engineer type (Number of participants = 55)

This cluster consists of plasterers in their aged 30 to 49 years with 10 to 20 years of experience as plasterers. The plasterers in this cluster typically inherited their occupation. Frequent responses in this cluster were "Plasterer's child" (74.4%) and "Business owner" (42.6%). Their dissatisfaction with their current profession is high. By obtaining national qualifications as architects and construction management engineers, these participants were aggressively working as subcontractor management engineers, not mere plasterers, and were using their technical plastering skills for non-plastering purposes.

8. Young employee type (Number of participants = 33)

This cluster consists mostly of plasterers in their twenties (69.7%) and/or plasters with 10 years or less of experience (66.7%). Almost all of these participants are company employees (93.9%). They have guaranteed positions as employees but are still growing as plasterers. They report no problems and have rather high degrees of satisfaction. Plasterers in this cluster can be further separated into those who are management-oriented and those who are skill-oriented (e.g., "Manager", 51.5%, "Master", 21.2%, and "Artist", 21.2%).

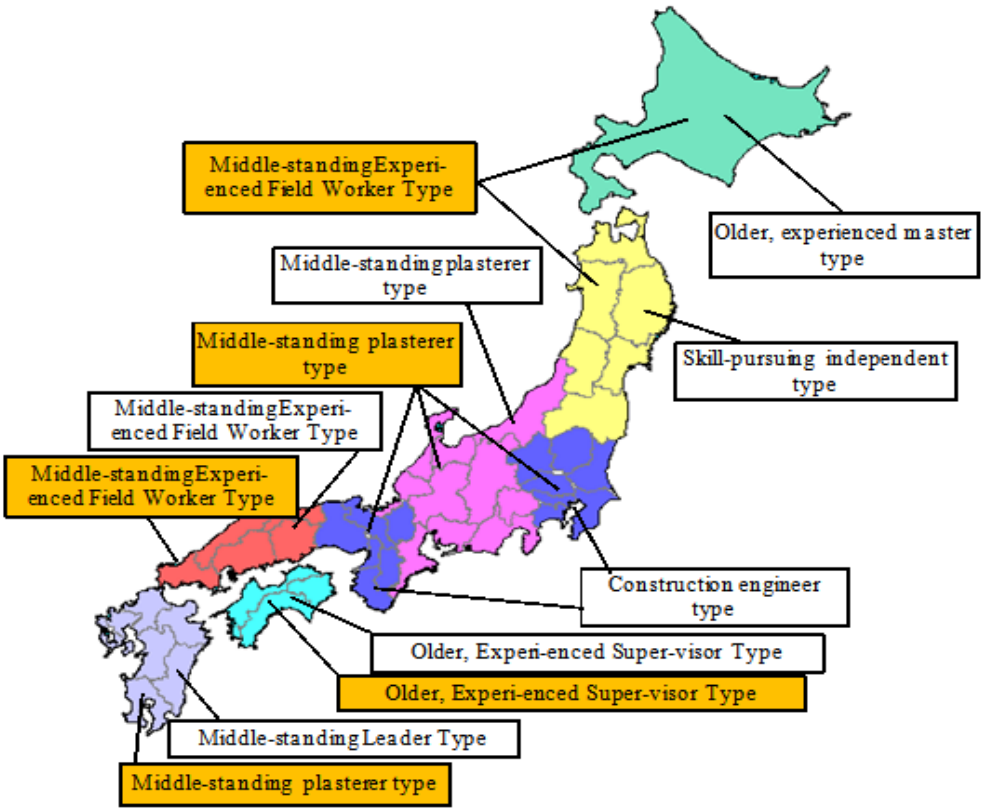
DISCUSSION OF REGIONAL DIFFERENCES IN PLASTERERS IN JAPAN

Table 3 shows the results of cross-tabulating 8 clusters and 10 regional blocks in Japan. The regional differences of plasterers in 10 regional blocks of Japan are shown as percentages of participants in each cluster by region. Figure 7 shows the regional differences of senior plasterers by type (cluster) and their distribution within Japan.

Table 3. Results of cross-tabulating 8 clusters and 10 regional blocks.

Upper row: number of participants Lower row: (%)		8 Clusters								
		Total	Middle-standing Plasterer Type	Middle-standing Experi-enced Field Worker Type	Middle-standing Leader Type	Older, Experi-enced Super-visor Type	Older, Experi-enced Master Type	Skill-pursuing Indepen-dent Type	Construc-tion Engineer Type	Young Employee Type
10 Regional Blocks	Total	614 100.0	139 22.6	102 16.6	85 13.8	80 13.0	63 10.3	57 9.3	55 9.0	33 5.4
	Kanto	89 100.0	19 21.3	12 13.5	7 7.9	9 10.1	11 12.4	12 13.5	15 16.9	4 4.5
	Tohoku	41 100.0	6 14.6	9 22.0	7 17.1	5 12.2	2 4.9	8 19.5	2 4.9	2 4.9
	Kinki	78 100.0	19 24.4	16 20.5	11 14.1	3 3.8	7 9.0	6 7.7	11 14.1	5 6.4
	Hokkaido	64 100.0	7 10.9	13 20.3	10 15.6	12 18.8	10 15.6	7 10.9	2 3.1	3 4.7
	Koshin-etsu	59 100.0	19 32.2	7 11.9	9 15.3	7 11.9	8 13.6	1 1.7	4 6.8	4 6.8
	Hokuriku	53 100.0	14 26.4	2 3.8	8 15.1	7 13.2	4 7.5	8 15.1	5 9.4	5 9.4
	Shikoku	38 100.0	6 15.8	6 15.8	6 15.8	10 26.3	4 10.5	2 5.3	4 10.5	– –
	Chugoku	55 100.0	13 23.6	16 29.1	6 10.9	9 16.4	6 10.9	4 7.3	– –	1 1.8
	Tokai	53 100.0	20 37.7	10 18.9	7 13.2	5 9.4	1 1.9	3 5.7	3 5.7	4 7.5
	Kyushu	84 100.0	16 19.0	11 13.1	14 16.7	13 15.5	10 11.9	6 7.1	9 10.7	5 6.0

Figure 7. Regional differences in plasterers by type (cluster) and their distribution within Japan. *(Approved by Geospatial Information Authority of Japan: 2001 - No. 367.)*



EDUCATION THAT SHOULD BE PROVIDED AT THE SKILLED LEVEL IN RELATION TO CURRENT EDUCATION

The following analysis method summarized 15 technical skill education types at the skilled level in the 10 regional blocs into tables in order to identify gaps in relation to national averages, and to compare and investigate these figures. Table4 summarizes education that should be provided at the skilled level in relation to current education by regional bloc. When examining the total points in relation to the current situation, rather than 0 point, to obtain a general consensus regarding what should be included in worker education at the skilled stage, two types of education that were found to be satisfactory are "on-site OJT" and "courses at professional training schools".

Future education should Of the top three⇒1, Everything else ⇒0	On-site OJT	Direct guidance from people with high-level skills	Direct on-site guidance in plastering skills from the master or boss	Company group training	Provision of textbooks and materials	Company study groups	Courses at professional training schools	Acquisition of skills at educational institutions	Classes provided by the JPA and others	on-site classes provided by building products manufacturers and local NPO groups	Interaction with people in the same profession at other companies	Enjoying work and acquiring skills in the process	Acquiring skills primarily by using traditional building methods for on-site work	Acquiring skills primarily by using contemporary building methods for on-site work	Other
HOKKAIDO	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0
TOHOKU	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
KO-SHINETSU	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
KANTO	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TOKAI	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0
HOKURIKU	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0
KINKI	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0
SHIKOKU	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0
CHUGOKU	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0
KYUSHU	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0
TOTAL	0	5	1	1	1	2	0	3	1	3	5	1	3	1	0
Three or more points	–	○	△	△	△	△	–	○	△	○	○	△	○	△	–
0 points	○	–	–	–	–	–	○	–	–	–	–	–	–	–	○

Table4 Summarizes education that should be provided at the skilled level

CONCLUSION

This study produced the following results:

1. The classification of senior plasterers was presented to be used as the foundation of various discussions about the technical education of plasterers throughout Japan.
2. The basic characteristics of senior plasterers in all regions were presented and senior plasterers were analyzed using cluster analysis.
3. The characteristics of senior plasterers throughout Japan were presented and the regional differences of senior plasterers and plasterers in 10 regional blocks were shown.
4. It was confirmed that in the Kanto and Kinki blocs, where the major cities of Tokyo and Osaka are located, Off-JT is being introduced into the education methods, so that the main form of education is developing into a combination of OJT and Off-JT.

The results from (1) to (4) above provide basic information about plasterers. They are applicable to various efforts at training young plasterers and promoting the handing down of plastering skills from senior plasterers implementing technical education for plasterers by region or labor area.

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EQUALITY AND DIVERSITY

GENDER INEQUALITY IN THE CONSTRUCTION INDUSTRY: LESSONS FROM PIERRE BOURDIEU

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Despite a range of equality legislation and initiatives, the construction industry remains one of the most male dominated sectors. Women are under-represented in all construction occupations and professions. Much of the current literature describes the difficulties experienced by women who work in this sector including cultural and structural barriers, such as harassment and discrimination, limited networking opportunities and long and inflexible working hours which often result in poor career prospects and high levels of stress for women. This paper proposes that Bourdieu's theoretical framework can be used to explain the continuing homogeneity of the construction industry professions. Bringing together qualitative interview findings from several research projects with construction industry students and professionals, this paper argues that Bourdieu's thinking tools of symbolic violence and misrecognition can be used to understand women's persistent inequality in the construction industry. The findings problematise existing policy recommendations that argue women have different skills that can be brought to the sector (such as co-operation). Such policies reinforce the gendered nature of the construction sector's habitus and fail to recognise how the underlying structures and practices of the sector reproduce gendered working practices.

Keywords: Bourdieu, equality, gender, construction, women

INTRODUCTION

Despite a range of equality legislation and initiatives, the construction industry remains one of the most male dominated sectors. Women are under-represented in all construction occupations and professions. Much of the current literature describes the difficulties experienced by women who work in this sector including cultural and structural barriers, such as harassment and discrimination, limited networking opportunities and long and inflexible working hours which often result in poor career prospects and high levels of stress for women (see for example, Dainty and Bagilhole, 2006, Fielden *et al.* 2001, Greed, 2000, Lingard and Francis, 2006, Watts, 2007, Whittock, 2002). However, more work is required to understand why this situation persists. In other words we must understand why and how it is that men maintain 'their control of and through organizations' (Cockburn, 1991). The work of Bourdieu

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Sang K and Powell A (2012) Gender inequality in the construction industry: Lessons from Pierre Bourdieu *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 237-247.

is useful in understanding the (re)production of gender relations, through the concepts of habitus and capital. This paper proposes that Bourdieu's theoretical framework can be used to explain the continuing homogeneity of the construction industry professions. For the purposes of this paper we focus on Bourdieu's concept of 'symbolic violence' and its role in reproducing societal gender relations within the construction industry.

Gender in the construction industry

The construction industry remains largely white, male and able-bodied, despite a range of initiatives over the last 20 years that have sought to challenge this profile. In the UK, women make up approximately 10% of employees in construction, compared to 46% across all industries (ONS, 2009). In higher education the figures are slightly better, with women representing 18% of civil engineering students and 31% of architecture, building and planning students (HESA, 2009). Evidence demonstrates that the persistence of gender inequality in construction effects women's recruitment, retention and progress and is largely attributable to cultural and structural barriers (Sang and Powell, 2012).

Calls for increased diversity are often supported by the business case which argues that diverse work teams are more effective (Ely and Thomas, 2001) and widen the available talent pool (EHRC, 2009). Loosemore *et al.* (2003) have asserted that fair treatment of all employees should be the cornerstone of good employment practice within the construction industry. However, Henwood (1996) has cautioned that the business case encourages women employees to be seen as a last resort – to be employed during times of skills shortage. This feeds into increased vulnerability for women, particularly during times of economic crisis (Government Equalities Office, 2009, Griffiths *et al.* 2006).

In parallel research addressing the dominance of white men in management studies, Nkomo (1992) considers how organisations reproduce societal race relations. Similar questions can be asked of the dominance of men in the construction industry. Much of the extant literature fails to interrogate gender relations in the construction industry. Rather it focuses on women's experiences and compares these experiences to an unexamined norm. This paper aims to use the work of Bourdieu, and particularly the concept of 'symbolic violence' to shed light on the continued dominance of white males in the construction industry and how the sector (re)produces societal gender norms and relations. This builds on the work of Gracia (2009), who argues that the notion of symbolic violence provides a useful mechanism through which to understand gender inequality in the workplace.

Symbolic violence and misrecognition

In order to avoid essentialism we view gender as a social construction (as does Bourdieu, 2001). We echo the arguments of Schippers (2007) in that that the social locations of 'man' and 'woman' are the places where characteristics of masculinity or femininity are embodied or displayed.

Bourdieu argued that symbolic violence is the means through which gender inequality is reproduced (Bourdieu and Wacquant, 1992) and that such violence can be emotional, social or psychological (Gracia, 2009). Symbolic violence then, is not physical, but may take the form of people being denied resources, treated as inferior or

being limited in terms of realistic aspirations. Gender relations, for example, have tended to be constituted out of symbolic violence which has denied women the rights and opportunities available to men (Webb *et al.* 2002).

Bourdieu suggested that the symbolic violence of patriarchal practices embed the naturalisation of gender into individuals' identities (Gracia, 2009). "Symbolic violence... is the violence which is exercised upon a social agent with his or her complicity... I call misrecognition the fact of recognizing a violence which is wielded precisely inasmuch as one does not perceive it as such" (Bourdieu and Wacquant, 1992). Misrecognition thus occurs when individuals 'forget' that they are produced by the social world as particular types of people. Bourdieu suggests that this 'misrecognition' means that those who are dominated (i.e. women) put up with conditions that would seem intolerable to others, thus helping to reproduce the conditions of their oppression (Bourdieu, 2001). In other words, individuals are subject to symbolic violence, but do not perceive it as such, because their situation seems to be the natural order of things (Webb *et al.* 2002).

Evidence of symbolic violence in construction

There is a paucity of research which has explicitly applied Bourdieu's theory of practice to the construction industry. The following section of the paper draws on the concept of symbolic violence while discussing the extant literature on gender in the construction industry.

The dominant heteronormative masculinist cultures in SET organizations are often starkly expressed through the objectification of women and their bodies; this may be through use of language or imagery that focuses on sexual aspects of women's bodies. The *sex* of women can undermine their professional place in organisations dominated by men, such as the construction sector. In their study of women engineers in the UK and US, Carter and Kirkup (1990) found that women HE students were not taken seriously by men students; rather it was assumed they were studying engineering in order to find a husband. Language is also a feature of the masculine culture in male-dominated professions. McIlwee and Robinson (1992), in their US study of women engineers, also describe women's irritation at being called 'Honey' and 'Sweetie'. They suggest that this behaviour is a form of sexual harassment, undermining women's professional status and reinforcing men's views of women as merely sexual beings. Similarly, Faulkner (2005) maintains that while many would probably argue the issues described above are 'only words', they send powerful subliminal messages to both women and men. The issue of language is often epitomised through the use of humour. Numerous research studies have addressed the teasing and joking faced by women in science and engineering. While such research indicates that women 'can handle it,' and see it as 'all in fun', such use of humour is problematic. Men and women can be deterred from challenging offensive humour by the perceived risk of alienating themselves from their men colleagues and, as a result, will often join in regardless (Faulkner, 2005, Faulkner, 2006). Holmes (2000) states that while humour can be used to reduce inequalities, it is also used to emphasise or reinforce power relationships. McLean *et al.* (1997) support this stating that sexualised and sexist jokes work to undermine women by emphasising that women are inferior and do not really 'belong'. Holmes goes on to state that humour is a means of embedding risky or unacceptable behaviour in superficially harmless statements, thus allowing the dominant figure to maintain authority while continuing to appear friendly. The

sexualisation of women and use of language in male dominated occupations such as construction, then, might be perceived as acts of symbolic violence against women.

Women and men are also subject to a process of 'professionalisation', which Dryburgh (1999) suggests entails learning the appropriate theory and code of ethics, associating with the professional regulating body, and adjusting to or internalising the values, norms and symbols of the professional cultures. For women, this is likely to include acceptance of masculine values. Miller (2002), for example, found that Canadian women engineers conformed to beliefs and values consistent with a masculine value system. Accepting traditionally masculine values was seen to be key to success both in engineering and in their organisations. In their study of women sports journalists (another male-dominated arena), Hardin and Shain (2006), in their study of journalists, found that women will often attempt to become 'one of the boys' and adopt masculine values and practices. The women may 'normalise' existing cultures, refuse to acknowledge, or are blind to, the disadvantage(s) that women face as a group, and may even blame other women for their own subordination. Furthermore they suggest that through professional socialisation, the authoritarian power structures that exist in the field are idealised, with the result that many women resist taking a stand on '*women's issues'* (Hardin and Shain, 2006). Walker (2001) found that women engineering students were often either ambivalent or rejected gendered explanations of their experiences. She suggests this is a result of normalisation and that women have an investment with dominant hegemonic masculinities. Hardin and Shain (2006) found similar evidence of women sports journalists downplaying situations that made them feel uncomfortable, accepting it as 'par for the course' and resisting the view that certain behaviours can be characterised as sexual harassment. However, as Martin (2003) argues, if people believe that behaviour is not gendered, often because of a lack of reflexivity, they can deny gendered behaviour exists, even if others see or experience that behaviour as gendered. This is what Bourdieu would refer to as 'misrecognition'.

RESEARCH METHODS

This paper brings together findings from a number of research projects the authors have been involved in examining gender amongst architects and engineers. Each of these studies used qualitative, semi-structured interviews. The use of a semi-structured interview guide for the interviews meant that key issues identified by the researchers could be explored, while at the same time interviewees could define issues according to their own experiences and understanding. In total this included interviews with 14 women undergraduate engineering students and 10 women architects practicing in the UK. The students were in at least their second year of university and had limited industry experience, but some had been on work-placements. The practising architects all had several years of industry experience (between five and twenty five years) . With the agreement of participants, the interviews were recorded, then transcribed verbatim and anonymised prior to being analysed with the aid of NVivo. The data was analysed for emerging themes, the identification of which was informed by the literature. Specifically, themes included, symbolic violence (conceptualised as denial of access to resources, treatment as inferior and limitations placed on women's aspirations) and misrecognition. While men and women were interviewed in the studies reported, this paper takes a feminist stance of prioritising the perspectives and experiences of women respondents. As with any qualitative research, the aim of this

paper is not to draw generalisations. Rather our intention is to prioritise the voices of the women in our studies. Doing so enables for a rich analysis of their lived experiences, as they reported them.

FINDINGS AND DISCUSSION

The following sections use Bourdieu's theory of practice, specifically the concepts of symbolic violence and misrecognition to examine the persistent inequality of women in the construction industry. We begin be examining symbolic violence.

Symbolic violence in construction

This study has adopted an understanding of symbolic violence, as violence which is not physical, but one which denies women access to important resources, limits their aspirations and being treated as inferior. Across both studies women clearly articulated examples of this. Women undergraduate students provided examples of when they had been treated differently to their male colleagues. For example, Carolyn a transport management student recalled that her colleagues had taken *'a bet on how long I'd last in this job ... they said I'd done really well*'. Her colleagues had assumed that she would not be able to last in her job.

Andrea, a civil engineering student recalled examples of where she had been denied access to resources which were important to her work, specifically, assessed group work:

> *Communication was non-existent and I was left out in one way or another. They wouldn't tell me there was a group meeting . . . It was peer assessed . . . they marked me right down, which I felt was completely unfair because within the boundaries they'd placed on me, I'd done the best I could.*

This exclusion from the group limited her ability to fully participate and this in turn impacted the peer assessment of the group work. Women working in the sector recalled similar examples of being excluded from key events. For example, Amy a practicing architect said that when she was an undergraduate student she had been the only woman on her course and that the male students carried *'on like it's a boys' organization…they just ignored me*'. This exclusion from formal and informal groups reflects exclusion once in work and has implications for career progression. A number of practicing architects (women) felt that they were excluded from informal networking opportunities which were essential to attend if they wanted to bring work into their practice (a necessity for progression). A student on work placement described how no-one showed her what to do when she first started the job, despite the fact that she was a student and the purpose of the placement was to gain experience:

> *When I first joined it wasn't very structured, my learning. I had to pick up the job on the go. I would rather someone sat me down – which is what happened to everyone else. Everyone else has had a handbook, and I've just been pushed out.*

Similarly other research about women in male-dominated occupations has found that women are repeatedly excluded from informal and formal networking opportunities

(e.g. Singh *et al.* 2002, Benckert and Staberg, 2000, Davis, 2001, Gray *et al.* 2007, Barnard *et al.* 2010). Such exclusion is also likely to mean that women in construction have less social capital in the workplace than their male colleagues (Kumra and Vinnicombe, 2010).

We can clearly see here instances of symbolic violence against women construction students and professionals with denial of access to resources – namely networking opportunities which are key to performance both at work and at university. As such this can place limits on their aspirations.

While denial of access to resources can include resources such as accrual of social capital (as evidenced through networking), there is some evidence that women in the sector experience a pay gap (European Commission, 2010). While the current studies did not ask respondents to report their pay, there was a feeling among some respondents that women working in the sector are paid less than their male colleagues.

Misrecognition in construction

Bourdieu argues that the process by which individuals fail to recognise the social origins of symbolic violence is *misrecognition* (Schubert, 2008). Misrecognition is useful when considering symbolic violence as it allows for analysis of how women may perceive their experiences as the natural order of things, rather than recognising discrimination as a form of violence. As such, misrecognition is key to symbolic violence (Bourgois *et al.* 2004). However, we are careful not to 'blame' women for this recognition, as this in itself would be a form of symbolic violence (Schubert, 2008). The following section provides examples of misrecognition from women in the current studies.

Carolyn, a transport management undergraduate student recalled a situation where a male colleague (during a work placement) was paid more than her:

> *There's a guy working there with me, he started a month before me ... I just found out he got a bonus in his pay packet for helping round the office in the first few weeks before I was there. To be honest, I don't think I'll get that, you know, he is an exceptionally good student.*

In this example, we can see that Carolyn reportedly feels that her male colleague is deserving of this extra pay because he *'is an exceptionally good student'* although how this would relate to his extra pay during a work placement is unclear. She does not perceive that her male colleague is paid more than her because he is male.

In both studies, there was also much discussion of how sexism and sexist jokes needed to be understood as nothing personal and only humour. For example, Hannah a civil engineering student stated:

> *You get the obvious, you know, bits of perving and stuff like that, but you've just got to learn to take it in the spirit that it's meant.*

This is significant because such 'humour' actually reinforces negative gender perceptions, as noted in the literature above, by presenting women as inferior. Such

humour is also notoriously difficult to challenge, particularly those that are the subject of the humour (i.e. women).

Dainty *et al.* (2000) has argued that women are focussed in office based, administrative support, roles within the construction industry, largely because of gender stereotypes beliefs of managers. Lack of access to skill development opportunities, such as working on site, limit women's career development within the sector. Our data suggests that women themselves may deselect themselves from these opportunities due to beliefs in innate gender differences which make them unsuitable for this kind of work. Andrea a civil engineering student felt that women (generally) were unsuited to site based work:

> *Although there are some women out there who want to go and play in the mud and enjoy surveying all day long, most women don't and that's because of fundamental differences between women and men.*

Katie, a practicing architect was passionately opposed to equality campaigns within the architectural profession which were intended to increase the proportion of women architects in practice. Katie felt that as a woman in her early 30s she was a 'complete liability' for an architectural practice. She went on to explain that 'maternity leave' can cripple a small practice and that:

> *[The] boys here are stronger and design and probably [stronger] technically…women and men argue it differently. They're [men] kind of more ballsy and, you know, they use long words that they don't know what they mean and things like that.*

During the same exchange, Katie went to explain that she felt 'girls' were more emotional than 'boys' and the *'world isn't equal, we don't have 50% of anything as far as I know:50/50 in nature?...we're actually built differently, were not naturally designed to do the same things'*. Katie had also refused to join any women's networking groups because she was opposed to *'that kind of thing'* despite feeling isolated due to being the only 'girl' in her office. The interaction with Katie was illuminating

The women in this research predominantly viewed their experiences as unrelated to their gender. Yet at the same time, they subscribed to gendered notions that women are not suited to careers in construction because of innate gender differences between men and women. The research also had examples of women explicitly expressing gendered views of women and their suitability for work in the sector. While these perceptions pervade, there is likely to be little resistance to the status quo (see also Powell *et al.* 2006).

CONCLUSION

Using evidence from women engineering students and practising architects, this paper has demonstrated the value of Pierre Bourdieu's concepts of symbolic violence and misrecognition. In particular, these are useful tools for understanding how and why women in construction continue to be under-represented and dominated by men. The concept of misrecognition is also valuable in understanding why women in construction do not challenge this dominance; that is, because they fail to see it as

such. Thus as Miller (2002) has argued there is often 'an unawareness of the masculine nature of the context'.

Witz (2004), and others, have argued that symbolic violence paints women as compliant and shifts the burden of responsibility for women's oppression from men to women themselves (Witz, 2004). However, we suggest that it highlights the importance of including men in any policy initiatives to address women's under-representation and discrimination, since women, usually unconsciously, can be complicit in their domination. As Bourdieu (2000) argues, complicity is not a conscious, deliberate act, 'it is itself the effect of power'. This also reflects women's assimilation into the masculine culture of construction (see also, Dryburgh, 1999, Walker, 2001, Miller, 2002, Powell *et al.* 2009). Such assimilation occurs when women learn the rules of the game. In other words, and borrowing again from Bourdieu, women learn the 'habitus', that is the values and dispositions, of the construction 'field', and that this field is intrinsically male and respond accordingly. Analysis of the experiences of women in construction using Bourdieu's concepts of habitus and field will be the focus of future publications.

This is also likely a result of the very low numbers of women in construction, which results in women individualising their negative experiences rather than perceiving them as a result of gender. In other industries where women represent a more sizeable minority, such as science, this may not be the case. This will be the subject of future research.

These findings also call into question existing policy recommendations that argue women have different skills that can be brought to the sector (such as co-operation). Such policies reinforce the gendered nature of the construction sector's habitus and fail to recognise how the underlying structures and practices of the sector reproduce gendered working practices.

This research has explicitly focused on the lived experiences of women in a male-dominated industry. Future research should examine the experiences of men in this context in order to consider how they practice symbolic violence and misrecognition. Any such future studies should be aware that the category of 'men' is not homogeneous. The framework of symbolic violence would enable an analysis of how the sector perpetuates inequalities against non dominated men, for example, ethnic minority men or gay men. Further research should also explore how symbolic violence occurs in sectors that are less male-dominated and where the organisational culture is likely to be different.

ACKNOWLEDGEMENTS

The authors would like to thank the participants that took participated in this research, as well as Professors Barbara Bagilhole, Andrew Dainty and Stephen Ison (Loughborough University, UK), who were involved in the original research projects on which this paper is based.

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WORKING HOURS IN A LARGE NEW ZEALAND CONSTRUCTION COMPANY

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Long working hours and weekend working are an integral part of many jobs in the construction industry, and are job characteristics that are linked to work-life conflict, which adversely affects employees' ability to achieve work-life balance. Furthermore, the industry's culture of long working hours limits its ability to attract and retain talented employees. Since much of the work-life balance research in the construction industry focuses on working hours, this research aimed to identify the typical working hours of the professional and managerial level staff within a single large New Zealand construction company. One hundred and twenty one (121) head office and site-based employees responded to an online survey. Results support the assertion that New Zealand construction industry employees tend to work long hours, and that work location affects working hour demands. Qualitative results suggest some work-life conflict associated with working long hours and weekend work exists. The New Zealand construction industry must provide a supportive workplace culture in which to address these issues, and provide reasonable working hours, in order to find a balance that is suitable to employees, companies, and the industry as a whole.

Keywords: contracting, human resource management, work hours, work-life balance

INTRODUCTION

The construction industry has a pervading work culture that promotes long working hours, which is one barrier to its employees achieving work-life balance (De Cieri *et al.* 2005). Recent research in the Australian construction industry suggests that there is a significant inverse relationship between employees' weekly work hours and the quality of their work-life balance experiences (Lingard, Francis and Turner 2012). Other research in the Australian construction industry found that burnout, stress, high turnover, and work-family conflict is common (Lingard and Francis 2005).

There has been some recent research into work-life balance in the New Zealand construction industry (see Wilkinson 2008; Morrison and Thurnell 2012), but no empirical work has been done regarding working hours of New Zealand construction employees. Much of the work-life balance research in the construction industry focuses on working hours, and suggests that long working hours without long breaks adversely affects the ability to achieve work-life balance, and that long working hours are a barrier to utilisation of work-life strategies (Lingard *et al.* 2012). Further research to investigate within a single large New Zealand construction company, to identify the 'typical' working hours of its professional and managerial level staff, is therefore warranted.

Morrison E. and Thurnell D. (2012) Working hours in a large New Zealand construction company *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 249-259.

WORKING HOURS

Working hours in New Zealand

New Zealand has been significant internationally for its high proportion (22%) of full time employees working 50 hours or more per week, second only to Japan (with 28%) amongst OECD countries (NOHSAC 2008). One reason for this trend is that in the 1980s, employer groups in New Zealand began to criticise the lack of labour flexibility, and in response, the radical policy of deregulation of the labour market was introduced in the early 1990s, so that matters such as hours of work, pay and working conditions could be determined at the workplace level, by using individual employment contracts rather than the arbitration system of collectivized contracts.

One indication of the relatively long hours work culture in New Zealand is that the U.K., U.S.A. and Australia often use 48 hours or more a week to define long working hours, whereas New Zealand research tends to use a cut-off point of more than 50 hours a week (Department of Labour 2008: 3). However, only 68% of New Zealand workers are satisfied with their current work time, and fewer workers want to work more hours for more remuneration (Otterbach 2010).

A national work-life balance survey found that just over half of New Zealand employees experienced work-life balance, but a significant number experienced work-life conflict, and found it difficult to achieve work-life balance, for a variety of reasons. A major source of conflict was that many people worked long hours and unpaid additional hours, and many New Zealanders wanted more time away from work and flexible start and finish times (Department of Labour 2006). In a study of young New Zealanders, long working hours were found to significantly increase the possibility of work stress giving rise to depression and anxiety (Mackenzie 2008).

Working hours in the New Zealand construction industry

The New Zealand construction industry has a culture of working long hours; workers are more likely to work very long hours than those in other industries, and have less employees working flexibly than in other industries (Department of Labour 2010; Skills Productivity Partnership 2012). The social costs of working long hours are considerable, and the New Zealand construction industry is similar to Australia's, where employees working extended hours and weekends reported issues such as marital problems and lack of rest, social life, and time for children (Townsend *et al.* 2006).

A number of the studies carried out regarding work-life balance in the Australian construction industry focus on working hours, perhaps due to the long hours employees within the industry typically work (see Lingard and Francis 2004a, 2005; Lingard *et al.* 2010a, 2010b, 2012; Townsend *et al.* 2006, 2011) . The construction industry has multiple barriers to the development, implementation, and effectiveness of work-life balance initiatives, including an organisa tional culture that supports long working hours and high commitment (De Cieri *et al.* 2005). Research in the New Zealand surveying profession echoes this, concluding that the "culture of unsocial working hours... is very strong and employers do not discourage out of hours working" (Wilkinson 2008:127).

The New Zealand construction industry currently employs around 157,000 workers [8% of the New Zealand total] and accounted for 14% of new jobs between 2001 and 2011, and yet it contributes only 4% of national GDP (Skills Productivity Partnership 2012). However, a critical shortage of skilled workers is considered imminent, due to

pent-up demand for affordable new housing, and the much-anticipated rebuild of earthquake-damaged Christchurch (estimated at as much as NZ$30 billion [US$ 24 billion]). The emergent challenge facing the New Zealand construction industry is to develop the capability to attract, motivate and retain a highly skilled, flexible and - particularly at management level - adaptive workforce. Townsend *et al.* (2011) asserted that the [Australian] construction industry's long term performance is threatened by its inability to attract and retain talented employees, due to its culture of long working hours, and failure to respond to employees' work-life expectations; this is also the case in the New Zealand construction industry.

RESEARCH AIMS AND METHODOLOGY

This research aims to identify the typical working hours of employees within a large New Zealand construction company, and to provide some insight on employees' views regarding their working hours and associated work-life balance issues, so that the needs of employees in the New Zealand construction industry are better understood. The research question is: 'What working hours do employees carry out in a large New Zealand construction company?' The research is exploratory in nature, as no previous studies have been undertaken on working hours in the New Zealand construction industry. The aim is to elicit a broad cross-section of empirical data from a large number of respondents, hence the use of a cross-sectional survey methodology, which produces data which is comprehensive and empirical, and provides a snapshot of the research topic at a specific point in time (Denscombe 2003). The sample population is professional and managerial staff, who all have work email accounts and computer access, and so it is deemed appropriate to use a web-based questionnaire in this instance. A possible limitation of this method is that employees who spend more time on their computer may be more likely to complete the survey, potentially producing biased data; however, this does not threaten the validity of the study. Furthermore, by having the General Manager of the company endorse the survey by sending out an initial email requesting employees participate in the study and assuring anonymity, respondents may be less likely to ignore the questionnaire.

RESEARCH METHOD

Due to constraints regarding accessibility and permission, an opportunity sample of employees within one large New Zealand construction company was used. The company is relatively large, and is involved across all construction industry sectors and regions of New Zealand. By using an opportunity sample from one construction company, generalisations may not be valid; the generalisability of the findings to other large New Zealand construction companies would depend on how similar the companies are. However, collecting data from one company was considered appropriate, as this has advantages, for example "that context variables such as organisational culture, policies and procedures are controlled" (Lingard and Francis 2004b: 21).

All the company's professional and managerial staff in the Auckland region were emailed with the questionnaire instrument. The email included a description of, and reason for, the survey. The first page of the survey contained a consent clause to which the respondent was required to agree before carrying out the survey.

The questionnaire contained closed questions which requested demographic information, which included: age; gender; number of years worked in the construction industry; type of employment (full, part time or contract); job role, and work location

(site-based or head office). Respondents were also asked to indicate the average number of hours typically worked per week. No questions were mandatory; that is, there were no forced responses. Open questions were included at the end of the questionnaire, where employees could provide additional feedback regarding their working hours and any issues relating to work-life balance.

The demographic characteristics data of the survey sample were tabulated to show the response count and percentage for each demographic category. In addition, the data regarding working hours were tabulated to show response count and percentage of employees according to working hours depending on job role and job location. The responses to the open questions were coded, based on topic, and considered in the discussion to assist in drawing inferences regarding the results.

RESULTS

Of a possible 174 respondents, 121 complete and usable questionnaires were returned (a 70% response rate). Table 1 shows the demographic characteristics and hours worked per week of the sample. (Note that not all respondents answered every question).

The mean age of the sample was undeterminable as responses were only given according to age bracket. The modal age was 40-49 years. Of the 120 responses to the question on gender, 108 (90%) were male while only 12 (10%) were female. Considering the number of years worked in construction, a relatively even distribution of respondents existed. Of the 113 responses regarding type of employment, the vast majority (104 respondents) had full-time working arrangements. Site-based employees made up 71% of respondents, while 29% were based off-site (in the head office). The largest groups of employees were quantity surveyors, estimators, and commercial managers (34% of respondents), and project managers, construction managers, site managers, package managers, and project leaders (33% of respondents).

Table 2 shows the hours worked per week by all groups of employees. Considering the two largest groups of respondents, for quantity surveyors, estimators, and commercial managers, 81% worked 40-49 hours per week, 12% worked 50-59 hours per week, and 5% worked 60 or more hours per week. For project managers, construction managers, site managers, package managers, and project leaders, 42% worked 40-49 hours per week, 43% worked 50-59 hours per week, and 15% worked 60 or more hours per week.

Table 1: Demographic characteristics of sample (n=121)

	n	%		n	%
Age			Type of employment		
Under 30 years	22	19	Full-time work	104	92
30-39 years	30	25	Part-time work	2	2
40-49 years	31	26	Contract work	7	6
50-59 years	26	22			
60 years +	10	8	Work location		
			On site	85	71
Gender			Head office	35	29
Male	108	90			
Female	12	10	Job description		
			Project managers*	40	33
Years worked in construction			Foremen, site managers	8	7
0-9	35	30	Site administration	8	6
10-19	27	23	Commercial managers**	41	34
20-29	28	23	Engineering services	7	6
30 years +	29	24	Upper management	6	5
			Other	11	9
Hours worked per week					
0-29 hours	2	2			
30-39 hours	5	4			
40-49 hours	69	57			
50-59 hours	36	30			
60 hours +	9	7			

* includes project, construction, site, and package managers and project leaders

** includes commercial managers, quantity surveyors and estimators

Table 2: Hours worked per week by job role (n=121)

Hours/ week	Project mgrs*		Comm mgrs**		Foremen, site mgrs		Site admin		Engineering		Upper mgmt		Other	
	%	n	%	n	%	n	%	n	%	n	%	n	%	n
0-29	0	0	0	0	0	0	12	1	0	0	0	0	9	1
30-39	0	0	2	1	0	0	12	1	15	1	0	0	19	2
40-49	42	17	81	33	50	4	50	4	58	4	33	2	45	5
50-59	43	17	12	5	50	4	13	1	29	2	67	4	27	3
60 +	15	6	5	2	0	0	13	1	0	0	0	0	0	0

* includes project, construction, site, and package managers and project leaders

** includes commercial managers, quantity surveyors and estimators

Table 3 shows the hours worked per week by head office (n=35) and site-based employees (n=85). For respondents based in the head office, 11% worked under 40 hours per week, 66% worked 40-49 hours per week, 23% worked 50-59 hours per week, and none worked 60 or more hours per week. For site-based respondents, 3% worked under 40 hours per week, 53% worked 40-49 hours per week, 33% worked 50-59 hours per week, and 11% worked 60 or more hours per week.

Table 3: Hours worked per week by location

	Head office (n=35)		Site-based (n=85)	
Hrs/week	%	n	%	n
0-29	3	1	1	1
30-39	9	3	2	2
40-49	66	23	53	45
50-59	23	8	33	28
60 +	0	0	11	9

DISCUSSION

Only 17% of females were over 50 years of age, whereas 32% of males were over 50 years of age, a gender distribution which indicated a younger cohort of females in general. The low proportion, yet younger cohort of females suggests that these large construction companies are still largely male dominated, but that more females may be starting to enter the industry.

The findings on working hours are in line with much of the other related research (Lingard and Francis 2004a, 2004b; Lingard *et al.* 2010a, 2010b, 2012; Townsend *et al.* 2011) that reported that employees within the construction industry tend to work long hours. Considering all types of employees in the current New Zealand study, 37% worked 50 or more hours per week, and when considering full time employees only, 40% reported working very long (50 or more) hours per week. This percentage of respondents[40%] who work very long hours is identical to that of Lingard and Francis (2005) (whose respondents were from one private and one public sector construction organization in Australia). As presented earlier in Table 2, only 17% of quantity surveyors, estimators, and commercial managers worked very long hours (50 or more hours per week), while 58% of project managers, construction managers, site

managers, package managers, and project leaders worked very long hours. Working hours of the latter group are similar to Lingard *et al.*s' (2012) findings that between 47% and 53% of salaried and waged employees of an Australian medium-sized contractor worked in excess of 50 hours per week.

The results suggest that the necessity to work very long hours varied depending on job role. A possible reason for this is because of different demands within different job roles. For example, construction managers often have to meet very tight daily deadlines which may affect a project's overall progress and completion date, hence they may often feel the need to stay late or work weekends to meet these deadlines. Another possible reason for this is that the job characteristics of some positions such as site managers or superintendents necessitate supervision of subcontractors who are carrying out their work at weekends. When examining the difference between working hours by work location, it was shown in Table 3 that site-based employees worked longer hours than head office staff. Twenty-three percent of employees based in head office worked 50 or more hours per week, whereas significantly more employees that were based on-site (44%) undertook very long working hours (50+ hours per week), once again revealing a specific group of employees who were more prone to working very long hours. Similarly, Australian research found that site office-based employees of a large Australian construction firm worked longer hours (averaging 56 hours per week) than those in the head or regional offices (averaging 49 hours), and because of this, experienced higher levels of work interference with personal life, higher levels of exhaustion, and lower satisfaction with pay (Lingard and Francis 2004a).

Answers to the optional open ended questions regarding work hours and work-life balance issues included several responses which concerned the need for reduced working hours and/or reduced weekend work. The desirability of flexible work options such as flexible working hours was also apparent. One respondent expressed the view that long hours must be accepted as part of working in the construction industry: "The construction industry is an extremely challenging game to get into but the rewards are fantastic, not necessarily money-wise but from a personal achievement point of view. If you want to run a large project and have the outcome of success, you had better be prepared to put in the long hours. To do so, you need a very understanding family also."

MacKenzie (2008) concluded that employees within the Australian construction industry found their work very satisfying but they also were "collectively weary" about the overall adverse impact on family, mental and physical wellbeing that stem from the confrontational, high pressure work combined with long working hours characteristic of the industry (p. 53). Furthermore, recent research in the Australian construction industry found that lower weekly work hours were a significant predictor of overall satisfaction with work-life balance, and that those employees that worked very long hours (and hence had problematic work-life balance), were least able to rearrange their work hours in order to achieve greater work-life balance (Lingard *et al.* 2012: 292).

One respondent suggested "reducing the number of working hours [and] increasing the number of paid annual holidays in line with more EU countries." Another respondent suggested providing "at least every second weekend off" while another declared: "[Saturday work] should not be expected by head office and not be thought of as our standard week. Otherwise another pay structure should be put in place for the workers on a salary, that they are rewarded for it, being a day in lieu or paid time and

a quarter". These findings are not surprising; many New Zealanders working long hours do not receive any additional compensation for working overtime, and feel undervalued in terms of pay, and their lives outside of work (NOHSAC 2008). Research in the Australian construction industry has shown a division between waged and salaried workers, where waged workers aim to work overtime because of their pay structure, while salaried workers would either prefer not to work overtime or similarly be compensated for working overtime (Townsend *et al.* 2006). However, the use of lucrative "penalty rates" for overtime worked by waged workers in the New Zealand construction industry is rare, which perhaps explains the respondents' comments reported above. Moreover, white collar, salaried staff working long hours (who, regardless of actual hours worked, tend to be paid a yearly salary) are an important means of generating surplus value in the construction industry (Townsend *et al.* 2011).

One employee in the current New Zealand research expressed insight about work-life balance and working Saturdays as follows: “It is important that work does not override your family life. Partners and children should be recognized and appreciated as family life is often overlooked... e.g. Saturday working when most families are involved in sport.”

One respondent suggested that monitoring work hours is a possible way of addressing the issue of long working hours: "monitoring work hours by keeping daily time sheets on high pressure jobs... ensures the right people and numbers are brought into projects to keep hours down, makes people more efficient by making them accountable for their hours of work [and] creates better time management". The New Zealand construction industry (unlike many internationally) is characterised by very low levels of unionisation, and individual employment contracts are the norm, rather than the exception, resulting in little constraint upon the number of hours worked per week. Indeed, long working hours is a matter of concern; in May 2012, the United Nations called on the New Zealand government to introduce a statutory maximum number of working hours in health and safety legislation, and expressed concern that some collective agreements failed to specify work hours (United Nations 2012).

Another employee expressed the need to reduce “peer pressure to be at work for longer when not necessary” and terms this “non-productive ‘appearance sake’ attendance”. This is similar to findings in the Australian construction industry where employees reported “substantial levels of peer pressure within the industry in relation to working hours [and] pressure to be at work on Saturdays, even if there’s nothing to do except read the paper” (Townsend *et al.* 2006: 14). Research involving a participatory work-life balance intervention in an Australian construction company found that, due to the long hours culture within the construction industry, even when employers allow some flexibility in working hours, there may be a gap between available flexibility and actual flexibility practised (Lingard *et al.* 2012: 293). Contracting companies aiming to increase competitive advantage need to develop a range of human resources strategies that embrace the changing societal attitudes and demographic trends of the workforce, and that empower employees with the use of more flexible working arrangements, including more control over work hours and schedules. Lingard *et al.* (2010) undertook a survey in Australia of waged and salaried project-based construction workers, and found significant correlation between job-related resources, including work time adequacy and flexibility, and work-family enrichment (p.476). The construction industry must meet employees' needs for more control over their working time arrangements in order to achieve better work-life balance; failure to do so will inevitably result in talented workers leaving the industry,

and future potential entrants to the industry choosing alternative careers, where more flexible working hours, and better work-life balance, may meet their expectations. Townsend *et al.* (2011) used four case studies in the Australian construction industry, implementing a working time intervention (i.e. a compression of the standard working week from 6 to 5 days), and found that this shift to a 5 day roster had few, if any, negative effects on the ability to achieve productivity targets on those work sites, and did lead to increased work-life balance of employees, i.e. "a standalone benefit at no significant cost to the organization" (p.82). Investigation into the potential for use of this compressed work week approach in the New Zealand construction industry warrants further consideration.

CONCLUSIONS

The research aimed to identify the typical working hours of professional and managerial staff, both head/regional office and site-based, within a large New Zealand construction company. It was found that 40% of full-time employees worked very long (50+) weekly hours. Site-based managers tended to work longer average hours than their head/regional office counterparts. These findings are in stark contrast with the previously noted 22% of New Zealand workers overall who work very long hours (NOHSAC 2008). These findings on working hours are significant, as there has been no previous empirical research on working hours in the New Zealand construction industry, and they strongly reinforce the findings reported in the Australian construction industry, where a similar working culture of long hours exists, particularly amongst site-based workers (Lingard and Francis 2005; Lingard *et al.* 2010b; Townsend *et al.* 2011)

The research also obtained qualitative feedback regarding employees' working hours, and any associated issues relating to work-life balance, which suggested that there is some work-life conflict associated with working long hours and weekend work. These findings are also significant, as they, too, are consistent with sentiments expressed by workers in the Australian construction industry (Lingard *et al.* 2010a; Lingard *et al.* 2012).

In order to meet the future demands facing the New Zealand construction industry's workload capacity, and competitiveness, both clients and contractors need to do more to meet employees' increasing expectations regarding working hours and work-life balance. One of many solutions to the productivity problems within the industry will be recognition by all industry participants that the somewhat traditional work patterns, which still persist, need to change, by the adoption of human resources strategies which reflect wider society's need for better work-life balance.

The research relied upon respondents' subjective reports of their working hours and opinions regarding associated work-life balance issues. It did not attempt to record, or otherwise verify the actual hours worked by employees in a longitudinal study, nor did it attempt to implement a variety of working time interventions, such as flexible working arrangements, or compressed work weeks, and then explore any change in employees' opinions on work-life conflict issues associated with working long hours and weekend work. Future research could use a case study methodology (as has recently been done in the Australian construction industry - see Townsend *et al.* 2011 above) to investigate the impact of such flexible working arrangements or working time interventions on employees within a New Zealand construction company.

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WOMEN AT TOP LEVEL MANAGEMENT AT CONTRACTORS IN DENMARK AND NORWAY

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Strategic management and leadership in the building sector will gain increasing importance as globalization and shorter product lifecycles will put pressure on company competences in moving fast and agile. A broader mobilisation of human resources at the top level could be a central avenue to improve strategic management. Through new recruiting the composition of the top level management could be strengthened. Today the building industry encompasses relatively few managers with strategic management competences and women at this level are very few. The paper uses institutionalist theory to explain the dynamics in changing and developing top level management. The theoretical framework argues for five interlinked domains of the individual, the enterprise, the strategic management, the board and the environment. Institutions in all areas contribute to the experienced constraints. Based on an exploratory study of Danish and Norwegian female representation as CEOs, member of boards of directors and member of boards shows very low representation of women. Four competing institutions regarding female representation are identified the male dominant, the hostage, the voluntarist and the politically correct. The present status for the Danish contractors can be characterized as the hostage, as one woman in the board seems to be the present pattern. And Norway is less different than one should think. In Denmark as a newly launched reform encompass a strong voluntary element. An EU reform is therefore a more likely driver for politically correct institutional reform.

Keywords: equal opportunities, institutional theory, women, top-level management

INTRODUCTION

The Danish government announced in May 2012 that it would implement legislation that will make it obligatory, for the 1,100 largest companies to develop and follow a policy of increased representation of women on the corporate boards. Several other countries have implemented quotas of gender representation in corporate boards, most notably Norway, but also Belgium, France, Spain, Italy and the Netherlands (Hastings 2011). This legislative pressure means that over the coming years, the construction industry in Denmark will have to develop their boards to increase formal

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Buser M and Koch C(2012) Women at top level management at contractors in Denmark and Norway *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 261-271.

representation of women. But today the construction industry encompasses very few women at this level.

The aim of the paper is first to offer an institutionalist theoretical framework for understanding the complex interplay between business environment, enterprise and the individual role, behind strategic management and board representation (Terjesen *et al.* 2009, Scott 2002); second, to review research on initiatives enabling women representation in strategic management, both in business in general, and in the construction industry. Strategic management is here understood as the CEO and boards of directors, the top level of everyday management. and boards, with external representation. Third, to provide an illustrative example of the status in Danish Construction industry comparing it with Norway, based on public avaible data.

The empirical contribution of the paper is to provide data on female representation in large Danish and Norwegian contractors, which add to our understanding of the construction sector status in the area of female representation at top level management through evaluating countries and companies assumed to be forerunners. The analytical contribution lies in differentiating several institutions of gender representation.

The paper starts with a theory review, provides a method section and then moves on to the empirical material on construction in Denmark and Norway. The discussion understands the situation in Denmark as interplay between three different institutionalising processes and the conclusion is critical to the coming Danish reform.

METHOD

The paper adopts an interpretive institutionalist approach to gender and representation in boards (Bilimoria & Liang 2012, Scott 2001, Terjesen *et al.* 2009). It presents a first small exploratory screening of contractors' board representation in Denmark and Norway. The companies for the board investigation were selected using a website of the thousand largest Danish enterprises and using websites with public avaible company information on Norwegian contractors. The selection covers some of the largest general, earthworks, and technical contractors in these two countries. This gives coverage of subdomains within contracting without engaging with SMEs as it is assumed that the larger companies would be leading on issues of female representation. Most of the companies are listed shareholder companies (abbreviated AS), or public listed companies whose activities are regulated by law. However two Norwegian companies are so-called common shareholder companies (ASA), which are covered by the Norwegian Quota law. Shareholder companies are required to have elected employee representatives in their board. They are treated together with other types of board members here as they do not make a gender difference in this case. Half of the selected companied are owned by multinational companies and operate in both countries – Bravida, Hoffmann/Veidekke, NCC, Skanska and YIT – but it is only the Danish and Norwegian managements which are investigated here.

When identifying the institutions active enterprise websites, reports and other materials were juxtaposed with the figures on representation. Quantitatively we evaluated boards, boards and directors with no women as male dominated, one women as token and two or more as politically correct. Whereas the voluntary are more process oriented and more constructed on the basis on public debate. A Danish study of diversity management in construction focusing on diversity efforts in a large Danish contractor serves as background (Kamp 2005, 2007).

THEORETICAL FRAME

There is a vast literature on equal opportunities to membership in corporate boards (Terjeson *et al.* 2009 provide a review). Grosvold and Brammer (2011) and Terjesen *et al.* (2009) propose drawing on theories spanning the domains of the individual, the board, the enterprise and the environment. This paper also includes a fifth domain of strategic management i.e. the CEO and the board of directors. The paper adopts an institutional approach to female representation in corporate strategic management and boards. This implies a perspective of gender as 'not only an individual property, but also as an institution embedded in the workplace, occupations, and occupational environments through formally defined rules, roles, and responsibilities and the way in which…individuals think about their social world' (Terjesen *et al.* 2009: 325). Gender is understood as 'socially constructed roles of and relations between women and men' (Bilimoria & Liang 2012:3). Hopefully, such a perspective can help overcome stereotyping men and women, and at the same time also find commonalities, for example, in the building of professional identities (Dryburgh 1999, Faulkner 2009). Moreover, gender equity/equal opportunities can be viewed as 'a social order where men and women share the same opportunities and the same constraints in both the economic and the domestic realm' (Bilimoria & Liang 2012:3).

The institutional mechanisms enabling or constraining women's access to the board are multiple and spans the domains of the individual, the board, the enterprise and the external environment. Terjesen *et al.* (2009) point at gender self-schema and status as characteristics of the individual domain. At the board level, the authors describe a privileged closed group with its own rules and ways of thinking. Their review focuses on group-level processes such as social identity, social network and social cohesion, gendered trust, ingratiation and leadership. In the enterprise domain it is resource dependency, institutional, and agency theories that are prevalent. Finally, in the external environment, it is again the institutional that is mentioned.

Grosvold & Brammer (2011) develop the external environment level by pointing at the role of national institutional systems. They investigate the macro-micro linkages of national institutional systems and their impact on board representation. Gender differentiation, i.e. the manner in which gender and the differences between genders are assigned meaning is different between the national contexts, leading to different possibilities for obtaining senior management positions. The Nordic European and Eastern European cultural clusters have lower levels of gender differentiation than the Anglo-Saxon and Latin cultural clusters (Grosvold & Brammer 2011:121). There are linkages between the market organisation and board representation of women. According to their analysis, liberal market economies (such as the US) have a higher proportion of women on their boards than do coordinated markets economies (such as Denmark) by around two percentage points (Grosvold & Brammer 2011:311).

Initiatives introducing females in strategic management

Past and present research on equal opportunities on boards has developed a range of explanations for barriers and enablers and carried out evaluations of a range of efforts (see for example Barnard *et al.* 2010, Terjesen *et al.* 2009). The discussion below is carried out by looking at voluntary and at obligatory measures, presenting a few examples of each type.

Voluntary initiatives

Companies and individuals across the world have taken a number of voluntary initiatives to improve equal opportunities. This encompasses developing a corporate governance code (EU 2012), either by complying with an existing code or by creating a code internally. Internal voluntary efforts encompass company programs such as leadership development (Hopkins *et al.* 2008), mentoring programs, flexible work hours and on-site childcare, which could help employees in advancing their careers as well as achieving work–life balance (Michailidis *et al.* 2012). Raiden & Caven (2011) find widespread informal practices in their UK construction investigation. As pointed out by Barnard *et al.* (2010) there is a risk when designing such efforts to fall back on essentialists' notions of gender, for example assuming that child care would be the women's responsibility, a finding similar to Raiden & Caven 2011, and thereby reproducing stereotypes. External voluntary efforts would typically encompass networking. Recruitment for board and strategic management memberships is often described as a network activity where existing members of the boards recruit their contacts and protégées (Heemskerk & Fennema 2009). Networks of (male) managers with, for example, similar educational backgrounds would thus obtain social cohesion, often described as an 'old boys network'. Heemskerk & Fennema (2009) find that the social cohesion in the Dutch business elite declined between 1976 and 2001 and norms of corporate governance have become blurred. As a result, one could expect a more diverse recruitment for the elite to occur. Such development could be supported by female managers forming networks, the creation of recruitment databases etc. In a Dutch context, however, Heemskerk & Fennema (2009) experience the intervention of a law reform, making female representation in boards obligatory, leaving it redundant to speculate whether the more open network would voluntarily have acted in new ways. Barnard *et al.* (2010) point out that even if women's networks are important, the making of the networks is considered laborious and engineering professions might not consider it as part of their job. O'Neill *et al.* (2011) demonstrate how networking is part of a voluntary institution as the strategic managers interviewed placed responsibility for women's career advancement upon the individual. However the situation was no different with the women employees interviewed. Both groups chose to overlook the firm's male-dominated culture and other organizational constraints.

Obligatory initiatives

The obligatory initiatives are typically public regulations intervening in the business domain, as other labour market regulation. Equal opportunity legislation has been in place in a number of societies, including the EU, for quite a long time. In recent years, the applications of quotas of gender in board representation have increased, and so has the debate about them. The oldest, best exercised and most studied example is the quota in Norway (Matsa & Miller 2011, Nielsen & Huse 2010, Storvik & Teigen 2010). After a long preparation phase, the Norwegian government implemented a quota of 40% of female representation in corporate boards in 2003. According to Storvik & Teigen (2010) the enterprises were given four years to meet the quota, data bases were established for listing prospective female board members and supporting the recruitment process. The Norwegian employers' association created a training program aimed at company employees. After an initial phase, the Norwegian law came to encompass sanctions supporting the implementation. The most radical sanction is the forced dissolution of non-compliant companies. During the initial phase, companies did not widely implement the policy on a voluntary basis. Storvik & Teigen note that:

> '*Seven years after it was passed, the quota is widely accepted in Norwegian politics and society. The employers' association has not reported any problems and interviews with business leaders suggest that the policy is no longer controversial'* (Storvik & Teigen 2010:3).

If the quota has become successfully institutionalized in Norway it remains controversial outside Norway (Grosvold & Brammer 2011), especially its potential benefits for business. Matsa & Miller (2011) compared Norwegian companies to other Scandinavian companies and found that firms affected by the quotas undertook fewer workforce reductions than comparison firms, increasing relative labour costs and employment levels and reducing short-term profits. Moreover they found that the boards appear to be affecting corporate strategy in part by selecting likeminded executives. On this basis, Matsa & Miller (2011) suggest that female managers may be more stakeholder or long-term oriented than their male counterparts (Matsa & Miller 2011). On the other hand, Ahern & Dittmar (2012) find that the value of the companies fell and that the boards tended to become less competent. Kossowska *et al.* (2005), using public statistical data, found that large Danish companies with female board representation either perform better or equal to other Danish companies over the period 1992-2001. Carter *et al.* (2010) could not demonstrate a link between female representation and financial performance in large US corporations. Nielsen & Huse (2010) note that many investigations on the issue remain descriptive, quantitative and superficial. They themselves used a survey of 201 Norwegian firms of all sizes, without a control group. Their findings support that the ratio of women directors is positively associated with board strategic control, with decreased level of conflict and with commencing board development activities improving the quality of board work. Nielsen and Huse (2010) contend that women's ability to make a contribution to the board relates to their different leadership styles.

As an overall status of these voluntary and obligatory initiatives, the outcomes are mixed and contested (Barnard *et al.* 2010, Bilimoria & Liang 2012), but/and the slow expansion of women representation in boards is one of the more disappointing developments (Bilimoria & Liang 2012), whereas the expansion of obligatory quotas moves the public debate and the research in new, more promising directions.

WOMEN IN MANAGEMENT AT CONTRACTORS: DENMARK

The development in Denmark when it comes to gender and gender representation in management is at best ambiguous. While there is a solid basis of labour market and employment for both genders, the pay and representation remain asymmetric (EU 2012). In 2011, the association of managers in Denmark announced that they had reached 25% female membership amongst their 100,000 members (Lederne 2011). This can be compared to 12% in 1991. Amongst engineers, which are a central recruitment group for managers in construction, the female membership ratio in 2012 was 20%. Kamp (2005) found that in 2004, 22% of the engineering students were women, with indications of growth among building engineers, a growth which appears to have been recruited predominantly by consulting engineering and public units. Holt *et al.* (2006) found that in Denmark, the lowest female representation in executive boards and as CEOs (2%) is in construction and that the construction sector employs 10% women, with some subsectors (bricklayers) virtually without female employees or managers. A Danish investigation of the 2300 major companies covering the period 1992-2001 (Kossowska *et al.* 2005) showed an unchanged low level of female managers and members of boards in construction. IFKA (2007) arrived at the same

result, finding that 70% of the investigated 100 construction companies count between 0-15 % of female managers. Kossowska *et al.* (2005) revealed an unclear answer to the issue of possible linkage between women at board level and performance and concluded that enterprises employing women in the board of directors or higher level of management either have performed better or equally, but at least they have not performed worse (!).

IFKA (2007) points at lack of systematic recruitment policies in construction companies as an explanation for the low level of female managers, IFKA (2007) found that a mere 2% of the investigated construction firms are systematically recruiting women. Figure 1 shows the female representation at the four largest general contractors, MTH, Pihl, NCC and Hoffman/Veidekke, two foundation and earthworks contractors Arkil and Aarsleff, and five technical contractors Bravida, YIT, Kemp & Lauritsen and Eltek Networks.

Table 2: Gender representation at a sample of Danish Contractors

	Board			Board of Directors			CEO	
	Men	Women	%	Men	Women	%	Men	Women
MTH	9	1		3	1		1	
E. Pihl & Søn	4	2		5			1	
Per Aarsleff	6			2			1	
NCC	5	1		2			1	
Arkil Holding	6	2		2			1	
Hoffmann	5			1			1	
Bravida Danmark	5			2			1	
YIT	4	1		1			1	
Kemp & Lauritsen	8			1			1	
Eltel Networks	4	1		2			1	
Total	56	8	12.5	21	1	4.5	10	0

If we look down the hierarchy where the potential female candidates can be found, the situation is not very optimistic. Kamp (2007) provides an insight among the operational site managers of a large contractor who at the time of investigation had around 25% female employees in this position. Nevertheless, the contractors' projects and operational level were still heavily male dominated. The female managers struggle to be understood and recognised as professionals, especially in the beginning of their career. They employ laborious and meticulous efforts to build a professional identity as women and project managers, controlling their behaviour, language and appearance, and by trying to obtain respect by being serious, fair and competent (Kamp 2007). These efforts explain why the female project managers probably do not envisage obtaining a strategic management or even a board position (Kamp 2007). Styhre (2011) has followed 19 Swedish male site managers working for three contractors, which do not employ any female in this position. A situation comparable to large parts of Danish construction. His study reveals the site manager, as somebody capable of enduring any work situation, handling unanticipated events excelling in crisis management and who is celebrating the ‘virtue’ of overworking. Styhre points out that the site management role are reproducing gender ideologies, imposing

expectations on individual site managers, and erecting entry barriers for e.g. women or individuals not willing to forsake family life. Many of Styhre's interviewees are very experienced site managers, with many years in the business behind them, and these managers voice their concerns over the site management work ethos as a concern for the coming generations. On the other hand this paternalistic approach is cancelled by Raiden & Coven (2011) who reports younger male site managers who, counter to the stereotypical view, voice a strong need to operate locally in order to stay close to home and family and even occasions where female respondents prioritise their career ambitions.

WOMEN IN MANAGEMENT AT CONTRACTORS: NORWAY

The development in Norway is actually less different from Denmark than one might expect. The female representation on the labour market spans from 24% in manufacturing to 34% in financing (Parmann 2012). Since the quota regulation has been implemented, there has been a lot of focus on female representation in the common shareholder company boards (ASA). The law covers a mere 400 companies, whereas public limited companies (AS) represent 200.000 companies and a female board representation at 17%. Parmann (2012) finds that the female representation in boards for Norwegian companies listed in the stock exchange (ASA) is an average of 35%, that there is 4% CEOs and 15% who are members of boards of directors. The figures for the investigated sample are in the figure below. Although women represent close to 20% of the board members, the CEO and boards of directors representation is still rather low. The two companies covered by the quota law are actually lower than 40% and the rest far lower.

Table2: Gender representation at a sample of Norwegian Contractors

	Board			Board of Directors			CEO	
	Men	Women	%	Men	Women	%	Men	Women
Veidekke ASA	6	3	33	6	1		1	
Skanska Norge AS	9	2		6	1		1	
AF gruppen ASA	6	2	25	6	0		1	
Mesta Gruppen AS	9	3		5	2		1	
NCC Construction AS	9	1		7	0		1	
YIT AS	7	1		3	0		1	
Bravida Norge AS	9	0		10	0		1	
Kruse Smith AS	3	3		3	1		1	
Reinertsen AS	8	2		1	0		1	
Peab Norge AS	8	1		9	1		1	
Total	74	18	19.6	56	6	9.7	10	0

DISCUSSION

According to the institutionalist argument, the explanations for the asymmetric representation are to be found in the intersecting domains of individual-enterprise-strategic management- board-environment. The exploratory screening of two times ten companies showed that the selected Danish contractors are behind the Danish average

as well as EU-27 average. Whereas the Norwegian public limited company contractors are at Norwegian average and above EU-27. The sample does not encompass a single female CEO and only two Danish boards count more than one woman representative. As Terjesen *et al.* (2009) point out, the legitimacy and effects of the presence are likely to change once there are two or three representatives.

The integration or rather non integration of women can be described by four institutions of gender representation. The first maintains males as the dominant leaders in strategic management in construction (Löwstedt *et al.* 2011). The second, the hostage or token, recognizes it looks good to involve a woman in the board and improves the image of the company. The third, the voluntarist, places the initiative and responsibility with the individual woman, who has to fight her way up by building up the necessary competences, creating the necessary network, and competing with her male counterparts. The third, the politically correct, calls for a set of institutional initiatives to assure women equal opportunities in all domains. This latter institution encompasses educational pipelines, recruitment policies, talent management and a portfolio of public regulation, including law regulated quotas for board representation. Actually, the educational and labour market pipelines are providing the qualified women for the Danish construction industry. The three first institutions are often interlinked and mutually enforcing each other.

The actual Danish construction enterprise strategic management and board institutions can be characterised as male dominance and 'taking hostages'. A single woman is present in the board, the companies cannot be accused of not having women but their number is kept to a minimum. The study by Kossowska *et al.* (2005) gives an average of 10.3% women in Danish boards based out of a population of 81 enterprises in construction and 4.8 % of women in top management. These results are similar to the present study, but measured in 2001. EU (2012) finds the DK share in boards of listed companies 16% (January 2012) across sectors compared to Norwegian 35%, Swedish 25% and EU-27 is 14%.Our sample companies could be viewed as dominated by the male dominant and the female voluntarist institution. Both Styhre (2011) and Kamp (2007) provide support for what can be understood as a silent consent to this institution among the operational site managers of both sexes. It also appears to be widely accepted in the industry that very few women are represented at a high level and it can even be speculated that the women that are managers at lower levels and have potential for climbing further up, are spokesperson for the voluntarist institution (which would be more active than silent consent). But maybe it is more precise to describe the voluntarist institution as one that is reinforced by the external environment. A recent poll shows a resistance by 75% of Danish citizens to obligatory measures and the public debate amongst female managers predominantly gives voice to the voluntary institution, whereas the politically correct is heavily criticised. Nevertheless the initiative taken by the actual Danish government can be seen as a combination of voluntary and softened obligatory elements. The companies are requested to develop a gender policy but not necessarily to apply it. Moreover it is proposed to cover the 1100 largest companies only. That comparable European countries have begun supporting the politically correct institution appears not yet of sufficient importance.

Also in Norway the level of representation in the construction industry appears low on the basis of the small sample made here. In the boards, the representation is at 19.6 % well below 40%. The surprise in this result lies in the fact that the official law only covers two of the large contractors. But it would not be the first time that the industry

places itself on the grey side of legislation. And it is more of a general national industry phenomenon.

Apart from Norway, many European countries such as Belgium, France, Italy, the Netherlands and Spain have all introduced laws that require gender quotas for company boards. France alone accounts for around half the increase in female European corporate board members over the past twelve months (EU 2012, press release). The level has improved by 10% in one year, 2011, moving to an average of 22%, way higher than the Danish figures (Brunet & Dumas 2012). Similarly the Netherlands law reform has improved the femal participation from 9 % in 2009 (Heemskerk & Fennema 2009) to 19% in 2012 (EU 2012). The voluntary and obligatory types of initiatives reviewed, each supporting the two institutions of the voluntary and the politically correct, might be well stabilized and normalized on restricted arenas (i.e. Norway as reported by Storvik & Teigen 2010), but on a larger European and US arena are accompanied with mixed and contested research on their results and impact (Barnard *et al.* 2010, Bilimoria & Liang 2012).

Meanwhile, the female managers working for contractors are busy demonstrating that they as individuals are serious, meticulous, professional partners and as competent as men are (Kamp 2007) leaving the discussions about board representation to others.

Future changes might either strengthen the voluntaristic institution, the politically correct or even show a new path. In the framework of the politically correct institution, reforms that can be employed from the public side might be a dangerous sleeping pill in coordinated economies. As pointed out by Gronvold & Brammer (2011), in coordinated economies state initiatives might be needed. It can be added that the private players might tend to await exactly that, and postpone single enterprise initiatives.

CONCLUSIONS

The level of female managers and board members in construction in Denmark seem to have frozen over the period of 2001-2012 at a level lower than the average EU-27. But then again in Norway the level of representation in the strategic management and boards of the construction industry appears, on the basis on the small sample made here, lower than the international reputation would expect. Even if official law demands a higher level in the boards, this is restricted to a specific part of the public limited companies. In the Danish context, women's representation appears to be supported by a voluntarist institution in tandem with the male domination and co-shaped and reinforced by the intersected domains of the individual, the enterprise, the boards and the external environment. This institution presents as legitimate that women need to climb up the career ladder alone. The slowly increasing number of women engineers in construction creates a contrast to the few women at higher management levels, which today are representing the token institution. This tension is unlikely by itself to create the institutional change, but the presence of qualified talented managers at lower levels provides a strong basis for a governmental reform changing the institution once and for all. This reform however has to be of a different kind than the presently proposed, which represents a compromised half-obligatory or half free solution.

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JUGGLING WORK, FAMILY… AND LIFE IN ACADEMIA: THE CASE OF THE "NEW" MAN

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Although the notion of the "new man" is gaining currency, there is very little research on how he manages to balance work and family. It is therefore timely to look more closely at this issue. We present preliminary results from an explorative pilot study on work-life balance and "new men" in academia. Using an interpretative approach, in-depth interviews were carried out with academics from construction-related university departments in Britain and Sweden. Drawing on figures from the OECD and on Hofstede's masculine (Britain)/feminine (Sweden) dimension, we found that the small population of academic respondents studied struggled with the same kinds of work pressures and desires to achieve/perform according to the traditional norm of a masculine society. However, the Swedish men were more inclusive of the whole family life/circumstances in their accounts while the British men tended to be more focused on themselves. Since the analysis of the data is still on-going, the findings remain tentative. Early conclusions suggest that a satisfactory juggling of work-life balance for all these men is dependent on negotiations and re-negotiations of responsibilities between them and their partners. Some British men seemed to expect compromise and sacrifice by their partners, while for all Swedish men there was an expectation of compromise and sacrifice by both partners.

Keywords: academia, family, new man, work-life balance, cross-national comparison.

INTRODUCTION

Traditionally the male role has been that of the breadwinner with long working hours (Watts, 2009: 43; Ranson, 2011). Concepts such as the "new man" (Hearn, 1999; Watts, 2009: 42) and "working father" (Ranson, 2011) have recently emerged to refer to men who do not conform to the traditional male work model, but value personal wellbeing, and are keen to spend time with their family (Bevan and Jones, 2003; Family Friendly Working Hours Task Force, 2010; Linkow *et al.* 2011). Importantly, most of these men seek to achieve "work-life balance" while also experiencing their work as rewarding and satisfying. Indeed, for professional employees in particular,

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Raiden A; Räisänen C and Caven V (2012) Juggling work, family… and life in academia: The case of the "new" man *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 273-283.

work is often a source of self-fulfilment and identification (Eikhof *et al.* 2007: 326-327; Watts, 2007; Ford and Collinson, 2011: 263-264).

Contemporary definitions of work-life balance tend therefore to emphasise the *balance* rather than viewing work as constraining personal life, or vice versa. Noon and Blyton (2007: 356) argue that work-life balance should be about:

"the ability of individuals to pursue successfully their work and non-work lives, without undue pressures from one undermining the satisfactory experience of the other."

In today's Western society, where it is quite common for both partners in a relationship to be pursuing professional careers, finding balance is not so easy. There is a plethora of research concerning women's (mothers) work-life balance, yet how men (and fathers) manage to balance their work and family roles and responsibilities remains under-researched. Here we focus the work-life balance of new men in academia.

Rapid and fundamental changes in Higher Education over the last few decades have transformed the culture and nature of the academic workforce, resulting in uncertainty, anxiety and stress among university employees (e.g. Woods, 2009; OECD 2010). The changes have mainly been driven by external pressures: increasing financial constraints; growing national and international competition; stronger demands on accountability; contradictory institutional goals; shifting disciplinary boundaries, restructuring of departments and knowledge areas; expanding use of ICT; and new types of faculty appointments competing with traditional tenured positions (e.g. Gappa *et al.* 2005). As a consequence of these pressures, job satisfaction seems to be on the decrease and stress and burnout on the increase (e.g. Woods 2009).

Work-life balance issues are therefore gaining increasing attention and support politically in the UK and the European Commission (Bryson and Karsten, 2009: 40) and within the academic community (e.g. Woods, 2009). Hakim (2008) points to the imbalance of men's much more restricted choices regarding their involvement with family than those of women. Despite advances in legislative provision (for example fathers' entitlement to maternity/parental leave), gendered-ness prevails: e.g., women are more likely than men to think they achieve the right work-life balance, and men are less likely than women to agree that their organisation is supportive in this area (CIPD, 2009: 12; Johansson and Kinth, 2008: 60, Allard 2007).

Accordingly, although contemporary definitions aim to enable individuals to maintain a satisfactory equilibrium between work and non-work, the reality is that the concept is synonymous with women and caring responsibilities. In the construction industry, the working population is heavily male dominated. Thus, it is no surprise that a large proportion of academics within University Departments of Construction, Civil Engineering and the Built Environment are mostly men. Organisational work-life balance initiatives that cater for the minority (women) in these types of environments are not achieving their full potential (Smithson and Stokoe, 2005: 149; CIPD, 2009) and indeed stand to reinforce the traditional gendered view.

Societal and cultural contexts and Governmental support for work-life balance vary considerably between countries. Our interest is directed to two countries, which the literature portrays as very different: the UK and Sweden. It is generally understood that in Sweden gender equality has come much further in terms of men's involvement with family. Certainly, parental leave campaigns since the early 70s have contributed

to the image of a Swedish new man that is masculine and baby-oriented, and interestingly called "soft man/soft daddy" in Swedish ("mjukisman/mjukispappa"). However, uptake of parental leave still remains a moderate 20% (Johansson and Klinth, 2008: 43-44). One could ask whether the soft man connotation has anything to do with the weak uptake! In the UK this process of change has only just began. While the public (political, expert and media) discourses promote "involved fatherhood", in practice low take-up of parental leave, and limited contribution to childcare generally, appears to be related to a traditional male long-working-hours culture (Gregory and Milner, 2011).

In an explorative pilot study, we have chosen two internationally acknowledged measures on qualitative data as an initial step to compare the work-life balance situations of a small population of new men in the two academic contexts. One measure is specific to work-life balance: the OECD better-life index (OECD, 2012); the other is one of Hofstede's well-known dimensions of national culture (Hofstede *et al.* 2010). The next section in this paper describes these measures. We then outline our research methods, before critical discussion of the research findings.

OECD BETTER LIFE INDEX

The OECD better life index (OECD, 2012) covers research on all aspects of well-being in society, including housing, education, income, safety, and work-life balance. Thirty-four OECD countries are ranked on a scale of 1-10 (ten being the best) on three key criteria: (i) employment rate of women with children, (ii) employees working long hours, and (iii) time devoted to leisure and personal care. Although unable to provide data on men and their involvement with family life, this index is a useful initial indicator of the overall societal and cultural context within which Swedish and British men work.

As shown in Table 1, in the overall ranking Sweden is positioned 7th (scoring 8.1) and the UK 17th (scoring 7.0). Key differences between the two countries arise from the number of employees who work very long hours and the percentage of working mothers.

Table 1: OECD better life index work-life balance data for Sweden and the UK

	Sweden	UK
Overall rank position	7th	17th
Score	8.1	7.0
Working long hours	1.24%	11.92%
Women with children in work	76%	67%

Concerning work hours, in Sweden only 1.24% work very long hours (defined as working on average 50 hours or more per week). This figure for the UK is 11.92%, which is not only much higher than that for Sweden, but also represents a relatively large proportion of the working population (near enough one fifth). This confirms other studies which suggest that the British work longer hours than their European counterparts (Sheddon, 2012: 8-9).

The other, although smaller, difference is in the number of working mothers. In Sweden three quarters (76%) of women with children are employed, which is higher

than the OECD average (66%). In the UK it is 67%. While these figures do not show a significant difference, closer examination of the number of hours both women and men in these countries work reveals marked differences between the sexes. Men tend to work full-time in Sweden and in the UK (OECD, 2011: 137). The work hours for women in Sweden is close to full-time employment, averaging 35hrs/wk (ibid). Women in the UK are much more commonly engaged in part-time work: over 40% of women work 30 hours or less per week (Sheddon, 2012: 9).

HOFSTEDE'S DIMENSIONS OF NATIONAL CULTURE

Geert Hofstede's work on national and organisational cultures is widely known, and widely debated. Already in 1980 he introduced the idea that established theories in psychology, organisation sociology and management theory may not be universally valid because of differences in national and organisational cultures (Hofstede *et al.* 2010: xi). He built his claim on extensive data from IBM employees world wide, which he later supplemented by material from the World Values Survey and other available databases. In essence, Hofstede measures differences in national cultures along six dimensions: power distance, individualism versus collectivism, masculinity versus femininity, uncertainty avoidance, long-term versus short-term orientation, and indulgence versus restraint (Hofstede *et al.* 2010). This approach has been met with mixed views. For example, Williamson (2002: 1391) identifies dangers in assuming that: (i) all members of a culture homogeneously carry the same cultural attributes and that a culture can be uniform, and (ii) individuals' values or behaviour are wholly determined by their cultural background. At the same time, he recognises the value in Hofstede's naming and describing attributes that enable the opening of what is otherwise a black box of cultural factors (ibid; see also Hofstede, 2002).

It is in this latter vein that we have applied his constructs of masculinity-femininity in our explorative cross-cultural comparison. Hofstede and colleagues recognise that there are absolute biological differences between men and women, but also that the two genders tend to conform to different social, culturally determined roles (Hofstede *et al.* 2010: 137). At national level:

"a society is called masculine when emotional gender roles are clearly distinct: men are supposed to be assertive, tough, and focused on material success, whereas women are supposed to be more modest, tender, and concerned with the quality of life. A society is called feminine when emotional gender roles overlap: both men and women are supposed to be modest, tender, and concerned with the quality of life" (Hofstede et al. 2010: 140).

Anglo-Saxons countries, including the UK, tend to be masculine while Scandinavian countries, including Sweden, are characterised as highly feminine (Hofstede *et al.* 2010: 140, 144).

When translated into a work context, the interesting issue is what motivates people: wanting to be the best (masculine) or liking what you do (feminine) (Itim, 2012a/b). A web resource that facilitates country specific research on Hofstede's dimensions provides the following excerpts for Sweden and the UK on the masculinity-femininity dimension:

"Sweden scores 5 on this dimension and is therefore a feminine society. In feminine countries it is important to keep the life/work balance and you make sure that all are included. An effective manager is supportive to his/her people, and decision making is achieved through involvement. Managers strive for consensus and people value

equality, solidarity and quality in their working lives. Conflicts are resolved by compromise and negotiation and Swedes are known for their long discussions until consensus has been reached. Incentives such as free time and flexible work hours and place are favoured..." (Itim, 2012a)

"At 66 Britain is a masculine society – highly success oriented and driven. A key point of confusion for the foreigner lies in the apparent contradiction between the British culture of modesty and understatement which is at odds with the underlying success driven value system in the culture. Critical to understanding the British is being able to "read between the lines''. What is said is not always what is meant. In comparison to feminine cultures such as the Scandinavian countries, people in the UK live in order to work and have a clear performance ambition." (Itim, 2012b)

The differences between the two national cultures, according to this description, is clear cut: Sweden is described as an environment where work-life balance is valued and people focus on *balance*. In contrast, the UK is a success-driven value system where performance ambition (work) clearly outweighs time with the family (life).

RESEARCH METHODS

Using an interpretative approach, in-depth interviews were carried out with academics from construction-related university departments in Britain and Sweden. There were no work-life balance preconceptions or theoretical framework informing the data collection, rather we wanted to see what perspectives would emerge through the stories in the interviews.

During the interviews, which lasted approximately one hour, the respondents were prompted to give retrospective accounts of their work and non-work trajectories from their university studies to the present day. The interviews were recorded and transcribed.

A narrative analysis was then applied on the data to code the various, and often overlapping, fragments of accounts. These fragments were then sorted and united by a plot that made the fragments cohere (Czarniawska, 2004). In applying this analytical tool, we are not claiming that our interpretations convey the truth, but rather they convey one point of view. From our close readings of the transcripts, a plot gradually emerged for each interview. The analysis was iterative and carried out separately first. We then compared our analyses and resolved the few discrepancies that arose through dialogue.

Our sample of respondents included academics from five institutions in the UK and Sweden: three of them are Swedish and seven British. Their job roles include Lecturer (4), Senior Lecturer (4) and Professor (2). Seven of the respondents work full-time at their respective Universities and three have part-time posts. Age range of the respondents is 39-57. Eight are married and two have long-term partners. Most of the couples have 2-3 children aged between 18 months and 25 years.

With regards to sampling, it is important to note that the research respondents were selected to take part in the study via informal approaches to people within our professional networks. Thus the sampling strategy was based on a purposive key informant approach.

RESEARCH FINDINGS AND DISCUSSION

The research findings are addressed under three sub-headings introduced in the theory section: orientation to work (informed by Hofstede's masculine-feminine cultural

indicators); employment rate of women with children; and working hours (the latter two issues are informed by key measures in the OECD better life index).

Overall the respondents reported a wide variety of interests/commitments which may be considered to fall outside their emplo3yment at the University as well as outside the family: one respondent runs a private architectural practice, another a yoga studio, and one works 50% in industry, two indicated keen interest in sports and one in music. Two had commitments that could be said to bridge both work and family: they were heavily engaged in building: one a new dwelling; the other renovating the family's summer home.

– Orientation to work

The achievement orientation (or performance ambition) noted in Hofstede's work on culture in Britain (Itim, 2012b) is strongly reflected in the interviews with the British respondents. However, two of the Swedish respondents manifested the same traits. Four respondents (two British and two Swedish) expressed their work-orientation in explicit terms, but the trend was detectable in most of the narratives in that more space was given to the work situations compared to family situations. Non-work or 'life' related references tended to be short and devoid of detail, and required prompting from the interviewers. In contrast, professional pride was clearly articulated, as were work/ educational achievements. Also, tendency to divert the conversation to work-related matters was evident in many interviews.

Success in life and in relation to family specifically was said to be

"… enabled by an understanding partner and children." (British man)

Interestingly, most of the respondents (both British and Swedish) reflected on their life in terms of maintaining work and family fitting-in with careers. For example, for one couple where both partners worked in professional roles, it had always been clear that they would be sharing the care responsibilities, but more importantly:

"…we wanted children, but… There was never any consideration that either of us would stop work to look after the kids." (British man)

Later in the narrative, care of the children and sharing the responsibility was mentioned mainly in connection with the work arrangements and drop-off and pick-up from school; a common situation among all respondents (British and Swedish). One Swedish man had committed to picking up his children from school and day-care regularly, but highlighted that:

"I will still be very much engaged in my work. I've always been like that, and I have stopped thinking that it will be something else, because my work is also my hobby, or it has become my hobby." (Swedish man)

He reflected on absent-minded conversations with his wife in the evenings whilst checking e-mails on a laptop. Another Swedish man noted that he had taken parental leave when his children were small, but now that they were older they complained about his work-oriented life style:

"…the kids still love me! They actually sang a song about me on my birthday, about how much I work…" (Swedish man)

Elsewhere (Raiden and Caven, forthcoming), typologies of work-family orientation were used to investigate construction professionals' life-priorities. Results showed that most individuals working in construction-related professional roles sorted under

"career/work-centred"; only a few sorted under "adaptive". The career/work-centred individuals prioritise professional careers over family commitments; and those who have adapted their careers to take as active a role as possible in parenting are termed adaptive (Halrynjo, 2009; Hakim, 2000).

This was also true in our small sample on British academics. Even though three men in the sample worked part-time at their Universities, their orientation was more career/work-centred than adaptive. They all had significant engagements with work elsewhere (for example at their private practices). Only one British full-time academic in the sample could be said to sort under the 'adaptive' category in that he abstained from advancement:

"I had the opportunity to [advance] and decided not to, for a few reasons [….] flexibility I've had, in that I can finish early or start later, or whatever, would diminish. At the moment, the kids are still relatively young, still need a lot of looking after, and that's how I want it to be." (British man)

Although childcare was described as shared, it was relatively shared not equally shared. The *relative* sharing of childcare was evident in the narratives of the Swedish men as well. Apart from the token parental leave, which is now fairly common in Sweden, especially among academics, the men talked about taking their children to school or day-care. However, it was clear that the main responsibility for childcare was with the partner; these did not work full-.

One British respondent who now worked full-time at the University referred to a career change due to his inability to spend time with family:

"I had fantastic time in xxx as a single person, as a newlywed, as a couple, but when the kids came along it was just a bit too much disruption. So when my oldest was three I'd only spent a year with him, so that watershed was a good time to come out." (British man)

Thus, even though his current work commitment to the university would indicate that he would sort under career-oriented, his career choices overall indicate that he made efforts to combine work with family.

There was one distinctively adaptive in the sample, who combines two jobs work and childcare in his working week: his own practice (three days a week); a part-time job at the University (one day a week); and one day being a "house husband" caring for his youngest child. He reflects on the journey that took him to this life situation with some seeming regret. His narrative indicates that the choices were not his, but circumstantial (for example to work only one day a week at the University): e.g., "I had to", "she had to", "ended up" and "It's not ideal…" In spite of this, he seems to have benefitted from the circumstances:

"I'm very happy that I can have one day a week with my family. I think it's quite unusual for a man to do that. It's becoming increasingly normal, but I'm quite glad I share responsibilities for family with my wife in a pretty equal kind of way." (British man)

Sharing the child care in this family does indeed seem to be equal: the younger child has three days a week in kindergarten, then one day with the father and one day with the mother, while the older child is at school five days a week.

The Swedish respondents tended to speak much more about their time with the family, and with positive associations:

"I'm happy every day I see, especially, Sara and Olle, but obviously my wife as well, so basically I think life is very good…" (Swedish man)

It is clear that the time with family is appreciated, especially by the adaptives.

– Employment rate of women with children

As alluded to earlier, much of the work-life balance within our sample of academics was achieved because the men enjoyed a traditional family set-up with the man dedicated to his work and the woman prioritising childcare over career. Thus, work-life balance seemed to be understood in terms of the family as unit contributing to the care of the children, rather than men and women contributing equally. Indeed, some of the partners of the British men in particular had put their careers on hold in order to be home with the children thus allowing their husbands to develop their careers. In the Sweden sample, all of the women worked, except for the time they spent on maternity leave. However, none of them worked full time, but rather between 60-80%. This supports the OECD (2011) findings.

There is a difference, however, in how the British and Swedish men reflected on the careers of their partners. All of the Swedish respondents volunteered details about their partner's work and explanations as to why responsibilities were divided in the way they were. They were more inclusive of the family unit as a whole in their narratives. This somewhat supports Hofstede's (2010) claim that Sweden has a feminine national culture. British men tended to be much more focused on their own careers and volunteered little information about the circumstances of their partners.

– Working hours

Many respondents in our sample (both British and Swedish) referred to working long hours regularly. In Britain, one Professor estimated that on average his working week totalled 65-70 hours; one senior lecturer mentioned working 12-hour days and taking work home frequently. In Sweden, a senior lecturer noted working 50 hours as his norm and also taking work home regularly most evenings. Another Swedish respondent referred to *"*stealing hours*"* in the evenings at home for work three nights a week. These figures do not support the OECD (2012) better life index data that suggests that very few people in Sweden work overtime. It may be that these hours do not get recorded as much of the work is done outside of the workplace.

Flexibility in the job was noted as the key to managing working time and commitments with family. Flexibility is further facilitated by new mobile technology, which, however, also generates challenges such as difficulties of setting clear boundaries between work and non-work time. Moreover, through mobile technology constant availability may cause undue stress (Nurmi, 2010).

For a British respondent, time with the family was referred to as a useful way of managing "spill-over":

"Those things that you have to do, picking the kids up from school, are often an excuse to say, 'I'm stopping work now, because I've got to pick up the kids from school so, it's a great thing to be able to say "It's 5 now, I have to go and get the kids from after-school club." So, actually, contact with the family puts a limit on the "creep"." (British man)

In contrast, another respondent finds that adjusting working time to put family first creates more "spill-over":

"with a new child, I am being more strict about leaving on time, because otherwise I wouldn't see her because she goes to bed early, but then that does lead to me spending the weekend working." (British man)

CONCLUSION

In the literature Sweden is portrayed as having a feminine national culture (according to Hofstede's masculine-feminine dimension) and thus being a family-friendly society. Our findings reveal that our respondents struggle with exactly the same kinds of work pressures and desires to achieve/perform according to the traditional norm within the masculine society/culture in the UK. Although the Swedish national social policy allows for much more extensive rights for men than is on offer in the UK, and official figures (from the OECD) suggest that few work long hours in Sweden, two of our Swedish respondents talk about frequently working at home in the evenings (2-3hrs) on a weekly basis, with core working hours in the region of 50-60hrs/week. Flexibility in academic jobs may allow them to leave early and collect children from school and day-care regularly, but ICT enables them to often amply "make up" for those allowances by working after the family has gone to sleep.

To sum up, contrary to Hofstede's claim we found little difference between British and Swedish men on the masculine/feminine dimension. What was interesting, and needs to be further researched, is the way the ways in which the men positioned themselves in their narratives. The Swedish men tended to be more inclusive; they talked about themselves as part of the family unit. The British men were more I-oriented, and sometimes seemed to distance themselves from family affairs. While some British women have sacrificed their careers to support their family, all Swedish families had explicitly considered both the women's and men's careers.

This small pilot study has highlighted some interesting discrepancies between theory and the life narratives of a few new men in the UK and in Sweden. These findings warrant further in-depth research on a larger population, using various theoretical lenses.

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STRIVING FOR INCLUSIVE DESIGN IN THE BUILT ENVIRONMENT: LEARNING STRATEGY ADOPTED BY POLICY IMPLEMENTERS AT LOCAL AUTHORITIES IN ENGLAND

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The research will explore views on inclusive design policy implementation and learning strategy used in practice by Local Authorities' planning, building control and policy departments in England. It reports emerging research findings. The research aim was developed from an extensive literature review, and informed by a pilot study with relevant Local Authority departments. The pilot study highlighted gaps within the process of policy implementation, a lack of awareness of the process and flaws in the design guidance policy. This has helped inform the development of a robust research design using both a survey and semi-structured interviews. The questionnaire targeted key employees within Local Authorities designed to establish how employees learn about inclusive design policy and to determine their views on current approaches of inclusive design policy implementation adopted by their Local Authorities. The questionnaire produces 117 responses. Interestingly approximately 9 out of 129 Local Authorities approached claimed that they were unable to participate either because an inclusive design policy was not adopted or they were faced with a high workload and thus unable to take part. An emerging finding is a lack of understanding of inclusive design problems, which may lead to problem with inclusive design policy implementation, and thus adversely affect how the built environment can be experienced. There is a strong indication from the survey respondents indicating that they are most likely to learn about inclusive design from policy guides produced by their Local Authorities and from their colleagues.

Keywords: implementation, inclusive-design, English local authority, policy, learning.

INTRODUCTION

The research is concerned with inclusive design within the built environment and its implementation through policy to ensure the built environment provides accessibility to a wide range of the population. It focuses on the exploration of a learning strategy of inclusive design policy adopted by local authorities. In addition general views on

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Amakali T. R.; Cook G and Larsen G. D. (2012) Striving for inclusive design in the built environment: Learning strategy adopted by policy implementers at Local Authorities in England *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 285-294.

the current approach of inclusive design policy implementation held by the key players at Local Authorities are also examined and some of the findings are included in this paper.

Firstly, the paper provides a summary of the background as a way of introduction to the topic area and its importance, and that of inclusive design policy implementation. The background information is focused on the need for inclusive design in the built environment and the importance of its implementation through the use of policy. Thereafter, a summary of a preliminary study was included. Finally, the questionnaire results are discussed, focusing on an inclusive design learning strategy adopted by the Local Authorities and gathering the views of policy implementers on inclusive design strategy.

The findings suggest that policy implementers are most likely to learn about inclusive design policy from policy documentation and colleagues. Because interpretation and meaning are part of a learning strategy; it is vital for policy guides to be self-explanatory and for colleagues to have adequate knowledge. In addition policy implementers appear to be shifting inclusive design responsibilities from those based in planning/development control to those in building control departments.

BACKGROUND

In the UK during the Second World War, many veterans were returning wounded, which prompted the Government to draft the Disabled Persons (Employment) Act, 1944; to allow disabled veterans, but also non-veteran disabled people, to interact within the labour market (DPEA 1944). In addition, the 1970 Act was further introduced to positively influence accessibility within the built environment (Health 1970). Both of these statutory instruments and successive legislation has thus far failed to deliver inclusive design as planned.

Imrie (1999) stated that most non-disabled people see disabled people as minorities; therefore access related expenditure will need to be justified. The recent National Statistics Survey 2009/2010 (Howe 2010) indicated that over 40% of people aged 65 are disabled, with the figure rising as age increases. The UK is one of the countries where the population of over 65 years old is approaching 15% (Crews and Zavotka 2006). It is suggested that one of the implications of an aging population is an increase in health care expenditure of 300% by 2041 (Crawford, Barton *et al.* 2010). Thus if the disabled population is to have access to the built environment additional research funding will be required. With life expectancy set to rise in the 21st century, this population is rapidly becoming a non-silent minority. The interaction of disabled people with the built environment is vital to avoid unnecessary institutionalisation such as the provision of special homes, schools and other services, which differs from the rest of the population (Imrie 1999).

The physical built environment needs to play a key role in accommodating disabled people, rather than disabled people accommodating the built environment. It is often the case that disabled people avoid inaccessible venues, leading to isolation from their communities (Oliver and Barnes 1998). Alternatively, it can be argued that where the built environment accommodates the accessibility needs of the wider population, it will consequently prompt an increased population to use it effortlessly. Furthermore, it can be argued that any choices which can result in the built environment focusing on accommodating younger and more active groups is more likely to exclude disabled and elderly groups.

Inclusive design implementation

To improve inclusive design policy implementation, the UK Government has introduced various access/inclusive design policies over the last 40 years, including an accessible housing policy in the early 1970's (Health 1970). After the introduction of the policy the Government passed legislation and allocated resources for its implementation (Barrett and Fudge 1981). Policy statements and circulars act to govern policy rules and objectives which in turn provide measurable performance indicators. The UK Government has effectively made discrimination illegal through the Disability Discrimination Act 1995/2005 (DDA 1995) recently incorporated within the Equality Act 2010 (ODPM 2010), and the Town and Country Planning Act 1990 (Government 1990), Planning Policy Statements 1 (PPS1) (ODPM 2005) and the Building Regulations 2000/2004 (ODPM 2004).

In order to examine the effectiveness of the policy implementation strategy, there are two useful areas to consider. Firstly, as Drucker (1999) commented that if policy objectives are only for good intentions, they are worthless. Secondly, performance objectives and purposeful actions are taken, when one knows what is needed to be done and more importantly how to go about doing it. We argue that one will know through learning. In order to examine these two areas it is vital to look at these policies implementation strategy adopted by Local Authorities.

The introduction of policy does not guarantee its implementation, nor does it guarantee that the policy intention will be clearly understood by policy implementers. In addition the policy implementer's effort to follow the policy is also regarded as one of the key contributions towards implementation (Sabatier and Mazmanian 1980). However, for individuals to perform their tasks they should understand what is expected of them and how to interpret it in order to fulfil their responsibilities (Martin 2005). There are several ways of policy learning through direct experience, debate and through indirect learning such as learning from other people and organisation's experience (Levitt and March 1988). Learning is regarded as a way of gaining new understanding such as the viability of policy introduction and policy implementation strategy. Tracing successful conditions through broader evaluation can strengthen learning (Levitt and March 1988; May 1992).

It is the Local Authorities' statutory obligation to design and implement a policy to integrate disabled people within their communities rather than segregating people into for example residential care homes (Barnes 2000). It is suggested that under the Disability Discrimination Act 1995 that disabled people who are discriminated against have a right to legal redress (DDA 1995). Recent research (Roulstone and Barnes 2005) shows that only 16% to 20% of all the DDA related cases are heard at tribunal. This is mainly because most disabled people are unaware of the process of taking cases of discrimination to court, with those who are aware being unconvinced there will be a positive outcome and finding the task daunting, costly and stressful (Gor 1999; Jaeger 2006). Moreover most disabled people are impaired and/or illness which will inevitably reduce their ability to defend their legal rights (Morris 2001). Therefore, it is unreasonable to assume that inclusive design can be implemented through the actions of disabled people challenging service providers alone.

Although it can be argued that there is an improvement in disability awareness amongst policy implementers involved in the building design process, the progress appears to be relatively slow. The degree of knowledge and resourcefulness of Local

Authority officers are part of the critical ingredients in responding to disabled people's access needs (Imrie 1999).

BACKGROUND TO THE WORK TO DATE

In order to help shape the research and gain an initial understanding of the disability policy landscape, a series of preliminary semi-structured interviews were conducted within eight Local Authorities in England. These provided initial data and allow a series of research questions to be developed. Each interview lasted for about one and half hours. The interviewees were eight professionals, mostly Access specialist professionals employed by some Local Authorities to assist with inclusive design implementation.

The purpose of these interviews was to understand the approach to and constraints impacting upon inclusive design policy implementation. This preliminary study concluded that there were many technical and practical guides available; however their implementation was obscured. This was caused by a lack of ownership, monitoring and knowledge amongst those responsible for policy implementation. This appears to be a major problem with the policy implementation process.

It was also evident that Access officers are finding the task of policy implementation increasingly difficult under the current workload. Inconsistencies have dominated inclusive design implementation across Local Authorities and even between one officer's policy interpretation and another's. In addition to these findings, research carried out in Sweden highlighted the barriers in achieving inclusive design as due to a lack of time, limited budget, lack of knowledge and lack of evidence on the profitability of inclusive design products (Björk 2009). The research described in this paper is taking a different stance, investigating the learning strategy adopted by Local Authorities to improve their understanding of the implementation of inclusive design policy. Focus on key players active in policy implementation and exploring their views on inclusive design implementation as applied through their practical experience offer the prospect of some novel findings. This paper aims to describe where professionals engaged in inclusive design policy implementation are likely to learn about this policy and what their views are on the inclusive design policy adopted by their Local Authorities.

RESEARCH DESIGN

This paper is focussed on the learning approaches adopted by Local Authority employees as they work to implement inclusive design policy.

This research was designed to examine the extent of the inclusive design learning strategy adopted by Local Authorities, and the suitable method for collection of the data was a questionnaire survey. The questionnaire was administered to target a large sample population of access policy implementers across England. The time and resource together with a clear choice of research questions merit that the survey approach was a suitable option for the purpose. Furthermore, research can benefit from data generalisation when the findings are replicated on many different sample populations (Johnson and Onwuegbuzie 2004).

Focusing upon the questionnaire which forms part of the main empirical work; the sampling template of Schofield (2006) was used to obtain consistency and to minimise bias amongst the responses. This aided the identification of a relevant sample population deemed to be suitable for this study. The wording for the questionnaire was

carefully chosen to secure the maximum accuracy for the candidates interpretation and response (Dillman 2000).

Local Authority employees are the key players responsible for enabling the building of inclusively designed developments in their local communities. They also oversee the implementation of the inclusive design policy, promote inclusive design in their local areas and eradicate/minimise discrimination (ODPM 2005).

The researcher was also aware of the limitations of pre-design/categorised questions and that they may not reflect some local constituencies' understanding of basic concepts, therefore open-end questions were also included within the questionnaire. Open-end question gave flexibility to allow the respondents to give their views at the end of the questionnaire and to describe any additional information related to inclusive design policy implementation with which they were familiar, about half of the respondents participated in the open-end question.

SURVEY APPROACH

The researcher obtained the Local Authorities' contact details through their websites. Thereafter Local Authorities were contacted with a request to speak to a senior professional based in either planning/development control, building control or policy departments to whom the project was briefly introduced. They were asked to confirm their interest in participating in the research. Following confirmation the questionnaire link and a brief description of the questionnaire were sent to them. The senior persons were requested to distribute the questionnaire to 4-6 professionals based in those departments. About 129 Local Authorities randomly selected across England were contacted and 120 Local authorities confirmed their participation. There were 117 responses and it took one month to complete the questionnaire.

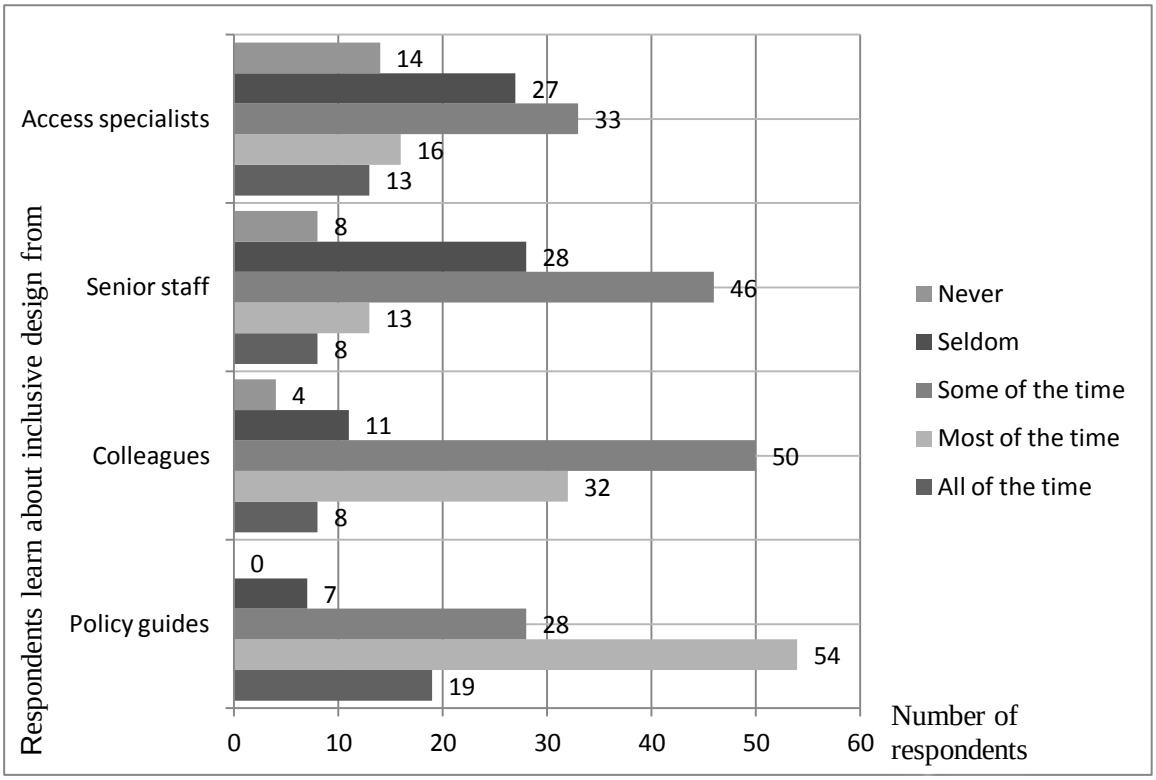
SURVEY RESULTS

Table 1, The question asked the respondents is as follow

Please rate how you learn about inclusive design. (Please answer all 4 boxes)					
Answer Options	All of the time	Most of the time	Some of the time	Seldom	Never
Access specialists	13	16	33	27	14
Senior staff	8	13	46	28	8
Colleagues	8	32	50	11	4
Policy guides	19	54	28	7	0

The questionnaire results show that policy implementers are most likely to learn inclusive design requirements from policy guides; there is also a significant amount of respondents who learn from colleagues most of the time; refer to Table 1 and Figure 1. It can be argued that learning from written policy documents, will give the policy implementer a factual source in case of any challenge in any decisions made. The respondents revealed that they seldom learn from senior staff and access specialists. It must be noted that, Access specialists are employed only by a few Local Authorities and the data does not allow the identification of Local Authorities with Access Officers.

Figure 3, From where do you learn about inclusive design policy



Besides a learning strategy adopted by Local Authorities, the respondents were asked to share their views on the current approach to inclusive design policy implementation in their perspective Local Authorities. The question asked was "*Anything else you would like to share regarding the current approach to inclusive design policy implementation in your Local Authorities?*"

Although most Local Authorities have adopted a common policy this seems to be nebulous. As one respondent stated "*Inclusive design seems to be a box to tick, rather than a criterion for assessing the success of a scheme. In general, the accessibility of a development, including its legibility and fitness for purpose, is a rather nebulous quality that many planners interpreting drawings submitted with applications find difficult to conceptualise." (By: planning/development control officer)*

It was also noted that a responsibility/accountability strategy was unclear for the parties involved to act upon, those respondents who are based in planning/development control view inclusive design policy implementation as building control responsibility and vice vase. As one respondent stated:

"Not really something that plays a significant part in the approval process for Building regulation purpose, our role is relatively straight forward in looking for part M compliance although the interpretation can vary significantly." (By: building control officer)

Furthermore the results show that in most cases planners see themselves as promoters and facilitators of inclusive design. As one of the planning respondents stated:

"Inclusive design is generally promoted and facilitated through the planning process and most larger developers / building companies incorporate these in their standard

builds however it is generally building regulations that enforce its implementation".(By: planning/development control officer)

The implementation of inclusive design policy is regarded as a Building Control job; however it should be noted that Building control enforcement of accessibility issues are based on the Building regulation (Part M). As stated by a number of respondents:

"Whilst inclusive design is important and access for all is essential, in planning terms it is sometimes ignored or not considered as important as it is mainly dealt with in Part 'M' Building Regulations. Access for all can also be compromised when dealing with listed buildings or retail/residential units that are raised above an adjacent public walkway."(By: Policy officer)

"While the Local Development Framework does include an inclusive design policy, there is often an expectation in practice that these issues will be dealt with at a later stage by Building Control, leading to problems where the Building Control plans are different from the approved planning permission, which might need to be regularised through a revised planning application. There is better communication now than there was in the past, as awareness improves."(By: policy officer)

"Overkill, dealt with by Part M of the building regulations" (By: planning/development control officer)

Results have also revealed that policy implementers are working under time restraints and limited knowledge; therefore they are unable to give a thorough scrutiny to designs submitted to them.

DISCUSSION

Over sixty percent of respondents highlighted that they learn about inclusive design from policy guides all or most of the time. It is thus argued that clear policy guides will increase confidence and understanding amongst policy implementers to take decisions (Underwood 1981). As stated by one of the respondents

"Whilst we have policies regarding inclusive design, the main issue is the way in which they are worded, as they are very vague and do not necessarily relate to all development types. This in turn makes the issue less important in the decision making process as the policies are not strong enough to justify giving sufficient weight to the matter".(By: Policy officer)

The second most rated learning strategy as indicated by thirty-six percent of the respondents is learning from colleagues all or most of the time; this approach can be useful in organisations where explicit and tacit knowledge is recognised in the organisation (Nonaka 1994; Nonaka, Toyama *et al.* 2000). Besides, a learning strategy has meaning and an interpretation attached, and different policy implementers might interpret a different meaning to similar situations (Mowrer 1960). As argued by Sabatier (1988) that the importance of a policy-oriented learning framework will highlight the value of the policy and the associated problem and consequences. Learning is likely to equip professionals with a better understanding over time and experience is likely to help to improve this understanding (Sabatier 1988). Although it can be argued that senior staff has the advantage of experience from which the rest of the organisation can learn, the questionnaire results show that a large number (over sixty-five percent) of response seldom or some of the time learn from their senior colleagues. The authors support Pressman and Wildalvsky (1973) statement that " an individual who fails to learn from experience is forever lost in a chaotic world".

However, learning from experience requires a system in place to record past experiences (Nonaka 1994), this view will be explored in detail in the next phase of this research. There is an inconsistency in the respondents about learning from Access Specialists; similarly there is an inconsistency in Local Authorities employing Access Specialists or their job descriptions. As one respondent mentioned

"An Access Officer is no longer employed by the Council and Building Control rarely comments on applications, so there is a lack of expert advice on this issue at the current time". (Responded by: planning/development control officer)

Planning/development control deals with external aspects of the inclusive design i.e. in ensuring access to and around the building as well as egress of the building, while building control examines access issues in detail i.e. the size of the stairs, handrails and colour contrast. For the building control personnel to ensure physical features are designed to the required standard the provision of the space needs to be allocated at the early stages of design. However, due to the division of these departments the design might be given approval at the planning stages but prove difficult to satisfy the basic requirements of Part M. Part M defines some accessibility issues, but it is not a comprehensive extensive inclusive design standard.

Planner/development control officers view inclusive design as the responsibility of Building control officers. On the other hand Building control officers' views inclusive design implementation as a role of planning/development control. Limited knowledge and resourcefulness has been criticised in the field of accessibility for the past decades (Imrie 1999). It can be argued that limited knowledge of inclusive design may result in reduced confidence amongst policy implementers in Local Authorities to take action or make the right decision in inclusive design issues.

CONCLUSIONS

Policy implementers have adopted a wide range of learning approaches at their Local Authorities, with the majority of the respondents learning inclusive design policy from policy documents. Therefore policy documents should be very clearly worded.

The paper also argued that with Local Authorities reluctant to employ Access Specialists, learning from the past experience of their own professionals can help individuals to do better in the future. The lack of a past experience recording system in place can result in professionals having a poor or incomplete record of the level of inclusive design progress in their local environment or ways of learning from past good designs and/or poor designs. A further complication is that building control and planning/development control departments have different views, hence development assessments are subject to the individuals' knowledge or the prioritisation of inclusive design policy in a particular Local Authority or department. In addition these departments appear to work towards separate goals.

The shifting of the responsibilities between planning, building control and planning policy was highlighted as one of the possible contributing factors to poor inclusive design in the industry. The lack of clear definition of responsibilities and accountability of inclusive design amongst parties is likely to discourage professionals from acting effectively.

Due to the high work load faced by Local Authorities, some employees were unable to participate in the research. There was also an absence in questionnaire participation from Local Authorities who have not adopted an inclusive design policy.

The next phase of research will focus on evaluating the policy goals adopted by Local Authorities and comparing them to the UK government goals for inclusive design policy. The research will also further explore the understanding of inclusive design policy amongst policy implementers and the influences of the policy in the decision making strategy of inclusive design.

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AN ASSESSMENT OF OCCUPANTS' EXPECTATION IN THE DELIVERY OF LOW-INCOME HOUSING IN SOUTH AFRICA

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Low-income housing provision has been a major focus of the government in post-apartheid South Africa. While success can be noted, there is a growing concern on the housing expectations and satisfaction of the housing occupants'. Utilizing post-occupancy survey conducted in four locations that had benefited from the government housing subsidy scheme, the research identifies how the expectations of the occupants of low-income housing can be met in the Gauteng Province of South Africa. The results from the post-occupancy survey revealed that most of the beneficiaries' housing needs were not met, as a majority of the respondents informed that they had expected bigger units; however, when they were allocated the houses, the expectation was not met. Though, a major obstacle while the respondent's expectation was not met pointed toward the lack of consultation between the Department of Human Settlement and the occupants'. A comparison is also made to ascertain the correlation between meeting of occupant's expectation and the maintenance of the houses. It is suggested that the Department of Human Settlement should conduct occupants need assessment on future housing project to be developed and on a consistence basis should employ post-occupancy survey to inform, improve and guarantee the expectation and housing satisfaction of the beneficiaries' of subsidised housing units in South Africa.

Keywords: housing subsidy beneficiaries, housing satisfaction, low-income, needs and expectations, occupants.

INTRODUCTION

In spite of the numerous measures to improve low-income housing quality in the new South African state, the standard has remained a persistent and divisive social issue among the practitioners of social housing studies, academia, non-governmental organizations, government, and the affected citizens amongst others in South Africa. Virtually all beneficiaries of low-income housing in South Africa desire to live in a conducive housing environment, but the housing condition has been gradually deteriorating without due consideration to the needs and expectations of the beneficiaries by the housing providers. This is due to the continually formulation and

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Aigbavboa C and Thwala W (2012) An assessment of occupants' expectation in the delivery of low-income housing in South Africa *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 295-304.

diminutive implementation of housing policy without a meaningful consultation with the eventual beneficiaries of the low-income houses. Hence, Ha (2008) posits that the failure of many housing projects may be traceable to the lack of knowledge on the determinants of housing satisfaction from the occupants of the houses. He stressed that the success of housing programmes does not only depend on merely provision of housing units, but also on other factors that affect the needs and expectations of the residents. This is because the achievement of occupant's satisfaction in terms of their needs and expectations, aside quality, time and money, in any housing project is a key factor that contributes to the ultimate success of that project.

Therefore, the South African National Department of Human Settlement must take a proactive step towards an understanding of the beneficiaries' expectations with respect to the houses being delivered, in order to improve the quality of the low income houses. This can be done effectively through the assessment of the occupants' expectation prior to the houses being constructed and allocated to them. Because the present and future successes in the low-income housing sector in South Africa will depend on the extent to which occupiers are satisfied with the built houses. Without a consideration of this factor the measure of housing success through the quantity produced will be a contradiction of the principles governing basic housing provision, which serves to improve the lives of the low income and slum dwellers as contained in Millennium Development Goals 7 (Target D). This importance is based on the fact that many problems in the existing low-income housing environment are the result of neglecting the beneficiaries' expectation before the houses are built. Fatoye (2009) and Lahdenpera and Tiuri (1999), also noted that beneficiary satisfaction is not only a matter related to the handing-out of a freshly completed building, but is a life-cycle issue which has to be taken into account right from the policy initiation phase. There is therefore need to first understand and establish what the beneficiaries' expect from the houses to be given to them both real and perceived expectations, because only then could such satisfaction with the built houses be met.

Hence this research explores how the expectations of the occupants' of low income housing can be met in the Gauteng Province of South Africa, thus ensuring that the occupants' are satisfied with the houses being provided. Also a comparison is made to ascertain the correlation between the meeting of occupant's expectation and the maintenance of the houses. It is recommended that the investigation of beneficiaries' expectations should be used to assess the quality of low-income housing and as a benchmark to quality improvement in housing production and delivery in South Africa. It is thus believed that the research will help the Department of Human Settlement build better low-income houses that will assist in providing healthy, better quality of life, productive and comfortable in/outdoor environment and long-term benefits to the low income group as well as for the South African society at large. Hence the next section of the article presents an overview of housing needs and expectation.

SATISFYING HOUSING NEEDS AND EXPECTATIONS

As part of the conceptual framework of residential research, the gratifications of occupants housing needs and expectations should have the noteworthy prominence. For people with different housing needs and expectations, the same housing condition could bring different satisfaction levels because their needs and expectation are different. Also, residential satisfaction is basically formed under the condition of what level of housing needs is currently pursued by the occupants (Yiping, 2005). Unless

level one need is sufficiently satisfied, they will remain in the occupant's consciousness and will thus become the prime determinants of housing behaviour. In earnest, the living condition that is currently pursued forms the housing expectation of the individual, which is highly related to the overall residential satisfaction.

From the literature on housing research, from various perspectives, there have been many studies separately addressing different needs level of individuals and social groups, or its significance on informing policies on how best to handle a need of a particular social group. For instance, Marcus (1995) studies the self-actualization level and believes that housing is like a mirror which has a powerful effect on our sojourn toward a state of wholeness. Also, research on social needs in housing environment has increased in which social capital is the focus (Putnam, 1995). Social capital refers to social trust, norms and networks that people can draw upon to resolve common problems such as a housing problem (Lang and Hornburg, 1998). All over the world, and in South Africa, there is a growing agreement that social capital constitutes a significant new dimension of community development and establishment, as occupants are directly involved; which means their needs and expectations would have been taken care of through their activate participation in the development process. Furthermore, the security needs of housing extend to another large area of research. For example, Newman (1978) addresses the relationship between built environment and security using his theory of defensible space. Related to the security issue, there have been proposals and projects on urban renewals (Smith, 1996); also, debate on the gated community (Hamnett, 2001; Landman, 2004), and on social issues of residential segregation (Hamnett, 2001). Housing needs as a shelter are mostly a concerned by those who struggle for these needs, such as the homeless, those previously disadvantage from owning property as a result of government policy such as the apartheid rule in the previous South Africa government.

All these social researches on housing can be grouped within a system relating to different needs order. Individually, every household is inspired to pursue the higher level needs in the housing needs order when the lower needs have been satisfied. Collectively, it brings social issues regarding the processes of different level of housing need's satisfaction. Discrepancies in housing priorities are so big that housing provision sectors has to provide a wide variety of dwelling types with all forms of tenure to meet the demand. This is because residents are only satisfied when their current housing needs and expectations are satisfied. However, it must be noted that the satisfaction will not stay unchanged, because soon, there will be other higher level needs and expectation that will have to be satisfied. More so, households who are dissatisfied are likely to consider some form of adjustment. They may attempt to make adjustment to reduce dissatisfaction by revising their needs and expectations to reconcile the incongruity, or by improving their housing conditions through remodelling ((Hamnett, 2001). According to Morris and Winter (1975), they may also move to another place to bring their housing into conformity with their needs and expectations. However, both mobility and adjustments are subject to the constraints posed by financial resources at one's disposal and by information regarding alternative adaptation opportunities (Morris and Winter, 1975). Thus moving behaviour is only one type of adjustment residents perform during the time of dissatisfaction of housing needs and expectations; but in the case of the low-income group, it might not be possible, as most cannot access housing on their own and the subsidized houses received might be their only life time opportunity to access

housing. Furthermore, the next section of the article discusses the methodology used in conducting the research.

METHODOLOGY

The data used in this paper were derived from both primary and secondary sources. The primary data was obtained through the survey method, while the secondary data was derived from the review of literature and archival records. The primary data was collected through a structured occupant survey questionnaire. Structured questionnaire was used to conduct interviews with beneficiaries at four (4) housing subsidy locations in Johannesburg, Gauteng Province of South Africa. These households had all benefited from the government housing subsidy scheme. The questionnaire was administered to the head of households or their spouses. One household head per house was engaged in the interview/questionnaire administration. However, it was recognised that this method has a few weaknesses in that; there is an absence of probing beyond the answer given; lack of control over who answers the questionnaire; and they can be characterized by a low response rate because of cost.
Beneficiaries were randomly selected from areas visited; these were interviewed based on the fact that they have been resident in the areas for more than a month and likewise the houses have been allocated to them for more than one month. All households from each location had an equal chance to be drawn and to occur in the sample. All completed and allocated subsidized housing units in each housing location area were chosen as the sample frame. A total of 30 households were chosen in each locality for the research, making the overall sample size to be 120 households. This was achieved as follows: each locality was divided into 10 regions using the streets, with each region containing 205 houses or more. A systematic sampling was then applied through the selection of every 20th house in each region; for easy identification of the 20th house, house numbers were used to calculate the number of the next 20th house. Thus in each locality, 30 households were selected. This process was essential to obtain true representativeness of the entire sample. Out of the 120 questionnaires sent out, 78 were received back representing 65.0% response rate. Also, a physical observation of the housing units was conducted during the survey. The next section presents the findings of the study and a discussion of the result.

RESULTS AND DISCUSSION

The findings from the occupant's survey as presented in figure 1 indications the length of stay of the occupants in the housing units. Findings showed that 28.6% of the occupants have been living in the subsidized housing unit for more than five years. Those who have lived in the houses between three and five years were 22.10% and 26.0% for those who have been living there for less than one year. In quintessence occupants who have lived in the subsidized housing units for many years completed most of the questionnaires, informing that the respondents have adequate knowledge of their apartments and the out-door environment.

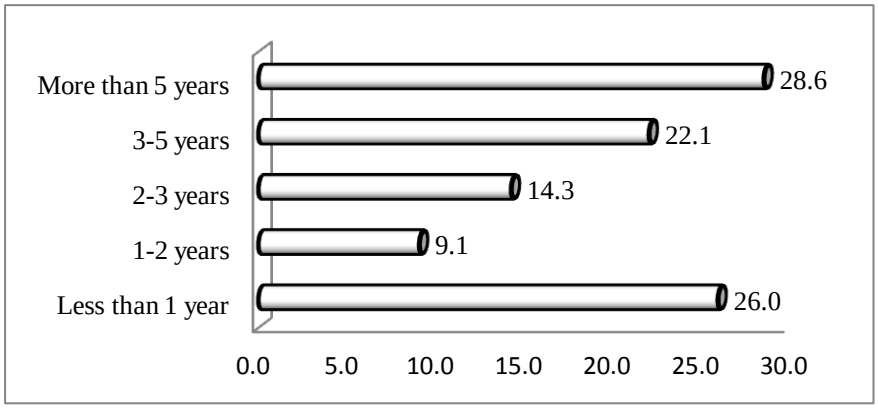

Figure 1: Length of stay in housing unit

Likewise, when occupants' were asked about their intended duration of stay beyond what has already been reported in figure 1. About 95.0% of the respondents indicated that they intend to reside in the houses for more than five years. This is a further confirmation that the occupant's responses in the satisfaction survey are based on unpretentious motive, because they seek the good and betterment of the dwelling units and neighbourhood environment; as most of them have been living in the houses for a long time.

Therefore when the occupants' were asked about their particular expectations before the houses were given to them; results as shown in Table 1, revealed that beneficiaries' expectation for bigger housing units (84.62%), free services (74.36%), adequate hot and cold water (89.74%), consultation with the DHS (92.31%), and structure with quality finishes (98.72%)- (this being the major problem in most constructed low-income housing units that has been evaluated in different studies) were all not met. The findings supported studies by Charlton and Kihato (2006) and Tissington (2010) where they found that a majority of the developed low-income houses in South Africa seldom meet the expectations of the eventual occupants.

Nevertheless, the respondents further indicated that their expectation of a housing unit with improved living condition from shacks (98.72%) was met representing 87.18%; likewise, 83.33% respondents informed that they now have more comfort than their previous living environment. This findings supports the 1948 Universal Declaration of Human Rights accord, which informs that everyone has a right to a standard of living that is adequate to the health and well-being of himself [herself] and his [her] family; and General Comment 4 1990; paragraph 8 of the Committee on Economic, Social and Cultural Rights which defined the concept of adequate housing, and making plain the wordings of Section 26(1) of the South African Constitution. Also, occupants had expected more consultation with the government prior to them being shortlisted to receive houses, but findings showed that this expectation was also not met. This was in contrast with the DHS goal informing that provincial and local sphere of government should consult meaningfully with individuals and communities in order to facilitate the active participation of all relevant stakeholders in housing development. From the above findings, it can therefore be inferred that the DHS did not succeeded in meeting the housing expectations of the occupants; but from the basic expectation of an improved living conditions from shack and more comfort that previous living, which agrees to the Universal Declaration of Human Rights and confirmed the wordings of Section 26(1) of the South African Constitution, it can be concluded that beneficiaries are satisfied with the overall housing condition even though most of their expectations were not met. This inference is made because additional findings

revealed that 97.5% of the respondents were previously living in shacks and other forms of slum housing before the subsidized houses were allocated to them; while 2.60% had no houses (were in a state of absolute homelessness) before the allocation to them.

Further, when the beneficiaries were asked the reason why their expectation for units with structure with quality finishes (98.72%) was not met, they informed that they have observed various defects on different part of the building, ranging from the floors, walls, doors, windows, roof, ceiling and on the plumbing works. When beneficiaries were further asked the types of defects that had been observed in these areas, they revealed that the floors were not finished which thus made the wooden doors to be infested and also caused the house to be damp; roofs were not firmly secured to the walls and/or trusses, causing them to rattle, or even blow off, when windy. Thus beneficiaries had taken to placing stones and used tyres on roofs to prevent it from being blown off. Also, they complain that the roofs leaks when it rains; cracks had appeared on the walls, which was a major problem to the beneficiaries of which they attested that these defects developed soon after they move in, particularly around the windows, doors and corners. Likewise, the doors did not fit securely into their frames and they had to stuff materials along the frames, especially at the bottom, to stem water from coming in when it rains.

However, from the physical observation of the doors, the researcher observed that the doors were also not varnished and as such some beneficiaries had to cover their doors with plastic to keep them waterproof. Also, some doors had gaps between the wooden slats and between frames and the actual door opening which were wide enough to see through. Also, in the houses that had sanitary fittings installed, the beneficiaries revealed that there was a common problem of pipe leakages and low pressure from the water closet cistern. As for the windows, there were gaps between the window frames and the wall; the metal frames had rusted and some windows do not close properly. Physical observation and general complains about the ceiling revealed that most units did not have ceilings, which greatly affected the occupants satisfaction and expectations levels of the units, as the units were very cold during the winter seasons and hot during the summers. Thus the research findings agrees with the work of Nobrega (2007) in a study of subsidized housing units in the Eastern Cape, South Africa and that of Ogunfiditimi (2007) a study done on four different subsidized housing units in Johannesburg, South Africa. Also, the present findings concurs with the work of Mkuzo (2011), who found that the beneficiaries of a housing project in Nelson Mandela Bay Municipality, South Africa, had problems with cracks on the walls, poor plumbing and door were not properly fitted. Overall, 78.0% of the respondent in that study rated the building quality very poor while 10.0% of the respondents were very satisfied with the quality of the housing units they had received; informing that they are happy and thankful to have received houses for free.

In addition, when the beneficiaries' perception was assessed on the physical quality of the housing units, findings revealed that 38.50% indicated it was neither good nor bad, while 15.40% indicated that it was very good. However, an overall assessment of the building quality revealed that 52.0% respondents revealed that the houses were not of good quality, while, 36.0% indicated that it was of good quality with a further 12.0% indicating they were not sure if it was good or bad. This finding concurs with a previous work done by Aigbavboa and Thwala (2011) on the occupants of Kliptown low-income housing, where they found that the occupants perceived very poor the physical quality of their houses and the building quality. However, in the present

study, the occupants' responds can also be attributed to the fact that most occupants' have not been able to repair the defects that has appeared on the buildings as the next set of findings revealed.

Table 1: Level of housing satisfaction according to beneficiaries expectations

Areas of expectations	Expectation After allocation		Expectation Before allocation	
	Yes	No	Yes	No
Improved living conditions from shacks	68 (87.18)	10 (12.82)	77 (98.72)	1 (1.28)
More comfort than previous living environment	65 (83.33)	13 (16.67)	77 (98.72)	1 (1.28)
Good sanitary systems	44 (56.41)	34 (43.59)	76 (97.44)	2 (2.56)
Clean environment	40 (53.33)	38 (50.67)	75 (96.15)	3 (3.85)
Bigger plots	36 (46.15)	42 (53.85)	64 (82.05)	14 (17.95)
Adequate hot and cold water	34 (43.59)	44 (56.41)	70 (89.74)	8 (10.26)
Consultation with the DHS	27 (36.99)	51 (69.86)	72 (92.31)	6 (7.69)
Free services	18 (23.08)	60 (76.92)	58 (74.36)	20 (25.64)
Structure with quality finishes	12 (15.38)	66 (84.62)	73 (98.72)	5 (1.28)
Bigger units	10 (12.82)	68 (87.18)	66 (84.62)	12 (15.38)

Note: Figures in parentheses are in percentages

Subsequently, when a comparison was made to ascertain the correlation between meeting of occupant's expectation and the maintenance of the houses, findings revealed that 59.0% respondents has carried out repairs to their housings units, while 41.0% have not been able to effect any repairs to the observed defects. Supplementary findings from those that have been able to effect repairs in their houses revealed that they were able to do so through their personal savings (87.0%), while 6.5% were able to effects repairs through helps from family and likewise from grants they had received from the government.

Those that had carried out repairs through government grants indicated that the grants were not given to them specifically for repairs, but it was through the child support, foster care and disability grants they had received that they used to carry out the repairs. Also, when the beneficiaries were asked about the nature of repairs that have been done, a majority of them informed that they have painted the whole house (internal and external) and also they have fixed burglary to the doors and windows which does infers that aesthetics of the building and security were two of the most valuable issues to the occupants'. Thus, the above findings inferred that there is no correlation between the meeting of occupant's expectation and the maintenance or repair of their houses. This indicate that regardless of their expectations not being met and the other concerns raised about the quality of the housing units, occupants' valued their houses and as such those that could afford to carry out repairs have done so and still some have to deprive themselves of personal and family upkeep to make the houses' comfortable.

CONCLUSIONS

This paper examined if the expectations of the beneficiaries' of four different subsidized housing schemes has been met in Johannesburg, South Africa. Findings

revealed that most of the beneficiaries' expectations prior to when they were allocated the housing units were not met. But they did indicated that through the housing units, they now live in houses with improved living condition from shacks and other slum housing situations and also that they now have more comfort than their previous living environment. Hence, this gives the South African government commitment to achieving MDGs 7 Target D, (achieving a significant improvement in the lives of slum dwellers) a leap. However, occupants' informed that they had expected more consultation with the government prior to them being given the houses; but findings revealed that this expectation was not met, which was in contrast with the DHS goal that provincial and local sphere of government should consult meaningfully with individuals and community to receive housing, in order to facilitate the active participation of all relevant stakeholders in housing development.

Therefore, in order for the expectations of the beneficiaries' of low income housing to be met in the Gauteng Province of South Africa, it is recommended that beneficiaries should be meaningfully involved in the housing development process right from the onset before any actual development is done. By so doing, a needs and expectations assessment consultation will be conducted to ascertain the needs of the beneficiaries' in order to channel the housing development plans to meet their specific needs if possible. Also, the expectations assessment will also ascertain the expectations they have with regards to the totality of the housing units. Thus after the assessments, if the expectations and the needs of the beneficiaries cannot be met with the housing units to be provided since there is a predetermined building design and cost allocation, an adjustment can be made where possible and if not possible, feedback should be given to them so that when the building is finally constructed, they already know what they are getting. Hence, these will thus guarantee that their expectations are met and satisfaction in the unit will be guarantee since they were consulted prior to the development process. Also, another area to be explored is the dynamics of the beneficiaries housing life cycle. This can be incorporated into the needs and expectations assessments consultation to ascertain the changing aspects of the home needs of the beneficiaries' in the present and in the future.

Also, the study has demonstrated that post-occupancy survey can indeed be useful to extract valuable inform from occupants of subsidized housing unit that can inform housing development stakeholders on the changes to be made so that new houses being constructed are done to elevate the quality of life of the beneficiaries' and serve as a route for them to contribute to the general economy.

Furthermore, when a comparison was made to ascertain the correlation between meeting of occupant's expectation and the maintenance of the houses, findings revealed that there was no correlation regardless of the fact that their expectations were not met and the other concerns raised about the quality of the housing units. This shows that occupants' value their houses and as such those that could afford to carry out repairs have done so even when they have to deprive themselves of valuable necessities.

Findings in this study are of enormous policy implications. First policy implication is that future construction of public housing should be responsive to occupants' need for adequate quality such as in safety, security, thermal comfort and adequate sleeping area; and that the housing units should be a means to empower the occupants to gain economic freedom and not to put burden on them to start carrying out repairs due to negligence from the contractors and limited level of supervision of building work

during construction. This is because the challenges are not peculiar to the South African housing space alone, but a revelation of the developing world. To this end, the workmanship level and supervisor of the housing unit during construction should be taken serious by the DHS. Also, the houses should be equipped with adequate measures and features that will keep the thermal comfort of the building at a level that will enhance the quality of life of the occupants'. Also, the DHS should solicit beneficiaries' involvement before the actual construction process starts.

Another policy implication is that the present model of public housing provision that delivers 40 square meters units should be revised to cater for the need of households with large family size, as the study showed that the occupants need for bigger housing units was not met. It is therefore suggested that a thorough needs assessments of the occupants in any area to be provided with housing units should be carried out before the actual construction. On the whole, findings from the research revealed that the advanced awareness of the right to adequate housing as contained in the South Africa constitution is being met by the government, as the occupants informed that their quality of life has increase because the provided houses has given them an improved living condition and they now have more comfort than their previous living environment. Hence the DHS objective of the broader housing vision in promoting and improving the quality of life for the poor is being achieved as findings have showed.

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FORECASTING AND DECISION MAKING

NEURAL NETWORKS FOR MODELLING THE FINAL TARGET COST OF WATER PROJECTS

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Producing reasonably accurate cost estimates at the planning stage of a project important for the subsequent success of the project. The estimator has to be able to make judgement on the cost influence of a number of factors including site conditions, procurement, risks, price changes, likely scope changes or type of contract. This can shroud the estimation process in uncertainty, which has often resulted in project cost overruns. The knowledge acquisition, generalisation and forecasting capabilities of Artificial Neural Networks (ANN) are explored in this pilot study to build final cost estimation models that incorporate the cost effect of some of the factors mentioned above. Data was collected on ninety-eight water-related construction projects completed in Scotland between 2007-2011. Separate cost models were developed for normalised target cost and log of target costs. Variable transformation and weight decay regularisation were then explored to improve the final model's performance. As a prototype of a wider research, the final model's performance was very satisfactory, demonstrating ANN ability to capture the interactions between the predictor variables and final cost. Ten input variables, all readily available or measurable at the planning stages for the project, were used within a Multilayer Perceptron Architecture and a Quasi-Newton training algorithm.

Keywords: cost estimation, cost modelling, neural networks.

INTRODUCTION

Cost estimation is a heavily experience-based process, and involves the evaluation of several complex relationships of cost-influencing factors, largely based on professional judgement (Alex *et al.* 2010). A thorough cost estimation exercise would involve the evaluation of the cost effect of factors such as site restrictions, ground conditions, contract type, location of the project, procurement method, etc. However, preliminary investigations show that this is rarely the case, most likely due to the difficulties of quantifying the cost implications of these factors. The classical way of accounting for the cost effect of these variables is using the so-called contingency fund (Baccarini 2005), which unfortunately has mostly failed to keep construction projects within budget.

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Ahiaga-Dagbui, DD and Smith, SD **(**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, 307-316.

Traditional cost estimation i.e. estimating the cost of labour and materials and making allowance for profits and overheads for individual construction items, is deterministic by nature (Okmen *et al.* 2010) and largely insufficient in reaching the actual final cost of a project. The approach largely neglects and poorly deals with uncertainty and their correlation effects on cost (Oztas *et al.* 2005). It is also difficult to account for the cost effect of some of the variables mentioned above using the traditional cost estimation method.

The aim of this experimental research, which is part of a larger research in integrating risk and cost modelling, is to explore the use of Artificial Neural Networks (ANN), as a data mining technique for developing cost forecast models of construction projects. ANN is employed to model the relationships between qualitative factors that have an impact on construction cost and quantifiable items that represent different cost centres in the bills of quantities. The paper provides an overview of cost estimation, estimation accuracy and cost models as well as neural network theory and applications. Details about the development of a predictive model for final target cost of water projects are detailed, with conclusions and recommendations for further research.

COST PLANNING AND ESTIMATION

Effective cost planning relates the design of construction projects to their cost, so that while taking full account of quality, risks, likely scope changes, utility and appearance, the cost of a project is planned to be within the economic limit of expenditure (Kirkham *et al.* 2007). This stage in a project life-cycle is particularly crucial as decisions made during the early stages of the development process carry more far-reaching economic consequences than the relatively limited decisions which can be made later in the process. This initial process may also influence the client's decision on whether or not to progress with the project. The cost planning process leads to the generation of a reliable initial project budget that sets up a cost control system to ensure that client expectations are met. For many clients, completing the project within this initial budget is a paramount determinant of client satisfaction. Despite the great importance of cost estimation, it is undeniably not simple nor straightforward because of the lack of information in the early stages of the project (Hegazy 2002).

Cost estimation, the determination of quantity and cost required to construct a facility or to furnish a service (Westney 1992), forms the crux of the cost planning exercise. The approach used for cost estimation normally varies from the early strategic phase of a project to the construction phase and will depend on a number of other factors including level of accuracy required, the speed estimation required, experience level of the estimator and the level of information available at the time of estimate. Accurate estimation of future cost however, is a difficult task (Nicholas 2004), if not an elusive aim. This can mostly be attributed to the fact that cost estimation, which must not be confused with budgeting, occurs at the conception phase of the project, before many of the cost influencing factors about the project are available even to the client (Hegazy 2002).

COST MODELS

Ferry *et al.* (1999) also describe cost models as the symbolic representation of a system, expressing the content of that system in terms of the factors which influence its costs. The models may be in the form of mathematical equations (eg. Regression

models) or a set of defined steps to estimate the cost of a particular item (eg. Storey enclosure method). Cost models can be very useful in strategic level decisions such as bid/not to bid decisions, with potential saving of time and effort on non-viable projects. They are furthermore appealing because of current harsh economic climate with tough competition and limited resources. However, the production of reasonably accurate, acceptable and timely parametric cost estimates can be a difficult task. For example, using only 4 different parameters for a project and considering three alternative values for each, and varying one at a time will produce 81 different project solutions or alternatives. This can be done rather rapidly using an computer-based model but will undoubted be a laborious task using traditional cost estimation (Sequeira 1999). The time, effort and resource level required for this task would mostly be unjustifiable at planning stages of a project, perhaps a strong suggestion that detailed cost estimates at strategic level are often far from the optimal solutions because of time and resource constrains.

ARTIFICIAL NEURAL NETWORKS

Artificial neural networks, henceforth referred to as neural networks (NN) with artificial implied, is an analogy-based, non-parametric information-processing system that has performance characteristics similar to a biological neural network of the brain (Anderson *et al.* 1992). They retain two features of the biological neural network: the ability to learn from experience and make generalisations based on this acquired knowledge (Haykin 1994).

Neural networks are structured to provide the capability to solve problems without the benefits of an expert and without the need of programming. They can seek patterns in data that are not obvious (Anderson and McNeill 1992) and are particularly suited for complex, hard-to-learn problems where no formal underlying theories or classical mathematical and traditional procedures exist (Adeli 2001). NNs are fundamentally different from algorithmic computing and statistical methods like regression in one way- they learn inductively by examples and then are able to generalise solutions (Flood *et al.* 1994). Modelling techniques including regression analysis, case-based reasoning and fuzzy logic analysis find it difficult dealing with problems such as imprecision, incomplete and uncertainty of data and other variables affecting costs and implicit combinatorial effects and inter-relationships of cost variables (Flood and Kartam 1994), areas where NN is often at its best.

Applications of neural networks

Neural network has been used successfully for foreign exchange prediction (Shi *et al.* 2011, Khashei *et al.* 2012); medical diagnosis (Dreiseitl *et al.* 2009); flight and robot control (NASA 2003, Lee *et al.* 2010); and loan applicant assessment (Malhotra *et al.* 2003). Earliest construction industry application of neural networks can be traced back to 1989 by Adeli and Yeh (1989) on engineering design and machine learning. It has since been used in construction management for estimating the cost of highway projects (Wilmot *et al.* 2005, Pewdum *et al.* 2009); predicting the cost of water and sewer installations (Alex *et al.* 2010) and building projects (Emsley *et al.* 2002); mark-up estimation (Li *et al.* 1999); risk quantification (McKim 1993); and tender price forecast (Boussabaine *et al.* 1999). Neural Network application bibliographies have been provided by Adeli (2001) for Civil Engineering and Moselhi *et al.* (1991) for construction management research.

Training the Neural Network

A neural network, like the human brain, learns from experience (Hinton 1992). Experience here refers to past data within the domain of the problem under study. The aim of any training regime is to help the network to continuously reduce the error of its predictions by varying the weights between its connections (Setyawati *et al.* 2003). Examples of the training set are presented to the network in its input layer. These are then transferred to the hidden layer by some form of activation function, normally a linear activation function. Random weights are applied to these input values in the hidden layer and then their cumulative weighted values transferred to the output layer. If the training algorithm adopted is a supervised one, the result of the training, called the output, is compared to the target (the expected real value) at the output layer and the error (difference between the output and the expected value, normally measured as the root mean squared error RMSE) is computed. This is then sent as feedback to the network and an error function is used to try and minimize the value of the error in the next cycle of training. The most common form of learning is the back propagation method, which is a supervised learning method (Setyawati, Creese and Sahirman 2003).

Neural Network Problems

Neural networks do exact their own demands however. NN are data-hungry, and performance is largely dependent on plenteous, representative and reliable data (Anderson and McNeill 1992). Another major criticism of the NN approach to data modelling is that it offers little explanation on the relationships between the variables it is modelling (Boussabaine *et al.* 1997, Hair *et al.* 1998). The technique is still disregarded by some researchers, referring to it as a 'black-box' technique because the network parameters do not offer casual explanations, making it difficult to elucidate what is learnt from the neural network model (Paliwal *et al.* 2011). To these criticisms, some have argued that it might be preferable to focus on how well a neural network model produces its results, rather than how it produces it (Hair *et al.* 1998). It is envisaged that further research into framework and internal processes within the neural network will offer better explanatory insight into the influence of independent variables in the modelling process.

DATA

Data was collected on ninety-eight water projects completed in Scotland between 2007 and 2011. The nature of the projects were rather varied, ranging 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-£14million and durations from 1-22months.

MODEL DEVELOPMENT

The modelling process involved investigating the performance of different network topologies and parameters in predicting the final cost of the projects. It was carried out using the Statistica 10 software, in the stages detailed below:

Data Pre-processing

The aim of data pre-processing is to structure and present the data to the model in the most suitable way as well as offer the modeller the chance to get to know the data

thoroughly. 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 BIS cost indices. Invariant variables, such as procurement option, payment method, fluctuation measure and type of client, were removed from the variable set as they would only increase the model complexity and yet offer no useful information for model performance. Finally, categorical variables such as type of project, need for project, etc. were coded using the one-of-N coding, resulting in 4 sub-variables for type of soil for example (Good, Moderate, Poor, Not Applicable). Twenty-eight sub-variables resulted out of the initial 11 input variables. This coding allowed the model to infer importance on its own without the modeller imposing weightings or subjective ratings to the variables. Ninety project cases remained after the pre-processing stage and were then passed on for the modelling proper.

Phase One: TC and FTC

At this stage, the model was developed using the raw normalised estimated target cost (TC) and final target cost (FTC). Two different network architectures, the Multilayer Perceptron (MLP) and the Radial Basis Function (RBF), were experimented initially. RBF models the relationship between inputs and targets in a 2 phases: it first performs a probability distribution of the inputs before the searching for relationships between the input and output space in the next stage (StatSoft Inc. 2011a). MLPs on the other hand model using just the second stage of the RBF. As expected, the MLP models were superior to the RBF networks for this regression problem and so the rest of the modelling was carried out using just MLPs.

The network was set to train 200 different models, iterating between 1-50 nodes in a single hidden layer using a data split of 75:15:10% for training, testing and validation sample sets respectively. The three best networks were retained and examined for further improvement. 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. Five different transfer functions- logistic, tanH, negative exponential, identity and sine were each tested. These transfer functions are used to squash the data range of the processing signals to values normally between 0 to 1 or -1 to +1 since the neural network algorithms are most sensitive to inputs within a small range. Gradient descent, Conjugate descent and Quasi-Newton (BFGS) training algorithms were also experimented for all the models. Early stopping, the process of halting training when the test error stops decreasing, was used to prevent memorising or over-fitting the dataset in order to improve generalization. Over-fitted models perform very well on training and testing data, but fail to generalise satisfactorily when new 'unseen' cases are used to validate their performance.

Overall performance of the network is 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:

$$SOS = \sum (O_i - T_i)^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (eqn.\ 1)$$

Where Oi is the prediction (network outputs)

T_i is the target (actual value) of the *i*th data case.

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 as

a test of whether the observed correlations were achieved by fluke. The higher the *p*-value, the less reliable the correlations observed.

The results from the best network for this phase was rather unsatisfactory as the errors observed were very high (See table 1.0), most likely due to the use of the raw data for the modelling. The best network at this stage was an MLP with 25 input variables, 31 nodes in the hidden layer. It was trained using a BFGS training algorithm, tanH and logistic activation functions in the hidden and output layers respectively.

Table 1: Network Performance: TC and FTC

Index	Net. name	Test perf.	Validation perf.	Test error	Validation error
1A	MLP 25-31-1	0.917	0.990	8.830E+10	2.096E+10
2A	MLP 25-37-1	0.928	0.988	8.163E+10	8.964E+09
3A	MLP 25-50-1	0.921	0.987	8.555E+10	1.348E+10

Phase two: LogTC and logFTC

The common log values of TC and FTC were then used for the next phase as it has been suggested that data transformation can significantly improve performance of NN models (Shi 2000). The 3 best networks were retained after training 200 different networks using the same parameters as above. The results showed significant improvement in the error values but slightly deteriorated in correlation (see table 2.0). This can be attributed to the fact that log of TC and FTC reduced the cost inputs to a smaller range, making them more sensitive to the training algorithms of neural networks. The common log of the target costs most likely made it easier for the network to learn the relationships between the variables than in the previous phase.

Table 2: Network performance: Log TC and logFTC

Index	Net. name	Test perf.	Validation perf.	Test error	Validation error
1B	MLP 25-29-1	0.925	0.933	0.091	0.131
2B	MLP 25-48-1	0.918	0.932	0.100	0.125
3B	MLP 25-16-1	0.893	0.936	0.174	0.134

Phase three: log FTC and logTC with Weight Decay

The effect of using weight decay regularisation in the hidden and output layers was then investigated. This was an attempt to encourage the network to develop smaller weights to further reduce the problem of over-fitting, thereby potentially improving generalization performance of the network. Weight decay modifies the network's error function to penalize large weights - the result is an error function that compromises between performance and weight size (StatSoft Inc. 2011b). The results showed a further improvement in both the error and correlation coefficient for the validation samples. The validation performance of the best network was now 0.968 with a p-value of 0.00 and an SOS of 0.062. The number of neurons in the hidden layer had also reduced from 29 in the best model to 19 when weight decay was applied.

Evidently, the model was getting better in predicting the final cost of projects based when the learning reinforcement technique of weight decay was used.

Table 3: Network Performance with Weight decay regularisation

	Net. name	**Test Perf.**	**Validation Perf.**	**p-value p<0.050**	**Test error**	**Validation error**	**Training algorithm**
1C	MLP 25-19-1	0.983	0.968	0.00	0.092	0.062	BFGS 89
2C	MLP 25-22-1	0.929	0.958	0.00	0.065	0.064	BFGS 26
3C	MLP 25-22-1	0.948	0.949	0.00	0.066	0.098	BFGS 56

A relative importance table below shows each variable's contribution to the model's generalisation abilities. At this stage, table four is indicative of the relative influence of the various inputs on the outturn cost. It gives the contractor important information on which factors need most attention during the tendering stage, especially in terms of final cost. The client/contractor would then be able to simulate the effect of changing these factors within the model to see its direct likely impact on the final cost. The SOS of residuals for the full model is computed and compared to that of the reduced model when each predictor is removed from the neural network. The variables are then arranged in order of importance according to the change in performance noticed when they were removed. The initial estimated target cost was the most important factor, as could be expected, and site access contributed very little to the model. Duration of the projects was unexpectedly ranked 7th in the relative importance table. In general, longer project durations tend to cost more than shorter ones. The observation here might be due to the poor representation of the number of projects across the range of durations used in the model building. More than 65% of the project cases were completed within four (4) months which would make the model biased towards projects within this class. This may mean that the model in its current form might not be a good predictor for projects with durations in excess of 4 four months. The high ranking of project frequency, tendering strategy and contractor's need for the project indicates the attention that has to be given these factors when preparing tender documents.

Table 4: Relative Importance of Variables

Factor	Weighting	Ranking
logTC	5.91	1
Project Frequency	2.55	2
Tendering Strategy	2.52	3
Need for Project	2.00	4
Ground Condition	1.45	5
Project Type	1.38	6
Duration	1.20	7
Location	1.16	8
Soil Type	1.05	9
Site Access	1.00	10

CONCLUSIONS

Artificial Neural Network is used to develop a cost estimation model for water projects in this paper. Their ability to capture and generalise non-linear relationships are exploited to detect the interactions in qualitative variables like tendering method, contractors need for the project, location, site access and project type in developing cost models to predict the final target cost of water projects. The use of weight decay regularisation to encourage the development of a parsimonious network to improve the model's performance and reliability was also investigated. This showed significant promise for future analysis if combined with other techniques like pruning and sensitivity analysis of predictor variables. As a prototype of a wider research, the results achieved are very satisfactory and will potentially be improved with a larger dataset in this on-going research

The developed models have several potential applications in industry and construction management. The model can easily be converted to a desktop package that construction professionals could use in rapid prediction of final cost of projects using only factors that are readily available or measurable at planning stage of the project. It is also very useful at the design stage of a project when information is incomplete and detailed designs are not available. The use of the model could also greatly reduce the time and resources spent on estimation as well as provide a benchmark to compare detailed estimates. It will further allow the generation of various alternative solutions for a construction project using 'what if' analysis for the purposes of comparison.

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FORECASTING THE NUMBER OF JOBS CREATED THROUGH CONSTRUCTION

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The construction sector is one of the largest single contributors to employment. A wide and varied set of metrics is used by official channels to predict the number of jobs that will be created for a given value of construction expenditure. These values tend to be shrouded in context specificity (ie, a peak workforce, or number of jobs created for one year) which meet the agenda of the organisation making the announcement. The research reported in this paper reviews the outcomes of five years of research into labour forecasting culminating in the development of the Labour Forecasting Tool (LFT). The research explores three approaches to deriving labour coefficients (the amount of labour per £m of construction value): i) a review of historic data produced by contractors; ii) a theoretical build-up of labour from bills of quantities and iii) an analysis of published UK national statistics. The shortfalls and advantages of each approach are discussed along with the results of a triangulation of the three methods to test the accuracy of the results. Encouragingly, the results point towards a strong agreement between the three approaches. However, whilst the labour coefficient can provide an estimate of the total labour demand in person-years this must be translated to a meaningful measure of the construction jobs created. To do so requires an understanding of the labour flow during a project. The LFT is capable of producing a month-by-month, trade-by trade forecast for a project by the use of a bespoke algorithm. Using the LFT, results are presented for eight typical projects within seven construction sectors. The significant impact of project duration on peak labour demand is shown. The conclusion can be drawn that any discussion of 'jobs created' must be clearly presented in the context in which it is reported.

Keywords: employment, labour forecasting, productivity

INTRODUCTION

In the current global economic climate, governments and developers are keen to predict the number of jobs created by their investments. Construction is one of the largest single sectors in the economy. Economically, the industry employs nearly 3 million people, outputs £100 billion worth of work per year and accounts for 8% of gross domestic product (HM Government, 2008). In these austere times the lack of

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Forbes D; El-Haram M; Horner M and Lilley S (2012) Forecasting the number of jobs created through construction *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 317-326.

growth in the construction industry is regularly cited as the cause of overall contraction in the economy (Office for National Statistics, 2012). However, at a more detailed level the question remains of how many jobs are created by construction expenditure for a given project.

There are a number of reasons why the number of jobs created by a given project might be required. One of the primary reasons is that those who are investing want to publicise the impact of their contribution. Therefore, public relation staff will issue press releases stating "X number of construction jobs created" by a particular new-build project. However, what is not immediately clear from such assertions is the rationale for calculating the number of jobs created and exactly what is meant by "a job". For instance, does it refer to the peak workforce and over what period of time will the jobs be created? A further reason for estimating the number of people employed is the increasing requirement from government at all levels to upskill the workforce. Planning requirements such as Section 106 Agreements under the Town and Country Planning Act 1990 allow local authorities to specify community benefits. Increasingly these are being used to ensure broader benefits such as increase in targeted recruitment and training. However, to be able to negotiate the training levels with developers, local authorities must first know the demand created by the project.

The aim of this research is to create a labour forecasting tool capable of forecasting on a project-by-project basis. This tool predicts at early planning stages when very little information is known about the project. The tool was originally commissioned by CITB-ConstructionSkills to inform the demands for training in its National Skills Academies for Construction (Forbes *et al.* 2009). The Academies focused on project-based training centres and therefore a need existed to forecast the demand for labour of all kinds, including professionals. Creating a fully evidence-based breakdown by month and by occupation is a vital starting point in developing realistic employment and skills plans for a project as well as determining requirements for targeted recruitment and training.

A secondary aim of the research presented in this paper is to compare the outputs of the Labour Forecasting Tool (LFT) with a selection of media reports of the number of jobs created by construction projects. Using articles publicising the number of jobs created in various projects and inputting these project parameters to the LFT estimates of the labour demand have been obtained. Using these it is possible to gain insight into the assumptions that are made in predicting the labour demand and the impact of these on the claims for the number of jobs created.

ESTIMATING THE LABOUR DEMAND IN CONSTRUCTION

Labour forecasting at an early stage of a project inception is a topic that has not received significant research attention in the literature. From a labour forecasting perspective Chan *et al.* (2006) developed a manpower planning model for Hong Kong. This model was designed with the aim of allowing government to compare where they might generate the most jobs from public investment. The tool split projects into 10 equal phases to determine the labour flow through the project and demand at each stage. Their approach calculates the average number of jobs created:

$$\text{Number of jobs created} = \frac{\text{Total labour requirements (in man-months)}}{\text{Project duration (in months)}}$$

Ball and Wood (1995) explored the issue of job creation from construction and reviewed the existing publications on the number of jobs per £1m of construction.

They found that these varied by up to 100% and that there was a need to develop new estimates using site-based information. Proverbs et el (1999) developed an approach designed for estimating labour at the inception stage. This created a measure of labour hours based on the floor area of a building and was restricted to a concrete framed high rise structures using productivity rates for each task. More recently, Anumba *et al.* (2006) considered the problem of supply and demand in construction labour market planning. They concluded that the GIS approach which they developed should be used in conjunction with other labour forecasting approaches and that there was a particular need to look at the sub-regional level. Such sub-regional data did not exist in 2005 and it is at this level that our Labour Forecasting Tool contributes.

In an approach that is designed to provide quick estimates of the number of jobs per year created from construction the former Regional Development Agency, One North East (2010) published guidance. For new build projects they recommended coefficients from between 10.6 and 21.0 jobs per £m output per year at 2009 prices. Personal correspondence in 2012 with Scottish Enterprise suggested a similar approach. They currently use one job per £75,000 of expenditure. This value is derived by assessing the turnover per employee in the construction industry from national statistics. This equates to 13.3 jobs per £m construction and is therefore comparable with the outputs from One North East.

Overall there is a need to explore how labour can be forecast at an early stage of a project when very little is known about the project except an outline budget. The research presented attempts to create a forecast with a rigorous, evidence-based approach and develop a tool which can forecast labour demand initially for the UK.

THE LABOUR FORECASTING TOOL

The Labour Forecasting Tool was initially developed in 2008 for CITB-ConstructionSkills. CITB-ConstructionSkills are the industry training board and the Sector Skills Council for Construction in the UK. The tool was developed to create project-based forecasts. It can be used to forecast the labour demand on a month-by-month basis broken down by each of 26 occupations shown in Table 1. To create this forecast the tool needs to know a) the project type; b) the project value and price ruling date (exclusive of any land or site preparation costs); c) the location (by UK region); and d) start date & end date/duration.

Land costs and site preparation costs are excluded from the forecast as preliminary investigation led to the conclusion that these tended to be site specific. Examples of site preparation costs include extensive earthworks or contaminated land restoration.

For the project types, the level of granularity is maintained at a high level. The types are defined by the seven sectors used by the Office for National Statistics (Office for National Statistics (2010). This produces high-level forecasts at a sector level and ongoing work is seeking to improve the granularity of these to improve the forecasts of specific building types. Forecasting at this level maintains consistency with the data which is available. The seven sectors are:

- Housing
- Infrastructure
- Public non-residential
- Private industrial
- Private commercial
- Housing repair and maintenance

- Non-housing repair and maintenance.

For each of the forecasts produced, it is possible to select which of the 26 occupations are required. These occupations are defined by the 26 Standard Occupational Classifications (SOCs) produced by CITB-ConstructionSkills. In producing a forecast using these occupations a picture is obtained of the total labour involved in a project including both site and non-site based staff.

Table 1: List of Standard Occupational Classifications

Senior, executive and business process managers (SOC01)	Plant operatives (SOC14)
Construction managers (SOC02)	Plant mechanics/fitters (SOC15)
Non construction professional, technical, IT, and other office based staff (excl. managers) (SOC03)	Steel erectors/structural (SOC16)
Wood trades and interior fit-out (SOC04)	Labourers nec (SOC17)
Bricklayers (SOC05)	Electrical trades and installation (SOC18)
Building envelope specialists (SOC06)	Plumbing and heating, ventilation, and air conditioning trades (SOC19)
Painters and decorators (SOC07)	Logistics (SOC20)
Plasterers and dry liners (SOC08)	Civil engineering operatives not elsewhere classified (SOC21)
Roofers (SOC09)	Non–construction operatives (SOC22)
Floorers (SOC10)	Civil engineers (SOC23)
Glaziers (SOC11)	Other construction professionals and technical staff (SOC24)
Specialist building operatives not elsewhere classified (SOC12)	Architects (SOC25)
Scaffolders (SOC13)	Surveyors (SOC26)

Sources of data

The aim of the LFT is to predict the labour demand at an early stage when there is little known about the specific characteristics of the project. For instance, it may not be known whether the housing project is timber framed or non-timber framed. Therefore, the data which underlies the tool is taken as an average across all of the sub-sectors within each of the seven sectors as data is not available at a sufficiently detailed level to allow a more detailed analysis to be undertaken. It is not the aim of this paper to outline the analysis undertaken in detail; the processes is summarised here for completeness along with the shortfalls and benefits of each approach. Please refer to Forbes *et al.* (2009) for more details.

At the seven sector level three sources of data are used to populate the LFT. The first of these and the most comprehensive is the analysis of Office for National Statistics (ONS) data. Data is published for the number of each occupation employed in each year and the total output (£m) from each sector. This data is used to create 26 occupational labour coefficients (person-years/£m) for each of the sectors. One of the difficulties in using national data is that the aggregation process provides an average across the sectors. However, at the stage the LFT is designed to be used this is not a problem and is far outweighed by the breadth of the data available for the analysis. The labour coefficient in each SOC is each industrial sector was established by

solving a large set of simultaneous equations. As data in from the ONS is published annually a continuous updating process can be undertaken.

Although the data from the ONS is the most complete and comprehensive two additional sources of data were analysed to verify the initial analysis. The first of these was a review of actual data from contractors on historic projects. This is the richest and most reliable source of data and would be the data of choice for use in forecasting. However this presented challenges in obtaining the data in the required format for the range of projects and trades. Where this data is available it is a very rich source which provides the exact labour data for a project. However, there were particular issues in relation to contractors who sub-contracted all or part of the works as labour records were rarely kept. The final source of data to determine labour coefficients was to create a theoretical build-up of labour by assigning the labour requirements to bills of quantities. This is similar to the approach used by Proverbs *et al.* (1999). Whilst this proved effective it was time consuming and therefore not feasible on a large number of bills. Attempts were made to automate the process but a lack of consistency in the production of bills of quantities rendered this ineffective.

However, following the two additional analyses there emerged sufficient data that the values arising from the ONS analysis could be triangulated. The results showed that there was a degree of uniformity between the outputs from the various analyses and thereby providing considerable confidence in the results.

Factors affecting the labour forecast

There is a multitude of factors which might affect the labour requirements for a construction project. The assumptions which are made regarding labour productivity (Horner and Duff, 2001) and the construction method are amongst a few. At the stage the LFT is designed to be used it is not necessary to take account of all of the differing factors and indeed likely to be impossible. However, the LFT does take account of two factors in determining the labour demand:

a) the different points at which each trade arrives on and leaves site (for instance finishing trades will start and finish on site later than ground works) and

b) the labour flow throughout the project (the shape of the "s-curve").

By taking account of these it is possible to translate the overall labour demand from a labour coefficient (person-years/£m) to a number of people in each month. However, both factors can have a significant impact on the peak labour demand and their interaction affects the peak. For instance, if the assumption is made that a particular trade is on site for the entire duration the peak will be lower than for the same labour profile that is only on site for say 75% of the project.

The Labour Forecasting Tool takes account of these factors by best-fitting s-curves and lead and lag times for each occupation in each sector. These have been fitted to historic data from contractors. Fitting data in this manner overcomes some of the limitations of models which split a project into a number of equal periods such as Chan *et al.*'s (2006) model for Hong Kong.

FORECASTS OF EMPLOYMENT ARISING FROM CONSTRUCTION

The media regularly run reports from developers, government agencies and other organisations providing headline-grabbing figures of the number of jobs that will be created by a particular new development. This section outlines outputs from the

Labour Forecasting Tool for projects which have hit the headlines. Table 2 outlines the characteristics of eight projects representing a range of sectors, regions and values. All have been featured in recent news articles from different sources. The sources of these are provided.

Table 2: The projects

Proj-ect	Type	Description	Location	Value	Duration	Source
1	Housing	Conversion of existing building to student accommodation	East Midlands	£30m	2 years	http://bit.ly/Ia1aBm
2	Commercial	Construction of new office accommodation	Scotland	£34m	20 months	http://bit.ly/IlmfEw
3	Public non-residential	Construction of University Arts Building	Wales	£40m	2 years	http://bit.ly/I31Qod
4	Commercial	New retail development	West Midlands	£150m	33 months	http://bit.ly/Jvysw7
5	Infrastructure	New road construction	Scotland	£320m	2 years	http://bit.ly/I6EuAn
6	Industrial	Pharmaceutical factory	North West/Scotland	£350m	6 years	http://bit.ly/JvfYN6
7	Infrastructure	New road construction	Scotland	£445m	3 years	http://bit.ly/JvfWF8
8	Infrastructure	Large infrastructure project to form new logistic park	South East	£647m	3 years	http://bit.ly/I31P3A

Each of the eight projects was input to the LFT and a labour profile created for the project. Sufficient information was available from each of the articles to assess the input parameters for the LFT. The assumptions which were made related to the project values. In none of the cases was it explicitly stated whether the value included land costs. Given the nature of the articles, it was assumed that land costs were excluded from the figures. It was not clear whether site preparation costs were included. However, it was assumed that the total jobs presented would relate to value which was presented and so site preparation costs would therefore be reflected in the overall labour demand. The impact of site preparation costs would be to produce a separate peak, or at the very least a rise in labour at an early stage in the project. This would reduce the overall peak labour demand but the effect of this is not likely to be significant as has been tested in preliminary forecasting work.

A further assumption was made in relation to the price ruling date. None of the articles stated the date for the value given. In the absence of this data it was assumed that the price ruling date was the date of publication. However, there has been very little fluctuation in tender price indices in the last four years, so this is likely to have little impact.

The Labour Forecasting Tool was run twice for each project. Figure 1 shows an example output for project 6 for all 26 occupations.

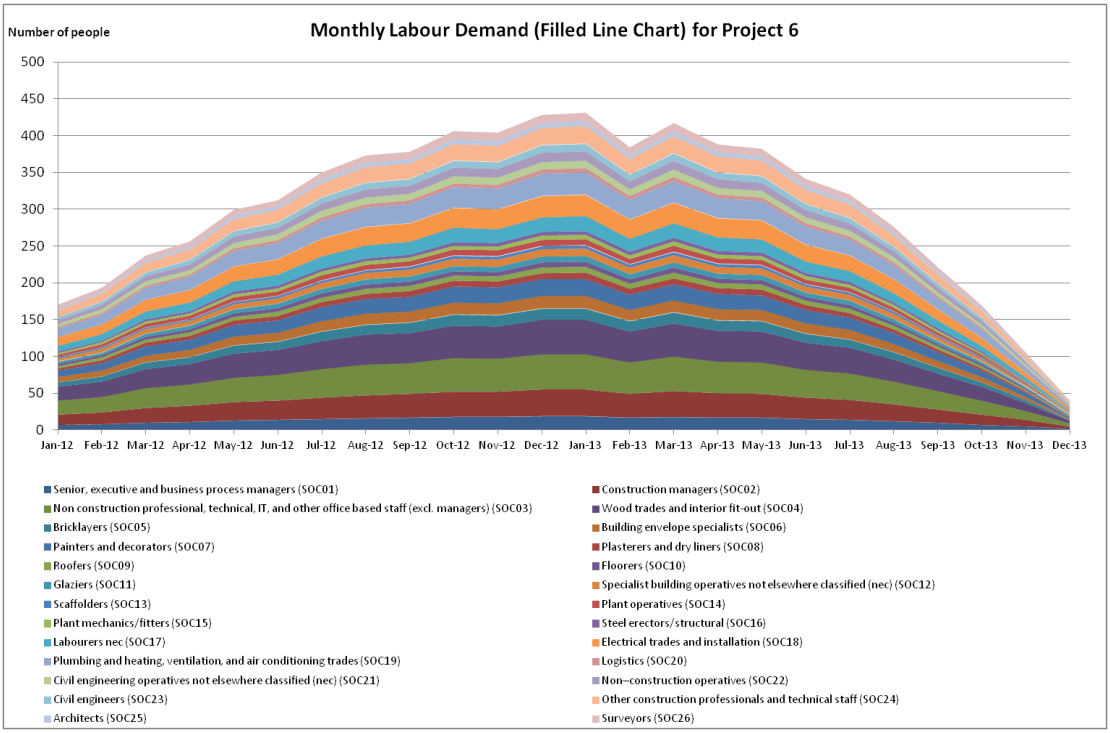

Figure 1: Labour forecast for Project 6 (total labour on the project)

An initial forecast was produced for the 19 of the 26 SOCs which are site-based. The outputs from the tool for this are shown in Table 3 for both the peak workforce (which may only last for one month) and the average workforce over the whole project. This average workforce uses Chan *et al.*'s (2006) conversion to number of jobs. The number of jobs created by the project as published is also shown. For project 2, which is split between Scotland and the North West, an average of the outputs for the two regions was used. This implies the assumption that the project is equally split between the two regions. It should be noted that there is a 5% difference in tender price indices between these regions.

Table 3: A comparison of the site-based jobs created

Project	Number of jobs created as advertised	Total Jobs Created		Site-based Jobs Created	
		LFT Forecast - Peak (% difference)	LFT Forecast - average (% difference)	LFT Forecast - Peak (% difference)	LFT Forecast - average (% difference)
1	200	431 (116%)	303 (52%)	276 (38%)	174 (-13%)
2	250	1290 (416%)	593 (137%)	834 (234%)	359 (44%)
3	350	361 (3%)	158 (-55%)	232 (-34%)	100 (-71%)
4	450	2127 (373%)	1463 (225%)	1359 (202%)	934 (108%)
5	500	1947 (289%)	1378 (176%)	1243 (149%)	879 (76%)
6	300	587 (96%)	438 (46%)	376 (25%)	280 (-7%)
7	350	1873 (435%)	1302 (272%)	1173(235%)	831 (137%)
8	700	2554 (265%)	1806 (158%)	1631 (133%)	1153 (65%)

Table 3 also shows the results for the second run of the tool for all 26 occupations. This produces an estimate of the total number of people involved in the project including both the site and non-site based staff. Table 4 explores the impact of

spreading the construction spends equally over each year of construction. From this and the number of jobs advertised by the developer the jobs per average spend per year can be seen. The table shows that there is a marked difference in the number of jobs which have been forecast. For comparison the number of jobs created using industry wide averages proposed by Scottish Enterprise have been included. These multiply the average spend by the coefficient of 13.3 jobs/£m. The total number of jobs per average spend of output is shown alongside. These show no correlation between the number of jobs advertised and the outputs from the LFT.

Table 4: An approximation of coefficients used in published articles

Project	Project value (£m)	Duration (years)	Average spend (£m)/year	Number of jobs created as advertised	Jobs/average spend/year (as advertised)	Number of jobs created using industry-wide average	Jobs/average spend/year (LFT outputs)	
							Total	Site
1	30	2	15	200	13.33	200	20.20	9.80
2	34	1.67	20	250	12.25	272	29.65	17.95
3	40	2	20	350	17.50	266	7.90	5.00
4	150	2.75	55	450	8.25	727	26.60	16.98
5	320	2	160	500	3.13	2133	8.61	5.49
6	350	6	58	300	5.14	777	7.55	4.83
7	445	3	148	350	2.36	1977	8.80	5.61
8	647	3	216	700	3.25	2875	8.36	5.34

DISCUSSION

The Labour Forecasting Tool is a unique tool which offers the opportunity to forecast the labour demand on a project at a very early stage in the UK. There are limitations associated with the use of the tool as it uses average outputs from historic projects and applies them to a new project. However, at an early planning stage it is not practical to produce a detailed build-up of labour that will be subject to much change. The LFT offers a quick estimate of the labour demand

The results presented in Table 3 shows that on the whole the Labour Forecasting Tool produces higher estimates of the number of jobs created from new-build construction work than those published.

There are a number of reasons why this might be the case. Whilst a developer wishes to promote their credentials by generating a large number of jobs from a new-build construction they may also wish this to be downplayed. Increasingly planning requirements are being placed on contractors to train a proportion of their workforce. Developers therefore may have a vested interest in keeping published figures as low as possible.

One of the key items that ought to be noted in the outputs is the differences between the peak and the average workforces. The peak workforce is dependent upon the lead and lag times for each occupation and the shape of the s-curve that has been derived for each occupation. The data presented in Table 3 shows some marked differences between the peak and the average workforces produced by the LFT. In some cases

these result in a reduction of 50% from peak to average. However, it should be noted that at some point in the peak month or months the number of people employed on the site will be equal or close to the peak workforce. However, it is unlikely that this will be sustained for more than handful of weeks. The project duration taken from Table 2 will also have an impact on the peak. A longer project than anticipated will have a lower peak; a shorter project will have a higher peak. It is clear from Table 2 that most of the projects have had their duration rounded to a yearly period. Therefore the exact peak labour demand may vary.

One particular sector forecast which should be used with caution is the infrastructure sector. This is a particularly broad sector ranging from tunnelling, highways, water treatment etc. Therefore it is difficult without greater degrees of granularity to produce detailed forecasts. This applies to projects 1, 3 and 7. However, the LFT outputs for these projects are not at the extremes of the divergence from the advertised number of jobs.

Table 4 shows that the variations in the number of jobs advertised do not vary in proportion to the project values. This is not unexpected as the sources of the articles vary, as do the reasons for publication. However, in effect they are all making the same claims and ought therefore to provide relatively consistent results. There is no consistency with the average spend per year. All of the projects, except 8 produce jobs per average spend that are below that proposed by Scottish Enterprise and 8 is within the range suggested by One North East. Using the industry wide figures proposed by Scottish Enterprise creates a forecast number of jobs that is greater than advertised in all the projects except 8. These figures are more closely aligned with the values forecast by the LFT.

CONCLUSIONS

The culmination of five years of research is a Labour Forecasting Tool which can generate an indication of the likely labour demand on a project at a stage when only minimal information is known about the project. It can act as a useful tool in workforce planning and in influencing employment and skills plans. There are obvious limitations to the tool given the stage at which it is designed to be used. It cannot be used to accurately plan and programme a specific project but instead provide guidance to the skills needs when no other information is available. The tool is fully functioning and usable at the seven sector level and current work is exploring how it can be populated with additional data at a greater degree of granularity. This work is focussing primarily on the infrastructure sector and the application to tunnelling, and energy generation projects.

The data underlying the tool is derived from a range of sources and its reliability has been tested by triangulating the outputs from national statistical data, actual out turn data from sites and theoretical approach from bills of quantities. All of the data sets were independent of each other and converge towards the same values. This would lead to the conclusion that a degree of accuracy can confidently be placed in the results of the tool. The research presented in this paper has compared the LFT outputs with the forecasts from the developers in the press and also the approaches proposed by Scottish Enterprise. The LFT outputs are aligned with the values from Scottish Enterprise even though they are divergent from the developers' articles. This would suggest that the LFT is an appropriate tool for government agencies and departments to use to predict the labour demand from construction projects.

The comparisons that have been undertaken between the numbers of jobs created as published by developers and as forecast by the LFT have highlighted some marked differences that exist. In most cases the total number of jobs predicted in the news articles is an underestimate compared to the LFT for both the peak and the average workforce values. Whilst it is difficult to draw any particular conclusions about the causes of this without obtaining further background information and data pertaining to the project it is vital that any figures relating to "jobs created" are treated very carefully. The context for which the numbers are presented ought to be clearly stated. It should be clear whether the total of people employed relates to a peak or average workforce. It has been shown that the impact of this can be substantial and can have an impact on training levels and the development of employment and skills plans.

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A SYSTEM DYNAMICS-BASED METHOD FOR DEMAND FORECASTING IN INFRASTRUCTURE PROJECTS - A CASE OF PPP PROJECTS

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Concession contracts are one of the most popular PPP arrangements. However, there are still a few problems regarding the successful implementation of such arrangements, such as estimating a realistic figure for the demand of services offered by the facility. Lake of demand, or demand variation, is a widespread practice when developing infrastructure projects. In the case of concessions, such practices are the origin of significant risk as the forecasted demand is a key variable in the financial and economic evaluation of any PPP project that needs to be accurately identified and then managed. Demand forecasting is a complex and dynamic process, as several inter-related qualitative and quantitative factors affect demand. This paper proposes a system dynamics-based method in which different factors affecting demand are considered and modelled holistically. The system dynamics concept has been employed to build up a set of cause-effect diagrams which will finally be incorporated to develop a conceptual demand model. This model establishes the causal structure of the demand system, which will help to portray and define the impacts of different factors on demand volume.

Keywords: cause-effect diagrams, concession, demand forecasting, system dynamics.

INTRODUCTION

Nations across the world have witnessed a major growth in the use of PPP over the last two decades. A study by McKinsey (2008) suggested that the private sector raised $105 billion to fund infrastructure facilities between 2006 and mid-2007. This growing trend of governments allocating major public investments for infrastructure projects to the private sector means, in many cases, that governments look to the private sector to finance projects using the projects' anticipated revenues as security rather than relying upon a direct sovereign guarantee for the projects. These kinds of PPP arrangements are broadly known as concession contracts. Concession contracts have widely been used to deliver economic infrastructure projects such as roads, water facilities and power stations (Zhang and Kumarswamy 2001). The World Bank

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Alasad R; Motawa I and Ogunlana S (2012) A system dynamics-based method for demand forecasting in infrastructure projects - A case of PPP projects *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 327-336.

reported that concession contracts accounted for about 50% of overall PPP contracts, making them the most popular type of PPP arrangements.

Despite the successful implementation of most concession contracts, in that they deliver the project on time and within the projected budget, financial difficulties faced during the operation stage have, in many cases, affected the success and overall project viability. The sluggish performance of many of these projects results in demand risk being of particular importance. Since the revenue for concession projects is basically based on service demand volume, any risk associated with demand in the operation stage will be translated into equivalent revenue risk, increasing the need to prioritise and address this type of risk appropriately when deciding, planning and operating these kinds of PPP projects.

The feasibility study of any infrastructure project entails forecasting the expected demand for the service provided by the facility in question. Several factors, both qualitative and quantitative in nature, need to be accounted for. In addition, many of these factors are inter-dependent, making demand forecasting a complex process. The conventional method employed for demand forecasting can be broadly classified into statistical and artificial intelligence methods. While most of the former cannot accommodate interrelations between factors, the artificial intelligence method can do this; however, the large amount of data required to model developments in the latter is still a concern.

Considering the deficiencies of traditional methods, the variety of factors and their complex interrelated structure, this paper proposes a system dynamics-based method to model such complexity. The SD method is well-known for its capacity to deal with the dynamic and complex nature of real systems. This research aims at developing a dynamic model to overcome the main deficiencies and drawbacks of the models in use. The dynamic model will help to derive elasticises of demand with respect to various potential influences. The proposed system dynamics-based forecasting model will advance the state of the practice and respond to the policy requirements of developing infrastructure projects.

The next section of this paper presents an overview of demand risk in infrastructure projects, followed by a literature review related to demand forecasting. System dynamics is then introduced as a potential tool for public service demand forecasting. Next, the proposed model for forecasting demand in PPP projects is introduced, and finally conclusions are derived.

DEMAND RISK IN INFRASTRUCTURE PROJECTS

Quiggin (2004) identified demand risk as “the possibility of unforeseen variation in the demand for services generated by a project.” Variations in demand volume have been observed in many infrastructure projects. Bain (2002) explored 32 toll road projects all over the world, which included bridges, highways and tunnels. The study illustrated that the actual traffic volume for 28 of the projects was below what was projected. This core sample was extended to include 104 international PPP toll road projects in 2005, but the main results regarding the discrepancy between actual and forecasted traffic volume did not change. The range of actual/forecast ratios is from 86% below what was predicted to 51% above what was predicted (Bain 2009). Flyvbjerg *et al.* (2005) investigated 210 projects in 14 countries. The study showed that over 50% of transportation projects average a 20% discrepancy between actual and forecasted demand. In addition, the study suggested that this inaccuracy in

demand forecasting is common across the different types of transportation infrastructures (highways, tunnels and bridges). Another study by Flyvbjeg (2007) indicated that the actual number of travellers on 22 urban rail projects around the world averaged 50.8% lower than predicted. The number of travellers for 75% of those projects was at least 40% lower than forecast, and only two schemes achieved the predicted demand. The work concluded that urban rail project projections are frequently far from actual demand. Moreover, a study by Engel *et al.* (2003) showed that inaccuracy regarding demand forecasting is common in highway projects in Latin America. Engel (2006) concluded that inaccuracy in demand forecasting was the major reason for transportation project distress in the United States.

DEMAND FORECASTING

The uncertainty inherent in demand volume in infrastructure projects necessitates employing more advanced methods to achieve realistic demand forecasting at the pre-project stage. This is particularly significant for concession contracts, where the demand-based financial performance is the main determinant of the project's success. The World Bank (2008) reported that unrealistic forecasts are a major reason for most toll road failures (cited in Li and Hensher 2010). In many infrastructure projects, the significance of undertaking the forecast process is underrated, and sometimes this is not even achieved. Trujillo *et al.* (2000) noted that while the employment of PPP to deliver infrastructure projects is increasing, there is growing evidence of a failure to appreciate demand forecasting in the formulation of partnership agreements. They added that it is not unusual for project partners to allocate larger proportions of the budget to construction studies than to demand estimations; this ratio averages 1:5.

Quinet (1998) categorised the sources of inaccuracy in demand forecasting as follows: inadequacy of the model structure, inaccuracy of the current data, and uncertainty in prediction of the future value of exogenous variables. In addition, a study by Flyvbjeg (2005) showed that there are two reasons for errors in traffic forecasting; namely technical mistakes in the methodology and the strategic behaviour of the bidders (optimism and bias). Moreover, Niles and Nelson (2001) identified uncertainty in model design and structure as one of the reasons for forecasting errors. They suggested improving the current models by integrating new variables, or introducing and designing new models for demand forecasting.

To overcome the optimism misrepresentation related to the strategic behaviour of the project stockholders, Flyvbjerg (2007) introduced a reference class forecasting method in order to build this optimism bias into the forecast. The main deficiency of this method is the large number of similar projects required to establish the probability distributions necessary to calculate the final forecasted figure. In addition, the similarity issue remains questionable, especially for those non- routine Greenfield projects where it is quite difficult to find two projects with similar attributes and built in a similar environment. Quinet (1998) argues that it is difficult to compare comparable things when topic is related to traffic, the conditions of implementing a particular project is different from that defined for any other. However, assuming the presence of optimism bias and that the forecasting figure should include it, based on the reference class forecasting method, the final figure is the initial figure forecasted by the model minus/plus a proportion of this initial figure in order to accounts for optimism bias. Given this, if the forecasting model produces initial figure which is unrealistic owing to any kind of deficiency in the model, the problem will be further exacerbated when calculating the optimism bias proportion based on this figure and

then including them together. Moreover, this problem will extend to other projects as this figure will be used as a reference to any potential future project. Therefore, to help the planners to include the right percentile of this bias in their models and to develop a reliable class of references for future use, it is necessary for their model to produce realistic initial figures. Given this and that several scholars attribute the variation in demand to reasons pertinent to the forecasting models themselves, the authors argue that the reasons related to model structure and design need first to be accounted for.

Forrester (1968) suggested that simple solutions to problems could have undesirable results, and more sophisticated levels of analysis could provide better solutions. It was observed that, for simplicity, many forecasting models identify only some of the influencing factors and assume that these could account for all the outcomes. Although quantitative and qualitative factors play an approximately equivalent role in shaping the demand behaviour for services provided by PPP infrastructure projects, most of the forecasting tools have mainly focused on quantitative factors, which often have external effects on demand. However, the worst situations occur when both these factors are totally ignored and the demand for the services provided by a facility is estimated based on the available statistical data of similar facilities (Ng *et al.* 2007). Moreover, these factors affecting demand in PPP projects typically have complex interrelations that need to be taken into consideration when developing the forecasting model. These factors dynamically interact, leading to constant changes in the system. Niles and Nelson (2001) mentioned that although the mobility and dynamism of the urban system is noticeable, decision-makers still utilise closed, static models to produce demand projections for transportation projects, which constitutes a major weakness in the modelling of demand forecasting. Subsequently, the method used for forecasting in many infrastructure projects could be highly misleading, and the inaccurate forecasting outputs could lead to business failure.

Owing to the particular nature of the factors affecting demand in PPP projects, this research is devoted to developing an enhanced demand forecasting approach which takes into consideration the factors and relationships among them, and provides a more realistic and reliable estimation. The modelling technique adopted is system dynamics, which is a powerful method that is designed to analyse complex systems by including all the relevant factors and their relationships. The following section briefly introduces the concept of system dynamics.

SYSTEM DYNAMICS

With the aim of improving the decision-making process, system dynamics (SD) was developed by Jay Forrester at Massachusetts Institute of Technology in the 1950s. SD is a method of representing complex and dynamic systems with the aid of computer simulation software. It is an experimental approach to system thinking (Sterman 2000), and a way to include all relevant factors, cause-effect relationships, time delay and feedback loops which factor in the unexpected behaviour of the complex system. The SD method has been successfully applied in different fields, including economics, ecology, health science, physics, mathematics and biology.

SD is an appropriate technique with which to study problems of a complex and time dependent nature. It is one of the most suitable approaches for dealing with causal structures governing the behaviour of complex systems. Demand forecasting is complex, integrating several inter-correlated factors whose behaviours are time-dependent. For instance, the change in the local economy at present may have impacts

on demand in the future. System dynamics has the ability to simulate this change over time, along with the effect it has on the dependent factors and the system in general. This method has the capacity to take into consideration different quantitative and qualitative factors in order to capture the dynamic interactions between these factors.

PROPOSED MODEL

The SD modelling process includes two main phases: Qualitative System Dynamics, or model conceptualisation, and Quantitative System Dynamics. While the former is mainly based on creating cause-effect diagrams, which is the main purpose of this paper, the latter is devoted to quantitative computer simulations.

Cause-effect or causal diagrams are a visual representation of the interactions and feedback loops between different factors affecting demand. These cause-effect diagrams, representing the hypothesis of the model, depict how each factor can affect the outcome, either directly or through other intermediate factors, as well as the effect that one variable has on the others. They clearly show the direction and the kind of causality among different variables (Love *et al.* 1999). A relationship between two variables (x1) and (x2) is represented by an arrow. For each relationship, the link between the two variables is noted as positive if the increase in the variable at the tail of the arrow (x1) would cause an increase to the variable at the head (x2). The relationship is noted as negative if increase in (x1) would cause a decrease in (x2). One significant aspect of the SD causal diagram is the feedback loop, which can be positive or negative. While variables in positive or reinforcing loops (R) increase or decrease indefinitely, variables in negative or balancing loops (B) stabilise over time.

The main factors affecting demand in PPP projects have previously been identified by authors (Alasad *et al.* 2011). With reference to the outcomes of this previous work, a conceptual demand forecasting model, which describes the relationships between different factors, is proposed (Figure 1). The demand forecast model consists of many cause-effect diagrams with several reinforcing and balancing loops. However, due to space limitations, the generic structure of the conceptual demand forecasting model as well as socio-economic and fee level cause-effect diagrams will be presented in this paper.

THE CONCEPTUAL DEMAND FORECASTING MODEL

The conceptual model for demand forecasting - Figure (1) - suggests that the level of demand for services provided by PPP facilities is jointly affected by several qualitative and quantitative factors. These factors include public acceptance, willingness to pay, fee level, socio-economic growth in the facility area, competition from existing facilities and availability of supportive facilities. The model depicts how these factors affect one-other and how they eventually affect demand.

The next two sections present cause-effect diagrams for two of these factors; namely the fee level and socio-economic factors.

Socio-economic cause-effect diagram

The socio-economic context in which the facility is operated has an impact on the level of demand, and subsequently on the future revenues of the facility. Infrastructure projects are known to be a generator of economic activities. In addition, the facility users play a significant role in shifting economic resources into the facility area, leading to substantial economic growth.

Introducing a new infrastructure project can have local and systematic impacts. While systematic impacts can influence all potential users of the facility, local impacts specifically affect those people in the immediate vicinity (Kanaroglou *et al.* 1998). In the local impact context, introducing an infrastructure facility to a specific region is likely to bring significant benefits. It can augment employment opportunities and enhance the productivity of the area due to enabling additional economic activities (agriculture, manufacturing, construction), which can trigger a significant increase in employment and income. This will finally result in a positive impact on the local economy in general.

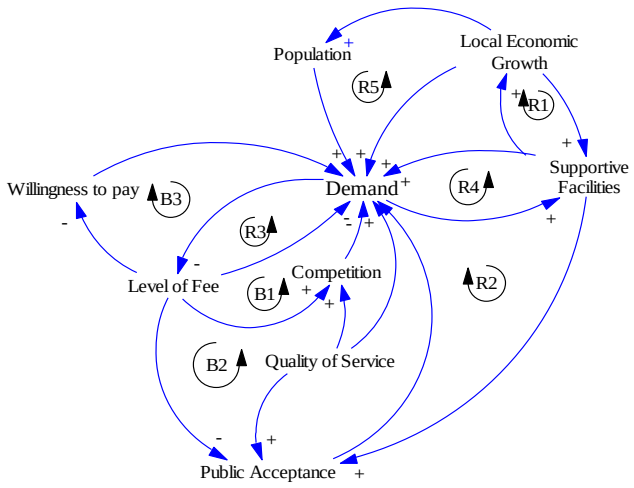

Fig.1: Conceptual Demand Forecasting Model

For instance, constructing a new highway will lead to many fuel and service stations, firms, retail stores, warehouses and restaurants being established along the highway and in the proximity of the facility. For example, it was declared that the realisation of the second Peace Bridge between Canada and USA facilitated $29 billion in trade and contributed to the construction of an international trade complex in the adjoining area. Similar situations were identified in the UK for the Humber Bridge and other projects (McQuaid and Greig 2002).

On the other hand, this growth in the local economy resulting from the introduction of a new infrastructure project is likely to cause changes in the local demographic over a period of time. This change in population number and distribution over the course of a few years can create tremendous changes in demand. When the population of the areas surrounding a facility grows, this is likely to be reflected in the growth of facility usage demand. The cause-effect diagram of socio-economic factors illustrates the impact of this change in the socio-economic context of the facility area on the level of demand.

The economic growth cause-effect diagram suggests many feedback loops, as shown in Figure 2. The first is a reinforcing loop, R1 (economic growth-labour supply-demand-alternative facilities-economic growth), where the economic growth in the facility area will trigger more job opportunities, attracting more labour to the area, which will consequently increase the level of demand. However, a continuous increase in demand resulting from more job opportunities and other factors will create the need for another facility to relieve inordinate pressure on the original one. This new project will eventually contribute to economic growth. However, it should be

noted that the construction of another facility in the area will most likely negatively affect the demand for the service provided by the facility in question (B1 loop). The second reinforcing loop, R2, suggests that the economic growth will enhance migration to the facility area, increasing the area's population and ultimately resulting in demand growth. The R3 loop suggests that economic growth will help increase the level of income, leading to a further increase in the purchasing power of potential users, and eventually having a positive impact on the level of demand. R4 is the final reinforcing loop, where the new constructed facility (alternative facility) will help attract more migrants to the facility area, causing population growth and consequently increasing the total demand.

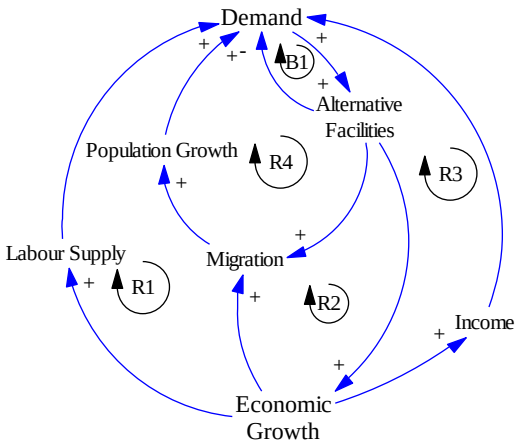

Fig.2: Socio-economic cause-effect diagram

Level of fee cause-effect diagram

For concession contracts to be financially viable, the total revenue collected from users over the concession period should cover the project cost plus expected profit. The project cost typically includes construction cost, operation and maintenance costs and cost of capital, including the interest on loans and dividends on equity raised to finance the project by the private company.

A study by Zhang (2005) showed that an appropriate toll/tariff level and suitable adjustment formula are the most significant factors for success within the critical sound financial package PPP success factor. The employment of PPP to deliver infrastructure projects requires an understanding of the trade-off between the financial and economic viability of the facility in question. In many cases, the expensive construction programme and the willingness of the private sector to fasten repayment of the debt service and achieve high profits leads to the levying of high tariffs. This high level of fee is likely to have a negative impact on the demand for services offered by the facility. In Sydney Airport railway link (in Australia), for instance, the high ticket price was the main reason for the low patronage observed. The ticket cost for using the railway was roughly three times more expensive than other lines (Zou *et al.* 2008). Furthermore, in the case of toll roads, a high-level toll will definitely cause traffic to divert to any available alternative route, leaving the facility in question under-used. However, while the private sector is worrying about its profit and risk, the major concern of the user is the service price and quality, which can seriously affect the demand (Trujillo *et al.* 2000). Therefore, the fee level imposed for using the

facility should strike a balance between achieving a reasonable return for the concessionaire and being compatible with the quality of service provided (Zhang and Kumaraswamy 2001). The level of fee cause-effect diagram illustrates how the change in fee level can influence the demand volume.

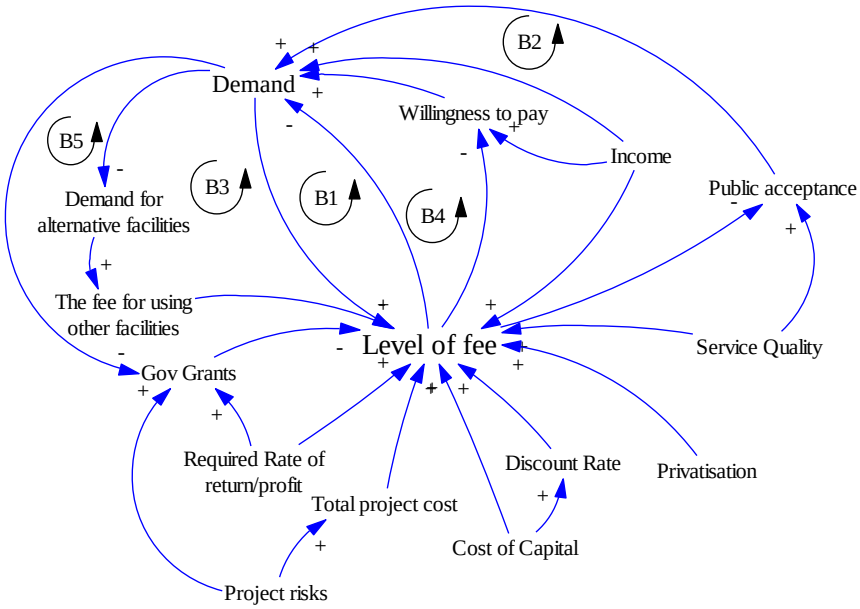

Fig. 3: Level of Fee Cause-effect diagram

The level of fee cause-effect diagram shows several balancing loops. The first balancing loop, B1, indicates that any increase in the level of fee will be directly translated into a decrease in the level of demand. However, a demand decline will most likely lead the operator to increase the fee for using the facility, causing further declines in the demand volume. The B2 balancing loop shows that when the level of fee increases, the public acceptance decreases, which will cause a further decrease in demand. This slackening of demand will lead the concessionaire to increase the fee for using the facility, and the loop starts again. As for the B3 balancing loop, any increase in the demand for the facility in question will be translated as a decrease in the demand for any other available alternative facility. The decline in demand for the alternative facility will lead the operator of this facility to increase the fee to compensate. This behaviour of the alternative facility operator will motivate the operator of the original facility to increase the fee as well, which will finally cause demand diversion to the alternative facility.

The B4 balancing loop suggests that the increase in the level of fee will lead to a decrease in willingness to pay, which, in turn, will lead to a decrease in the level of demand, causing the operator to further increase the fee level to compensate for the shortage in facility revenues. Based on the contract arrangements, the government is likely to provide grants to the private sector to ensure a reasonable user fee level. These kinds of grants will lead to a decrease in the level of fee for using the facility, causing a subsequent increase in demand. This increase in demand helps to decrease the amount of any further payment required by the government, as suggested by the B5 balancing loop.

As shown in Figure 3, several constant factors also affect the level of fee, such as the quality of service, cost of capital, discount rate, project cost and expected rate of return.

Finally, it should be mentioned that these cause-effect diagrams are barely developed, based on the literature review. Therefore, they need to be verified by a panel of experts and professionals in the demand forecasting and PPP fields, in order to produce validated cause-effect diagrams. The validated diagrams will be incorporated to form the final conceptual demand forecasting model.

CONCLUSIONS

Concessions, which are one principle of PPP, have been established by the government to pay for the construction of infrastructure projects and to make provision for the maintenance and operational costs. In addition to recouping its capital investment from the project revenue, the concessionaire is obliged to bear demand risk, which increases the significance of demand forecasting in these kinds of projects. Although many forecasting models have already been proposed, they remain primitive, and need major improvements in order to reliably forecast demand. These methods have some major weaknesses, including the huge amounts of data required, the fact that relationships between certain factors are ignored, and their static nature and simplicity. This paper has proposed a method to overcome these weaknesses. The system dynamics approach was employed to model and analyse the complex relationships among different factors affecting demand over time. The demand forecasting conceptual model portrays the interactions among different factors affecting demand, and defines how they do so. The cause-effect diagram of each factor, in turn, depicts the lower level interactions. The cause-effect diagrams will be verified by a panel of experts, and incorporated to produce the final conceptual model, which will then form the basis for the quantitative demand forecasting SD-based model. The expected model should help improve the practice of demand forecasting.

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AN EXPLORATION OF THEORETICAL CONCEPTS AND METHODS FOR ASSESSING RISK IMPACTS ON THE VARIABILITY BETWEEN CONTRACT SUM AND FINAL ACCOUNT IN DESIGN AND BUILD PROJECTS

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Design and Build procurement has been steadily increasing in popularity over the past number of years. Although it can provide some advantages, it can also lead to being a risky procurement method for both owner and contractor if the risks are not identified in advance and managed throughout. Therefore the overall aim of this study is to identify, assess and model the risk factors impacting the variability between the contract sum and final account in client-led and contractor-led Design and Build projects. The work presented in this paper is at the preliminary stage of the research programme and it looks into the possibility of developing a methodology for assessing risk impacts on the variability between contract sum and final account in design and build projects. As a first step, a detailed review of literature was made to establish the growing use of design and build procurement and the risk inherent in this procurement method. Secondly, different perspectives of risk were examined using the cognitive model of risk so as to position this study in the wider context of existing body of knowledge in this domain. The insights gained from the foregoing steps then helped in devising a methodological framework for assessing the variability between the contract sum and final account in client-led and contractor-led Design and Build projects.

Keywords: contract sum, design and build, final account, risk, variability

INTRODUCTION

Smith *et. al.* (2006), state that the construction industry has had a very poor reputation for coping with the adverse effects of change, with many projects failing to meet deadlines and cost and quality targets. Change is inevitable in construction, it cannot be eliminated and if it is not dealt with properly it can have detrimental effects on time, cost and quality targets. According to Lock (2007), the ever-present elements of

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Larkin K; Odeyinka H and Eadie R **(**2012) An exploration of theoretical concepts and methods for assessing risk impacts on the variability between contract sum and final account in design and build projects *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 337-346.

risk and uncertainty mean that the events and tasks leading to the completion of a project can never be foretold with complete accuracy. Lock (2007) also indicates that there are many examples of projects which have exceeded their costs by enormous amounts, finished late or even being abandoned before completion, and that such failures are all too common. Similarly, Burtonshaw-Gunn (2009) states that the failure to deal effectively with risk can lead to significant cost overruns, schedule delays and the inability to achieve the desired project technical objectives.

According to Flanagan and Tate (1997) clients want certainty of price, projects constructed within budget and no surprises. Flanagan and Tate (1997) state that the budgeted cost determined at the pre-contract stage of any construction project forms the basis of the contract sum and it is the amount established for the project, which is not expected to be exceeded. Flanagan and Tate (1997) indicate that a contingency sum should be included in the cost budget to cover unforeseen items and all eventualities which can occur during the construction of a project. This should ensure the completion of all projects within the cost budget. However according to Winch (2010) and Walker (2002) evidences abound in construction management literature which indicate that it is very difficult to find a project in which the initial contract sum is not exceeded at completion. Similarly, Magnussen and Olsson (2005) state that studies of major projects show that cost overruns are not uncommon, Odeyinka (2000) state that this could be due to the risk factors inherent in construction. The overall aim of this study is to investigate how risk factors impact on the variability between the contract sum and final account on client-led and contractor-led design and build projects, with a view to developing predictive models that can help the construction contractors to evaluate the impacts of risks eventuating at project level on final account. This study is at the preliminary stage and the work done to date and the proposed future works are presented in this paper. Essentially, a two-fold objective is the subject of this paper. The first is to explore the existing body of knowledge and risk theories in order to position this present study in the existing body of knowledge. The second is to explore the methods for evaluating risk impacts on the variability between contract sum and final account in client-led and contractor-led design and build project.

DESIGN AND BUILD PROCUREMENT

Gidado and Arshi (2004) indicate that although there has been a continuous increase in the use of Design and Build (D&B) over the last 15 years, recent research suggests that contractors may lack proper understanding of managing the varying types of design processes and that it is not uncommon to observe communication breakdowns on D&B projects, as well as misinterpretation of client goals or wrong interpretation of design documents. According to Oztas and Okmen (2004), D&B has been rising in popularity due to the advantages in can provide in terms of project duration, project cost and innovative solutions of project problems. However, apart from these advantages, D&B can lead to being a risky contract system for both the owner and contractor unless the risks are identified in advance and managed throughout the entire project.

Table 1 shows the RICS Contracts in Use (RICS, 2010); the basis of which was a survey carried out in 2007 to determine the main procurement methods currently in use in the UK. The table shows the trends in procurement methods in the UK over a period of 22 years by value of contracts.

Table 1: Trends in Methods of Procurement – by value of contracts.

	1985 %	1987 %	1989 %	1991 %	1993 %	1995 %	1998 %	2001 %	2004 %	2007 %
Lump Sum – Firm BQ	59.3	52.1	52.3	48.3	41.6	43.7	28.4	20.3	23.6	13.2
Lump Sum – Spec & Drawings	10.2	17.7	10.2	7.0	8.3	12.2	10.0	20.2	10.7	18.2
Lump Sum – Design & Build	8.0	12.2	10.9	14.8	35.7	30.1	41.4	42.7	43.2	32.6
Target contracts	-	-	-	-	-	-	-	-	11.6	7.6
Remeasurement – Approx. BQ	5.4	3.4	3.6	2.5	4.1	2.4	1.7	2.8	2.5	2.0
Prime Cost Plus Fixed Fee	2.7	5.2	1.1	0.1	0.2	0.5	0.3	0.3	<0.1	0.2
Management Contract	14.4	9.4	15.0	7.9	6.2	6.9	10.4	2.3	0.8	1.0
Construction Management	-	-	6.9	19.4	3.9	4.2	7.7	9.6	0.9	9.6
Partnering Agreements	-	-	-	-	-	-	-	1.7	6.6	15.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: RICS Contracts in Use 2010

As can be seen from Table 1, there has been a dramatic decline in the use of Lump Sum contracts with quantities, from 59.3% of the total value of contracts in 1985 to just 13.2% of the total value in 2007. In contrast, the use of D&B contracts has greatly increased from just 8% of the total value of contracts in 1985 to 32.6% of the total value in 2007. D&B contracts are now used for a bigger value of contracts than any other type of contract, which makes D&B procurement a very important procurement route to concentrate on, especially with regards to risk in D&B projects. Most researchers are in agreement that although D&B procurement can offer some advantages over the traditional methods of procurement, it can turn out to be quite a risky procurement route unless there is appropriate planning and control. For example, Chritamara *et. al.* (2002) state that there are a number of common risks on D&B projects that should they interact with each other, can lead to time and cost overruns on the project.

Fig. 1 illustrates the 'speculative' risk to a client and contractor for specific procurement methods; speculative risk is that which can be apportioned in advance of the project as decided by the parties in the contract. As can be seen from Fig. 1, under D&B forms of procurement the risk lies predominantly with the contractor, however there is some difference between the two forms of D&B procurement, under client-led D&B the risk is more evenly proportioned between client and contractor than under contractor-led D&B.

Fig. 1: Risk Apportionment between Client and Contractor

Source: Davis *et. al.* (2008)

COST OVERRUN IN CONSTRUCTION

According to Le-Hoai *et. al.* (2008) time and cost are the two main concerns of construction management. There are many factors which relate to delay and cost overruns and vary along with types of project, locations, sizes, and scopes. McCaffer and Edum-Fotwe (2005) state that while construction has previously been happy to encourage the practice of budget uncertainty with the use of contingency, there is now evidence to suggest that major clients are demanding more cost certainty. Similarly, Davey (2000) argues that it is not uncommon to find that the final costs of projects grow beyond the proposed estimates at the start. To some degree, construction has come to consider this as inevitable, and so it is all too willing to accept this as the norm. Inevitably, there is a real problem with projects exceeding their contract sum, with this being the subject of many studies. According to Magnussen and Olsson (2005), studies of major projects show that cost overruns are not uncommon. Also in their study of large transportation infrastructure projects, Flyvbjerg *et. al.* (2002) discovered that 9 out of 10 projects fall victim to cost overruns, and on average, actual costs are 28% higher than the cost estimate, they conclude that it is a global phenomenon observed over a long period of time.

According to Yabuku and Ming Sun (2009), cost and time overrun of construction projects has consistently attracted the attention of construction professionals all around the world and the situation in the UK is no different, as there have been reports of projects overrunning cost and time. In their investigation into cost and time control of UK projects, Yakubu and Ming Sun (2009) conducted a survey on 150 construction consultancies and 100 construction companies and found that more than 50% of both contractors and consultants experienced a cost overrun on more than 10% of their projects.

Winch (2010) states that evidences throughout construction management literature indicate that it is very difficult to find a project in which the initial contract sum is not

exceeded at completion. Similarly, Magnussen and Olsson (2005) state that studies of major projects show that cost overruns are not uncommon, Odeyinka (2000) state that this could be due to the risk factors inherent in construction.

RISK IN CONSTRUCTION

Risk is present in all construction projects; this is reinforced by Latham 1994, who states

"No construction project is risk free. Risk can be managed, minimised, shared, transferred, or accepted. It cannot be ignored".

It is widely acknowledged that the construction industry is both more risky and uncertain than most other industries. This makes the subject of risk a very important factor to be considered in construction projects. It is the general consensus that when risks occur on construction projects it can have detrimental effects on the main project objectives of time, cost and quality (Burtonshaw-Gunn, (2009).

According to Winch (2010), there are four schools of thought on the relationship between risk and probability; Objectivist school; Logical school; Subjectivist school; and Behavioural school. Winch (2010) looks at a cognitive approach to risk, where the occurrence of any event is either certain, impossible or somewhere in between the two. Fig. 2 illustrates the cognitive theory of risk and makes a clear distinction between when a probability distribution can be assigned to the occurrence of an event and the condition where it is not possible to assign a probability distribution. This approach is divided up into four categories; known knowns – when a risk source has been identified and a probability can be assigned to the occurrence of a risk event; known unknowns - when a risk source has been identified but a probability cannot be assigned to the occurrence of a risk event; unknown knowns - when someone knows about the risk source and the associated probabilities but it is keeping the information private; and unknown unknowns - when a risk source has not been identified and therefore the risk event cannot be known. In contrast to this, Williams (1996) looks at risk as being two dimensional, and states that risk can be measured by the probability of risk occurrence and the impact of occurrence. Whilst William's (1996) view has been widely held in project management literature, it has not differentiated the various risk categories identified by the cognitive theory of risk (Winch, 2010).

Winch (2010) identified three aspects of risk– the probability of risk occurring, the extent of risk occurrence and the impact of the risk occurrence. Using William's (1996) two-dimensional nature of risk, the three aspects of risk can be measured in two different pairs;

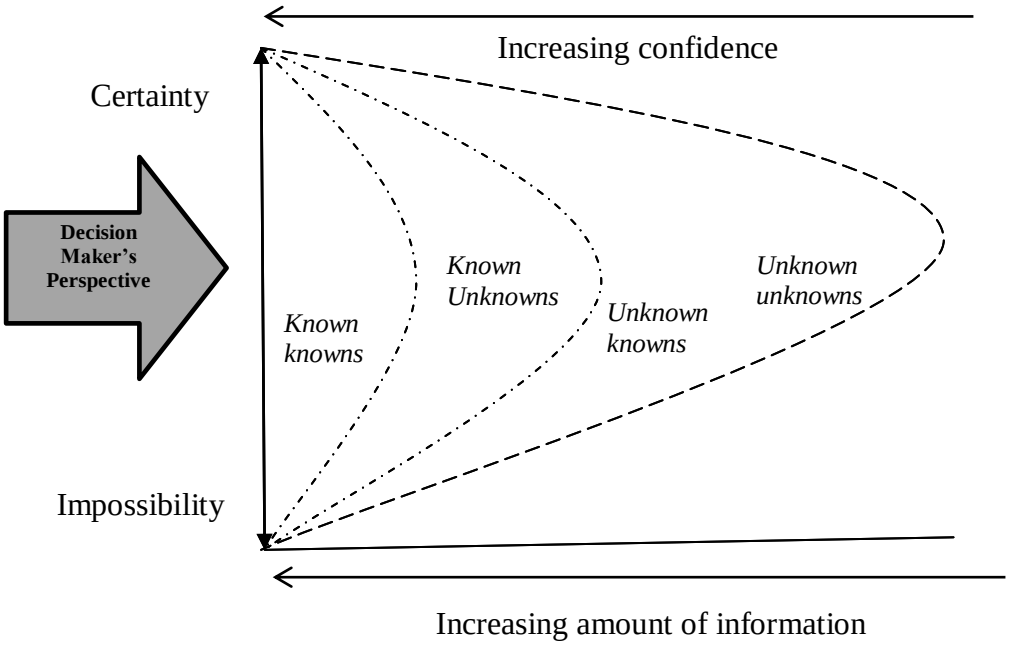
Probability of risk occurrence and the impact of occurrence (subjective)

Extent of risk occurrence and the impact of occurrence (objective)

Smith (2006) submits that combining the probability of risk occurrence with the impact of occurrence will help to determine the degree of risk. Whilst this approach has been adopted widely in dealing with risk in proposed projects, it is considered subjective (Winch, 2010). On the other hand, Smith (2006) considers combining extent of risk occurrence with the impact of occurrence to be based on prior knowledge, i.e. epistemic. This belongs to the objective school of thought which

attempts to predict future events from known data about risk sources; it is associated with the science of statistics and essentially looks at past projects where data is available.

Fig. 2: A Cognitive Model of Risk



Source: Winch 2010

OUTCOMES FROM THE REVIEW OF LITERATURE

It becomes evident from the review of the literature that the use of D&B procurement has been rising in popularity over the past number of years; it can provide advantages in terms of project duration, project cost and innovative solutions of project problems, however, it can lead to being a risky contract system for both the owner and contractor unless the risks are identified in advance and managed throughout the entire project. Fig. 1 illustrated the 'speculative' risk to a client and contractor for specific procurement methods; speculative risk is that which can be apportioned in advance of the project as decided by the parties in the contract. As can be seen from Fig. 1, under D&B forms of procurement the risk lies predominantly with the contractor, however there are some differences between the two forms of D&B procurement, under client-led D&B the risk is more evenly proportioned between client and contractor than under contractor-led D&B. This insight from the literature therefore suggests that a set of risk factors inherent in both client-led D&B and contractor-led D&B projects would need to be determined in taking the research forward.

Another important outcome of the review of literature on risk theory is the clarity provided by the cognitive theory of risk. The insight gained from the theory suggests that there are risk categories and that while some are not measurable, some are. This insight provided direction for positioning this study within the various risk categories. From the cognitive theory of risk, it becomes apparent that for any meaningful contribution to knowledge, this study will need to focus on the known category of risk. This is because this is the category of objective risk where probabilities can be assigned based on prior knowledge. This therefore defines the focus of this research

in the area of measuring objective risk with regards to the extent of risk occurrence and the impact of occurrence.

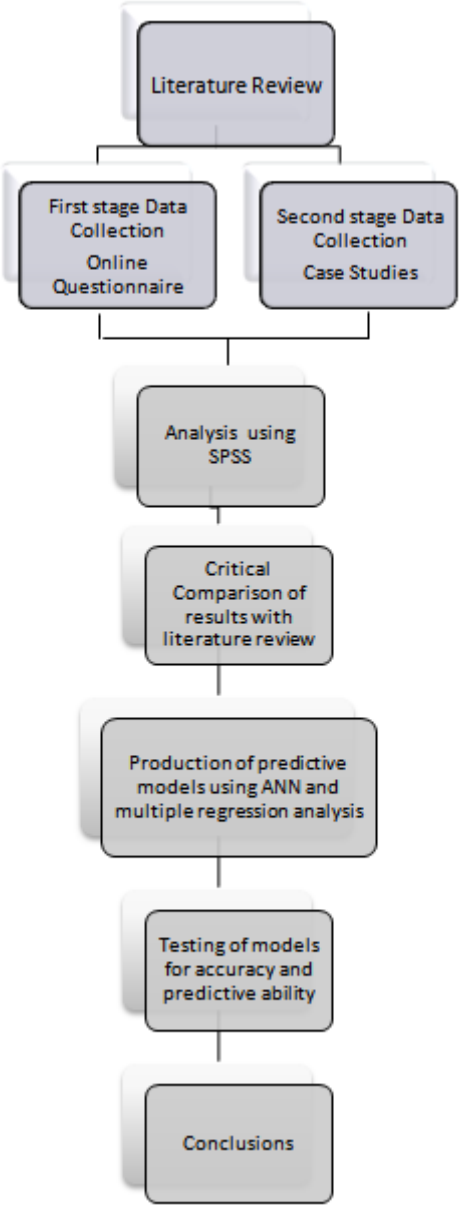
PROPOSED RESEARCH METHODS

Fig. 3 shows the proposed research methods. Following a detailed review of related literature, the primary data needed for the research will be gathered in two stages. Firstly a UK-wide online questionnaire survey will be administered to industry professionals. The questionnaire will seek to gather information on recently completed or on-going client-led and contractor-led D&B projects. The purpose of the questionnaire will be to gather information on the risk factors involved in these D&B projects. There will be a set of identified risk factors from construction management and economics literature which impact on the variability between contract sum and final account.

The data for the research will be obtained from professionals who have first-hand experience on completed D&B project with regards to the extent and impact of occurrence of risks on the project. Respondents will be asked to score on a Likert-type scale, the identified risk factors using two dimensional scaling of both the extent and the impact of occurrence on the selected project. This will involve an epistemic approach to risk as respondents will be expected to do their scoring based on their experience of past projects. From this information the significant risk factors that impact on the variability between contract sum and final account will be determined using mean ranking analysis. The significant risk factors identified will be used in the next stage of the research.

The next stage of the research will involve secondary data collection from case studies. The previous respondents will be asked to provide further information on some client-led or contractor-led D&B projects; other willing respondents will also be approached. This stage of data collection will concentrate on the significant risk factors identified in the first stage of data collection. A project-by-project approach to data collection will be adopted whereby comprehensive data regarding each case study project will be collected. Data from the case studies will be used to develop predictive models for assessing how complex risk factors combine to impact on the variability between the contract sum and out turn cost in client-led and contractor-led D&B projects. Models will be developed using multiple regression analyses and artificial neural networks. The developed models will be validated to determine their predictive ability and practical relevance to the construction contractor.

Fig. 3 Proposed Research Methods



CONCLUSION

As previously stated, two objectives were explored in the work reported in this paper. The first was to explore the existing body of knowledge and risk theories in order to position this present study in the existing body of knowledge. The second was to explore some methods for evaluating risk impacts on the variability between contract sum and final account in client-led and contractor-led D&B project.

From a detailed review of related literature, it can be concluded that the set of risk factors involved in client-led D&B projects will be different from those relevant to contractor-led D&B projects. As such, they will need to be treated separately. It can also be concluded that the cognitive approach to risk provides an insight into the direction of travel of this study. This approach divides risk into four categories; known knowns; known unknowns; unknown knowns; and unknown unknowns. The cognitive theory of risk helps to position this present study in the area of risks which are in the

known knowns category. This then suggests that objective risk would be the focal point of this study as opposed to the subjective risk.

The second conclusion from this preliminary study is that the proposed research methods help to clarify the issues involved at the different stages of data collection and risk measurement approaches that need to be considered. It also helps to clarify the data analysis methods that would be useful to accomplish this research as well as considering the appropriate modelling techniques.

FURTHER STUDY

The next stage of the study will be to identify the separate sets of risk factors inherent in both client-led and contractor-led D&B project in preparing for the empirical phase of the research. The primary data needed for the research will be gathered in two stages. Firstly a UK-wide online questionnaire survey will be administered to industry professionals to gather information on the risk factors involved in the two types of D&B projects. The second stage will involve secondary data collection from case studies. This stage will concentrate on the significant risk factors identified in the first stage of data collection. Data from the case studies will be used to develop predictive models for assessing how complex risk factors combine to impact on the variability between the contract sum and out turn cost in client-led and contractor-led D&B projects. Models will be developed using multiple regression analyses and artificial neural networks. The developed models will be validated to determine their predictive ability and practical relevance.

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FORECASTING CAPABILITY OF A CONSTRUCTION ORGANISATION MODEL: 10 YEARS LATER

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The overall financial performance of construction organisations in Malaysia depends on the level of construction activity in the national economy. This in turn is a function of the state of the national economy which is cyclical in nature with a return period of approximately 10 to 12 years. This research seeks to test the validity of an organisation model first developed in 2001. In addition, the model is tested for its performance forecasting capability by comparing the forecast result generated from the model against the organisation's actual financial performance over the most recent economic cycle. This study shows that the accuracy of the model's forecast is dependent on regular updating of the model. It is found that with regular updates of the model's internal and external variables to reflect the strategic changes in the organisation and the state of the economy, a model with good forecasting capability can be produced. The validated model can be used to test the impact of proposed new strategies on the organisation's financial performance.

Keywords: construction organisation, modelling, system dynamics, validation.

INTRODUCTION

In Malaysia, the construction industry has consistently contributed between 3% to 5% of the nation's total gross domestic product (GDP) and is one of the major movers of the national economy. The level of construction activity in Malaysia is determined by various factors such as the state of the economy and the government's initiatives mainly through the various economic development plans. The effect of the economy on the construction industry can be seen in the GDP growth pattern of the construction industry which tracks that of the country's economic cycle. The boom and bust cycle

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Tang Y.H; Lim P.G and Gan S.W (2012) Forecasting capability of a construction organisation model: 10 years later *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 347-356.

of the construction industry significantly affects the performance and survival of construction organisations in Malaysia particularly in periods of economic downturns.

Tang and Ogunlana (2003a) developed a system dynamics model to forecast the performance of a mid-range construction organisation subject to the effects of the economic cycles. The model (Figure 1) consists of five sectors representing aspects of the projects undertaken and the organisation's capability to deliver the projects successfully. The remaining four sectors deal with the financial aspects of the organisation particularly the impact of projects undertaken on the balance sheet. They also forecasted the performance of the organisation from 2001 to 2010 based on various proposed strategies (Tang and Ogunlana, 2003b).

Ten years (approximately the return period of the Malaysian economic cycle) has passed since the model was developed. This provides an excellent opportunity to compare the performance forecasted in 2001 against the actual performance of the organisation from 2001 to 2010. This study seeks to build confidence in the model as a tool for forecasting the performance of a construction organisation. In addition, this study also provides an understanding of the strategic changes in the organisation over the last decade and their impact on the organisation's financial performance.

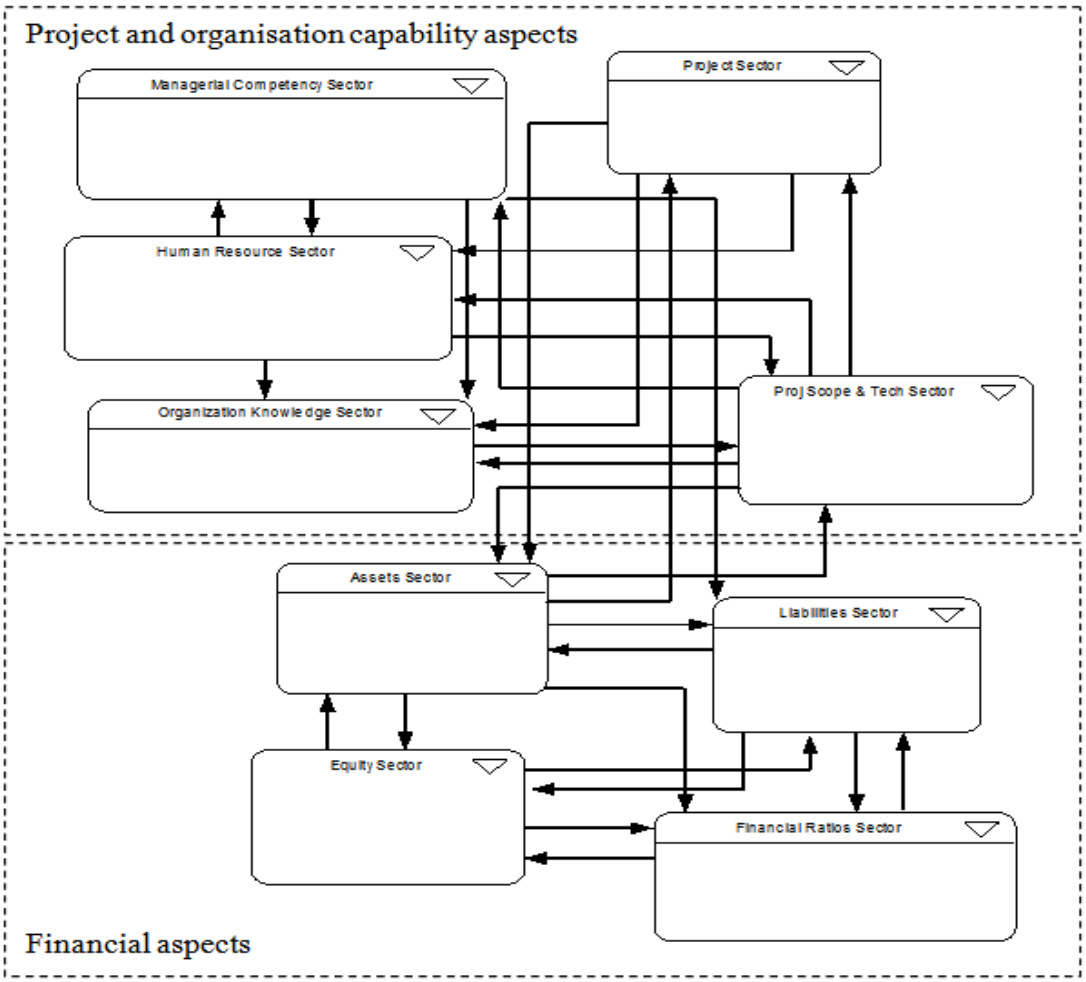


Figure 1: High Level Map of Organization Model

MODEL VALIDATION

Before testing a model's forecasting capability, the model has to be validated and this is an important element in system dynamics modelling. Generally, validity tests

consist of structural and behavioural tests. Firstly, it is crucial to establish that the model is structurally valid before proceeding to validate the system's behaviour. The purpose of a structural validity test is to determine the adequacy of the model's structure in representing the actual structure (Barlas, 1989). Qurat-Ullah (2005) showed that structural validity tests are the core of system dynamics modelling and have a temporal precedence over behaviour validity test. There are several tests used to structurally validate a system dynamic model, as described by Forrester and Senge (1979) such as boundary adequacy test, structural verification test, parameter verification test, dimensional consistency test, and extreme conditions test. In recent years, structural validation tests have been divided into direct structural tests and structure-oriented behavioural tests (Barlas, 1994). Once the confidence level from structural validation is achieved, behavioural tests are conducted to determine how accurately the model reproduces major behaviour patterns of the real system. If a model is built to a high confidence level structurally, and yet produces a weak behaviour pattern, it is an indication of a possible result of misrepresentation of some parameter values or exogenous input in the model.

Historical fit is one of the tests found to be important in building confidence in system dynamic models (Sterman, 1984). Forrester and Senge (1979) also showed several behavioural validation tests which include behaviour reproduction test, behaviour prediction test, behaviour anomaly test, family member test, surprise behaviour test, extreme policy test, boundary adequacy test as well as behaviour sensitivity test.

In this study, the main test used is the behavioural prediction test, i.e. the ability of the model to replicate the actual behaviour of the system. Sensitivity analysis is an important tool used to evaluate the reliability and robustness of the model output (Hekimoglu & Barlas, 2010). The importance of sensitivity analysis in system dynamics is prominent due to the presence of assumptions and uncertainty in the model. According to Forrester and Senge (1979), parameter sensitivity testing is capable of not only demonstrating the robustness of a model's behaviour but also an important test in policy testing.

RESEARCH OBJECTIVE AND METHODOLOGY

This study is a continuation of Tang and Ogunlana's (2003a & 2003b) earlier work on the modelling of a construction organisation's dynamic performance under cyclic economic conditions. The main aim of this study is to determine the reliability of the system dynamics model as a forecasting tool in predicting organisational financial performance. The "classic system dynamics method" discussed by Saeed (1995) is adopted in this study. In addition, the construction organisation model used in this study is adapted from Tang and Ogunlana's model.

Using the empirical evidence which consists of a collection of historical data from the construction market and the construction organisation particularly through the organisation's annual reports over the period between 2001 and 2010, a reference mode as represented by the financial performance of the company and the economy can be formulated to validate the model. The causal relation of key elements in the construction organisation is then modelled as the dynamic hypothesis. Figure 2 shows the causal loop diagram for the organisation's financial balance sheet which forms one of the feedback diagrams in this model. Subsequently, this is converted into a formal model using a system dynamics software called STELLA Research which is then tested and validated for its confidence level by comparing the result obtained from the model against the reference mode. If the model fails the validity tests, the dynamic

hypothesis is rechecked and changes are made to the model. This is a iterative process until the model is validated.

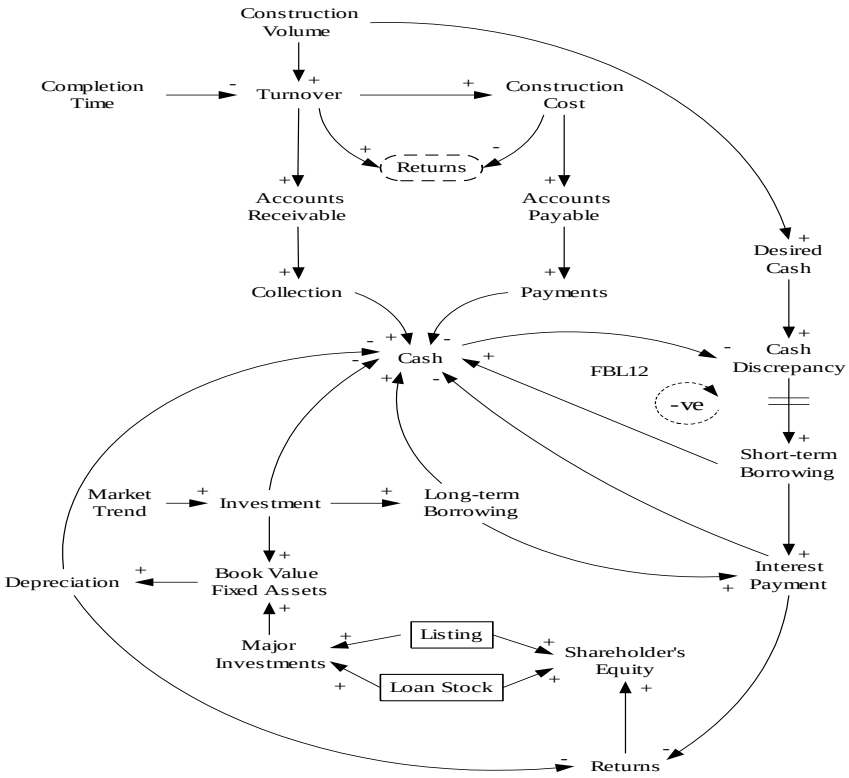
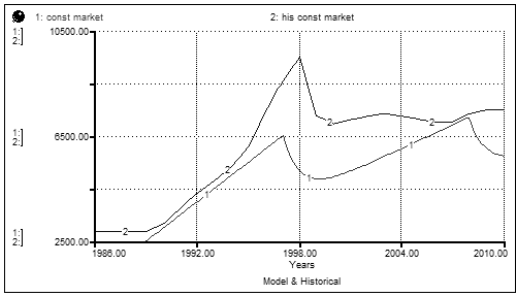


Figure 2: Financial Balance Sheet Feedback Loop Diagram

The model's structural validity was tested by using tests proposed by Qurat-Ullah (2005) and Forrester and Senge (1979). However the extreme condition testing was not carried out, as it is similar to the sensitivity analysis carried out in the later part of this study. Since the model simulated displayed a transient and highly non-stationary behaviour with sudden boom and bust pattern, it was not practical to use statistical tools to perform behavioural validation. Therefore graphical/visual measure was adapted to validate the model. The behaviour reproduction test recommended by Forrester & Senge (1979) was principally used to validate the model. Results generated from the simulated run of the original model are tested against data collected from historical data or the reference mode using the graphical/visual method.

ORIGINAL MODEL FORECASTING PERFORMANCE

Figure 3 and 4 graphically display the model forecast of the construction market and market trend of the original model compared with data from 2001 to 2010. The data showed a timeline from the years 1988 to 2010 with the time frame of 2000 until 2010 being the forecasted market. Visual inspection of the graphs indicate that the original model had underestimated the growth of the construction market. However, the market trend shows a similar pattern when compared to the historical data. This indicate that even though the forecasted performance of the construction market is lower than that of the actual construction market, it displays a similar pattern of between 10 to 11 year economic cycle as postulated by Tang and Ogunlana (2003a).



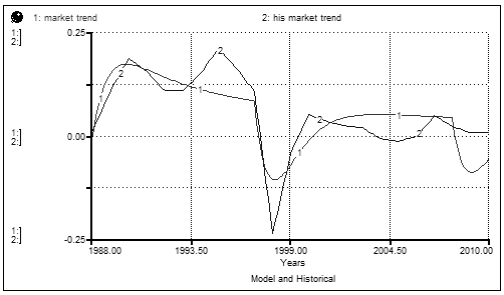


Figure 3: Construction Market *Figure 4: Construction Market Trend*

Due to the underestimation of the size of construction market, the behaviour of the annual turnover, net profit after tax and total asset showed large discrepancies when compared to the historical data. Consequently, a large difference in magnitude and direction of change in the behaviour is observed in the financial ratios used to measure the organisation's performance. Based on the visual evaluation of the results, it shows that without any model update, the model do not produce a good behavioural fix. This can be observed from the high discrepancies in behavioural pattern and amplitude of key variables which suggest that confidence level for the forecast model is low. The six financial ratios used to measure performance did not perform well in the behavioural validity test except for return on equity and return on total asset with marginally acceptable results. This is expected as ten years is too long a period for forecasting to be carried out accurately, due to the many external and internal variables affecting the construction environment and the construction organisation respectively. All the unforeseen changes in these variables make long-term forecasting difficult.

MODEL ADJUSTMENT AND UPDATES

Adjustments and updates are made to the original model to better reflect the external and internal changes that affect the organisation over the past 10 years. The model is updated with the actual market conditions from 2001 to 2010 and organisation strategic changes identified from reviewing the organisation's annual reports spanning the same duration. These include:

Actual construction market condition

The main external factor affecting the organisation performance is the state of the construction market which is a function of the overall national economy. From historical data, the construction market is at approximately RM2 billion for the year 1988 and remained at a steady state. The construction market was originally simulated in Tang and Ogunlana's model to grow at a constant rate of twenty five percent annually with a slump of forty percent in 1997 due to the Asian financial crisis and another slump forecasted around 2007, which incidentally coincide the global financial crisis in 2008. However, the actual growth in subsequent years after 1997 was stronger than forecasted partly due to the development of Putrajaya as the new administrative centre. Other major exogenous factors affecting the construction market in the last decade were the 9/11 incident in 2001, the oil inflation in 2005 and the sub-prime crisis during 2008 which caused the construction market to contract by ten percent during each major slowdown. The model is updated by making the necessary changes to construction market converter (P1) as shown in Figure 5.

Regional expansion

The organisation expanded their project scope overseas and secured a project in Thailand in 2006 with the value of RM100 million. This is represented by regional

market converter (P2) in Figure 5. The expansion of construction work to the regional market increases the level of complexity faced by the organisation. This is in line with the recommendation given by Tang and Ogunlana (2003b) which suggested this strategy as a means of reducing the risk of exposure to Malaysia's economic cycle.

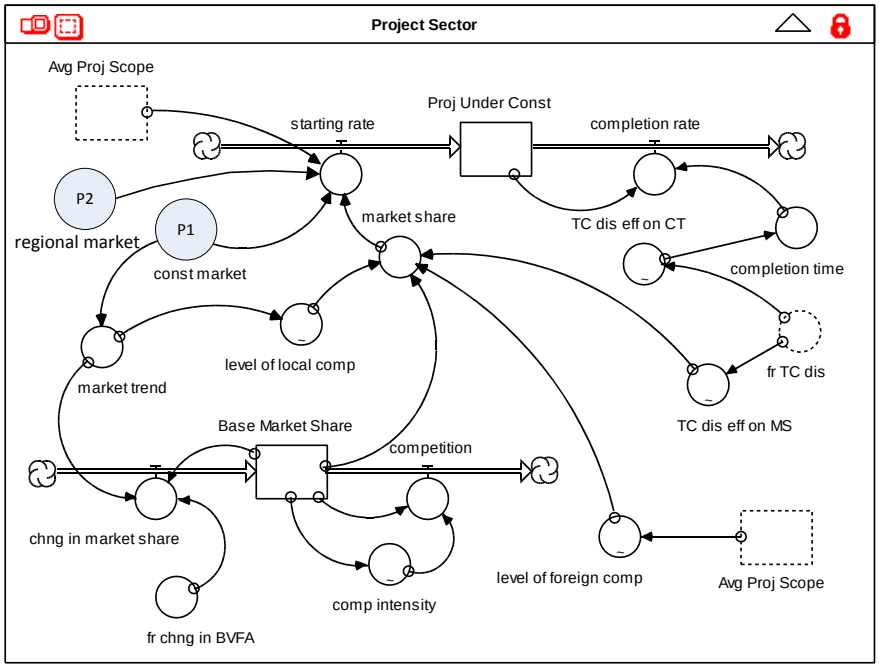


Figure 5: Updated Project Sector

Issuance of Bonds

In the year 2002, RM62 million worth of ABBA bonds were issued by the construction organisation which matured in mid-2008. This increased the level of total liability in the organisation. This is a strategic decision of the organisation to increase its financial capability.

Effect of technical capability discrepancy on project scope

One major adjustment to the original model is on the relationship between the organisation's technical capability and the project scope. Initially, it is suggested that the lack of technical capability would limit the organisation's ability to take on larger scale projects. However, the revalidated model shows that project scope actually grew despite the lack of organisation capability. This suggests that the size of projects undertaken by the organisation is not constrained by its technical capability. This issue will be discussed further as part of the research findings.

VALIDATION OF UPDATED MODEL

The updated model of the construction organisation is retested for its validity through structural and behavioural validations. The structural validation test is conducted based on the methodology discussed earlier. No illogical parameters or equation is found present in the model. Furthermore, boundary conditions as well as parameters of the model are satisfied. This demonstrates that the model is valid structurally with acceptable confidence level.

The updated model successfully simulated the construction market and the market trend in that it displays almost identical behaviour to the actual market conditions. The annual turnover and net profit after tax displayed patterns and behaviours similar to

the real system. However, both the modelled graphs showed a slightly higher magnitude. The total asset and shareholder's fund graphs demonstrate good resemblance to the historical data with minimal deviations. The financial ratios are represented by Figure 6 to Figure 11 which demonstrate good behavioural similarity to the actual system. However, Figure 8 and Figure 9 which represent the efficiency ratios showed the model's lack of ability to duplicate the erratic changes in the historical data. Minor variances in the graphical result throughout can be caused by random occurrences as well as time deviation in reporting the financial activities of the construction organisation. Reproduction of sudden fluctuation in the time series variables also appear to be difficult as system dynamics models produce a more gradual increment and decrement.

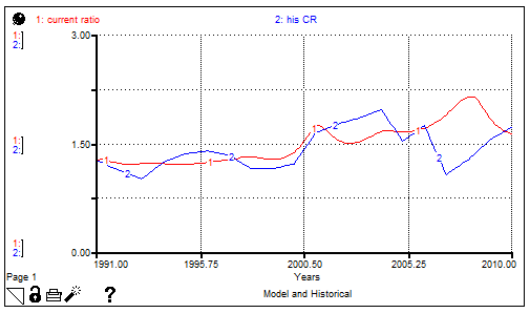


Figure 6: Current Ratio

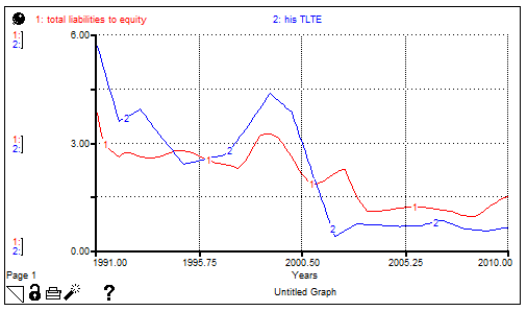


Figure 7: Total Liabilities to Equity

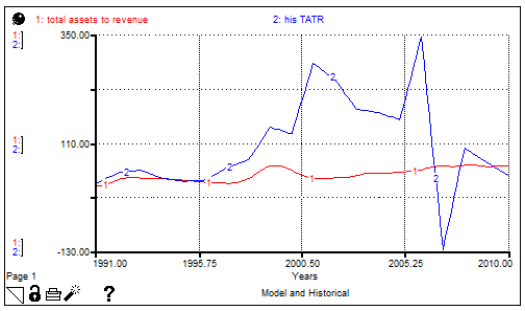


Figure 8: Total Assets to Revenue

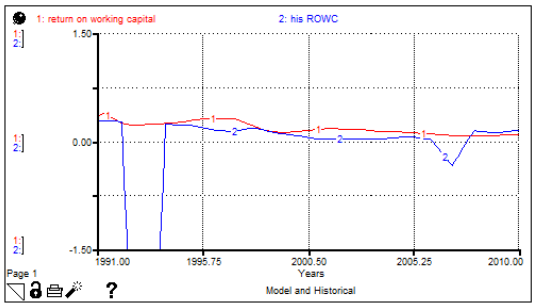


Figure 9: Return on Working Capital

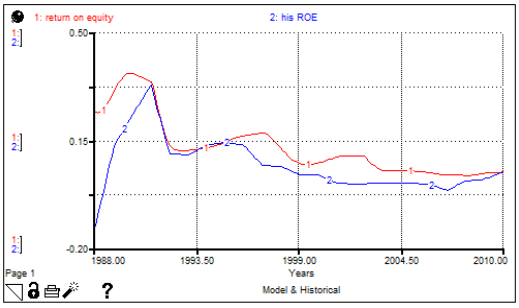


Figure 10: Updated Return on Equity

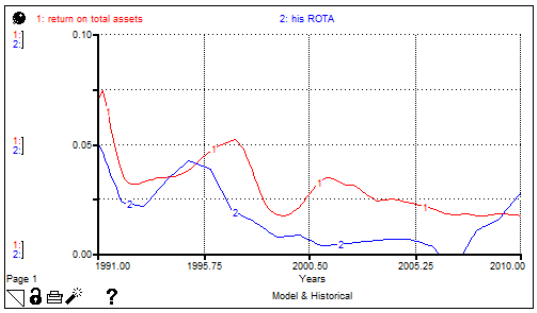


Figure 11: Updated Return on Total Asset

In summary, the key variables in the model such as construction market, construction market trend, annual turnover, total asset and shareholder's fund demonstrated similar behavioural pattern when compared with actual historical data. The six financial ratios used to measure the organisation's performance are reasonably capable of emulating the actual system, with the exception of the efficiency ratios. Generally the behavioural validity test validates the model with a good level of confidence. The results obtained from the sensitivity analysis of stock and converters indicate that parameters with high sensitivity are fraction rolling fund, project under construction

and time to train. Other sensitive parameters are technical capabilities discrepancy effect on completion time, project scope and market share. The results of the sensitivity analysis demonstrate the robustness of the model. Moreover, all the variables with high sensitivity can be used as important leverage points for the formulation and design of improvement policies.

MAIN FINDINGS

Firstly, even though the system dynamics model is capable of reasonably replicating real life dynamic behaviour of the construction organisation, unforeseen and unpredicted variables make forecasting long-term behaviour of a construction organisation difficult. This study demonstrates that using system dynamics for performance forecasting has its limitations. Good understanding of the construction industry and the construction organisation is needed in formulating a good model. However, it is found that with updates of the external and internal variables of the organisation, a model with fairly good confidence can be produced. This suggests that with periodical updates to reflect internal strategic changes as well as changes in the external environment, a good forecasting model can be developed. It should be noted that long term forecasting is fraught with high levels of uncertainty which make accurate modelling difficult. Therefore, a shorter forecasting horizon is strongly recommended. It is recommended that the model should only be used for testing medium term strategies where the construction market can be forecasted more accurately.

Secondly, the lack of technical capabilities within does not limit the organisation's ability to take on projects of greater complexity. Instead, financial capability is the main determinant in the selection of projects undertaken by the organisation. The lack of technical capabilities could however affect the expansion of an average project size, due likely to an increase in reworks or variation orders. The lack of technical capabilities is a growing problem in the industry. Ibrahim *et al.* (2010)'s study of the Malaysian construction industry showed that there is a shortage of technical, managerial and skilled personnel in the country and therefore identified human resources as one of the key challenges faced by the industry. Workers need to be trained in order become competitive and capable, as well as to enhance operational performance. Similarly, Tabassi and Abu Bakar (2009) found that with proper human resource management, low quality construction, additional project cost and projects delay could be minimised. This finding challenges the dynamic hypothesis of the original model which states that the level of technical capabilities in a construction organisation limits the size of projects undertaken. Such findings are not unusual as the process of model building often results in the organisation learning about the flaws in their earlier assumptions. (Senge, 1990)

Thirdly, the expansion of the organisation to Thailand in 2006 provided an additional income stream for the construction organisation that helped mitigate against the economy downturn in 2008. Managing construction projects in foreign country increases operations complexity and cost due to the distance and the difference in both culture and practice. Overseas project are generally more risky (Zhi, 1995). However, this study suggests that contracting overseas project could be a strategic move for local construction organisations to mitigate against the risk of downturn in the national economy and by extension the national construction market.

CONCLUSIONS

The construction industry is a very competitive industry and during recent years, the construction industry in Malaysia has been in a slump and this has negatively affected many construction organisations. Therefore it is important for construction organisations to improve their performance and competitiveness to survive periods of economic downturn. Tang and Ogunlana (2003b) demonstrated how system dynamics model of organisations could be used to help its senior management test the impact of proposed new strategies such as implementing new management information system, adopting a new quality system or expansion to regional market, on the organisation's financial performance subject to the impacts of the economic cycle. However, this is dependent on the capability of the model to forecast future performance. Ten years or one economic cycle has passed since the model was first developed and the historical data available was used to test the validity of the model and its capability to forecast future performance by comparing the organisation's actual performance with the model's forecast. The study shows that with regular updates of the organisation's internal variables and external market variables, a model with good short to medium term forecasting capability can be produced. The validated model can be used to test the impact of proposed new strategies on the organisation financial performance.

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DECISION-MAKING IN FAÇADE SELECTION FOR MULTI-STOREY BUILDINGS

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The design and construction of multi-storey buildings faces a multitude of demands such as aesthetics, cost, energy efficiency, and occupier comfort; with façades on both new and re-used buildings playing a key role in helping to meet these demands. The process of façade selection is aided by a plethora of decision-making tools, yet façade decisions are often largely guided by cost and aesthetics. Poorly specified façades can potentially expose developers, owners and occupiers of multi-storey buildings to risks such as poor thermal comfort, glare, and increased operational costs. The aim of this paper is to explore the current state of façade decision-making, with the objectives of discovering who is making the decisions and when, and what problems are perceived and what potential solutions might exist. Literature pertaining to façades, multi-storey buildings and façade decision-making is reviewed. Experience of façade decision-making in today's construction industry in the UK is collected via semi-structured interviews with construction professionals. The findings show architects as leading the initial façade decisions, with clients and planners making the final decisions. Very few decision-making tools were revealed as being used: namely whole life cost analysis, life cycle cost analysis and simulation. Further research is proposed to define the roles participating in façade decision-making for multi-storey buildings.

Keywords: building façade, decision-making, multi-storey building.

INTRODUCTION

This paper presents the initial findings of an exploratory study, conducted at the start of a larger research project that aims to provide decision support to the construction industry in the selection of façades for multi-storey buildings. The building façade is an outward facing component that has developed from being essentially protective, i.e. to shelter man from the elements, to playing also a key role in the architectural expression of buildings (Schittich 2006). In current building practice, façade selection appears to be largely driven by cost considerations and building aesthetics (Høseggen *et al.* 2008; Săparauskas *et al.* 2011). However, given the many demands on buildings, this approach can expose businesses and building occupants to risk. Buildings have to meet increasingly stringent requirements in terms of reducing carbon emissions, enabling high comfort and productivity of occupants, while also providing good return on investment; these requirements exist throughout the new and re-used life of a

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

building. Meeting these requirements together is a complex task. People spend around 90% of their time indoors (BRE 2011) engaged in varying activities and in varying locales, meaning that buildings need to respond dynamically to changes in occupation and environmental load (Wigginton and Harris 2002). While façades exist on all buildings, this paper focuses only on multi-storey buildings, for which the term 'multi-storey' is used to denote any building containing two or more storeys above ground level. The focus on multi-storey buildings, as opposed to single storey buildings, is because of their increasing prominence due to the global trend towards urbanisation (Wang *et al.* 2012; Tang and Yiu 2010). Façade decision-making involves multiple participants, including: "client, design team, main contractor, specialist sub-contractors, and manufacturers" (Du and Ledbetter 2006: 1). Reaching a consensus in multidisciplinary teams can be very difficult (Šaparauskas *et al.* 2011), yet literature relating to façade decision-making appears to pertain more to building simulation (Høseggen *et al.* 2008; Stec *et al.* 2005) or multi-criteria analysis (Šaparauskas *et al.* 2011), as opposed to investigating the human element. Where it does focus on participants in decision-making in design and construction, much of its focus is on the architect (Emmitt and Heaton 2003; Luck and McDonnell 2005). This paper aims to help address this gap in the knowledge by providing an insight into façade decision-making in today's construction industry. The objectives of this paper are to:

1. Establish who makes façade decisions for multi-storey buildings, and when;
2. Identify the problems perceived with façade decision-making;
3. Explore the potential solutions to the problems in façade decision-making.

BUILDING FAÇADES

The façade is an outward facing building component that has developed from being essentially protective, i.e. to shelter man from the elements, to playing also a key role in the architectural expression of buildings (Schittich 2006). It is further defined by BS6100-1:2004 (BSI 2004: 33) as being the exterior surface of a wall enclosing a building, which is usually non-loadbearing, and which can include a curtain wall, cladding or some other exterior finish. Façades often have protective or insulating cladding attached to them, with the cladding sector accounting for a substantial proportion of UK external wall construction (Doran and Anderson 2011: 1).

Buildings have to meet increasingly stringent requirements in terms of reducing carbon emissions, enabling high comfort and productivity of occupants, while also providing a good return on investment. Du and Ledbetter (2006: 1) succinctly describe the part that façades can play in helping to meet these requirements, showing clearly the multi-factorial contribution that just one element must make in helping to meet the overall demands placed on a building (Figure 1). These demands differ according to world view of an observer. From an occupiers view point, warmth and air quality are highly important (Humphreys 2005), as is user control (Stevens 2001). When architects, designers and builders consider the needs of building users at an early stage, it can lead to improved comfort, energy efficiency, and health and safety in buildings (Săparauskas *et al.* 2011). However, certain aspects of building performance can sometimes be reprioritised in the face of other drivers. The building client wants a good return on investment; therefore, as the façade can account for up to 25% (Layzell and Ledbetter 1998: 351) and sometimes even up to 40% of a total building's cost (Hall, 1997, in Wigginton and Harris 2002: 5), façade selection can often result in being cost-driven (Høseggen *et al.* 2008; Rosenfeld and Shohet 1999).

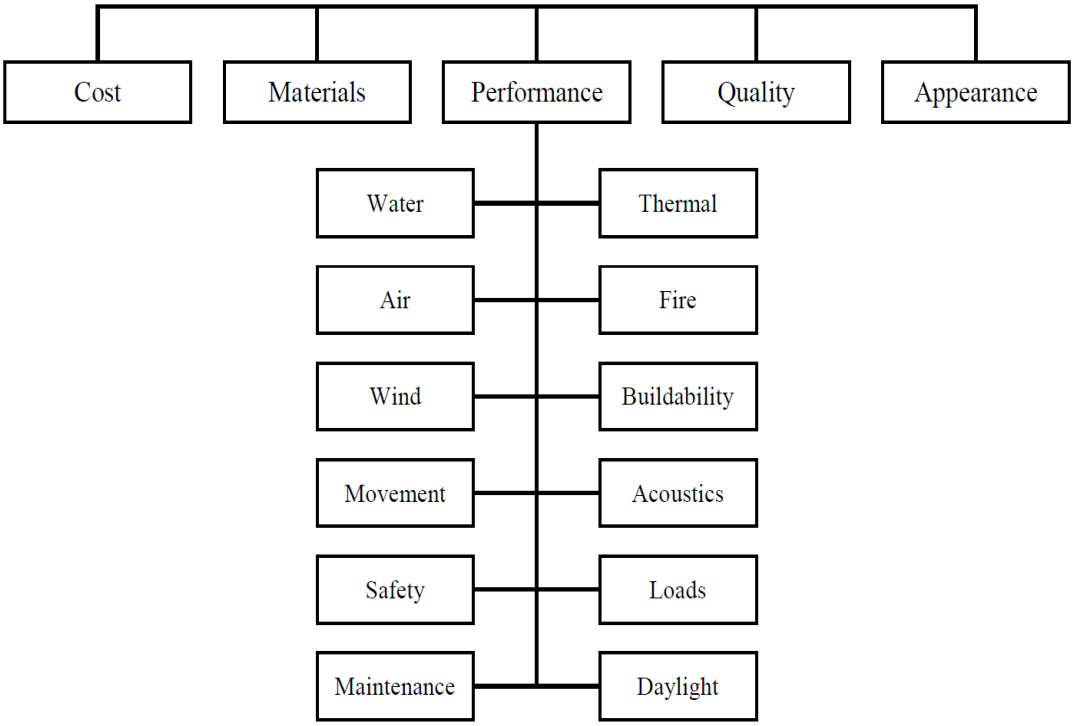

Figure 1: The ingredients of cladding design (reproduced from Du and Ledbetter 2006: 1)

FAÇADES ON MULTI-STOREY BUILDINGS

Multi-storey buildings are required to meet certain statutory drivers, such as building regulations, of which many also apply to single-storey buildings. However, due to the potential height of multi-storey buildings, these statutory drivers often contain stricter elements solely for use on multi-storey buildings. For example, a proposed new dwelling building that is over 18m in height and located in England and Wales, may need to supplement the fire safety requirements of 'Approved Document (AD) B - Volume 1 - Dwellinghouses', with some of the guidance contained in 'AD B - Volume 2 - Buildings other than dwellinghouses'. Volume 2 states that "in a building with a storey 18m or more above ground level any insulation product, filler material (not including gaskets, sealants and similar) etc. used in the external wall construction should be of limited combustibility" (HM Government 2006: 94). The use of limited combustibility material is required "because of the increased risks associated with external flame spread on buildings of this size" and thus cladding must pass the testing criteria in British Standard 8414 in order to demonstrate compliance with AD B (Baker 2012). This requirement applies to façades on both new and re-used buildings, the latter of which is felt to be an under researched area, despite being a significant proportion of the European building stock (Zavadskas *et al.* 2008). Multi-storey buildings comprise thirteen per cent, and over one-third, of the existing building stock, in the old EU member states, and in the new Central and Eastern European member states, respectively; the majority of which has poor structural and thermal quality (Zavadskas *et al.* 2008). Furthermore, as “it is estimated that by 2050 two thirds of the UK’s housing stock will be made up of dwellings built before 2006” (Business Link 2011), the refurbishment of existing high-rise (EST 2006) residential buildings is seen as a necessary part of improving the energy efficiency of the UK housing stock.

BUILDING FAÇADE DECISION-MAKING

Numerous methods exist that can aid façade decision-making. These include multi-criteria analysis (Šaparauskas *et al.* 2011); building simulation (Høseggen *et al.* 2008; Stec *et al.* 2005); life cycle analysis (Radhi 2010); and bespoke façade selection software (Chartered Institution of Building Services Engineers (CIBSE) Façade Selector (CIBSE 2004); Environmental façade design tool (Robinson-Gayle and Tanno 2004)). Despite using such tools, decisions are shown in the literature as sometimes being 'disadvantageously' over-turned by human intervention in the final stage. This is demonstrated in Høseggen *et al.* (2008) where the most environmental façade option (derived using building energy simulation ESR-r) was not selected on grounds of cost; and in Rosenfeld and Shohet (1999: 510) when after conducting a building refurbishment exercise (using semi-automated selection), it was declared that "if the budget is really tight, the decision-makers may decide consciously to choose alternative #2, which requires the lowest initial investment despite its short life (5 years), poor service, high equivalent annual cost, and high uncertainty". Reaching a consensus in a multidisciplinary team is known to be very difficult (Šaparauskas *et al.* 2011). Where the literature focuses on the participants involved in decision-making in design and construction (as opposed to the decision-making aids) much of the research appears to focus on the architect, e.g. Emmitt and Heaton (2003) conducted an observational review of specifiers in the face of a new edition of Part L; while Luck and McDonnell (2005) investigated architect and user interactions. Research into the interaction that occurs between all participants involved in façade selection appears to be minimal, with perhaps the exception of Du and Ledbetter's (2006) research into decision-making in the cladding supply chain.

METHODOLOGY

In order to produce robust results that are of benefit to the construction industry, this exploratory study is being used to discover the state of façade decision-making in today's construction industry in the UK (Davis 2006). The exploratory study uses semi-structured interviews, containing ten questions in two parts; the first part (questions 1-4) asks about the interviewees' role in construction, while the second part (questions 5-10) asks about the interviewees' experiences in façade decision-making. To determine when façade decisions are being made, one question asks at what stage of The Royal Institute of British Architects (RIBA) Outline Plan of Work the interviewees generally observed decisions as being made. The Outline Plan of Work is comprised of the following stages: A - Appraisal; B - Design Brief; C - Concept; D - Design Development; E - Technical Design; F - Product Information; G - Tender Documentation; H - Tender Action; J - Mobilisation; K - Construction to Practical Completion; and L - Post Practical Completion (RIBA 2009). Despite the varied construction roles being interviewed, the RIBA Outline Plan of Work was used, as it is "the most widely used model of building design" (Austin *et al.* 1999: 281).

Semi-structured interviews were adopted for the exploratory study, as it was deemed important to know the interviewees' opinions, as they could reveal aspects of the decision-making process that might benefit from further study (Bryman 2012). A semi-structured approach, also allowed the necessary "latitude to ask further questions in response to what are seen as significant replies" (Bryman 2012: 212). The interviews were mainly conducted face-to-face, but were also carried out as telephone interviews when this was more convenient for the interviewee. The interviews were recorded when permitted by the interviewee, or extensive notes taken, if recording

was not permitted. All of the interview recordings were transcribed. The interview sample group was created with the purpose of capturing the opinions of construction professionals, who were deemed commonly involved in construction and thus, highly likely to be exposed to the intricacies of façade selection. The term ‘construction professional’ was used to denote that the interviewee was in receipt of some form of membership with one or more construction professional body, e.g. Chartered Institute of Building, Royal Institution of Chartered Surveyors. The construction professionals were categorised to ensure that all expected key areas concerning façade decision-making were captured. BS6100-1:2004 (BSI 2004: 74-75), which describes the persons involved in construction projects (user, operative, client, contractor, manufacturer, supplier, specifier, and consultant) was used to guide the interviewee categorization for this study. Further guidance was taken from Du and Ledbetter (2006: 1) who describe the participants in the cladding supply chain: "client, design team, main contractor, specialist sub-contractors, and manufacturers". The interviewees for this exploratory study are therefore grouped into six categories: client; design team; consultant; contractor; building control; and façade specialist and supplier. The method used to obtain the interviewees reflects purposive sampling (Robson 2011), as specific individuals were contacted and invited to participate in the study. The method also reflects an element of convenience, as some interviewees were already available to the researcher, while some further interviewees were proposed by interviewees taking part in the study. Convenience sampling is however, an acceptable method of sampling, when "getting a feeling for the issues involved" is the chief aim of the exploratory study (Robson 2011: 275), and this study's learnings should be of a suitable nature to guide the main study methodology for the larger study in question.

The semi-structured interviews, which were used to aid discovery in this exploratory study, resulted in a qualitative data set (Davis 2006), which was analysed by coding to a thematic framework. These findings were combined with the literature review to produce a rich picture of façade decision-making. The data set size is a limitation of this study. While theoretical saturation is stated in research methodology literature as being difficult to define (Bryman 2012; Robson 2011) it is however, unlikely that this sample group (itself split into six separate smaller groups) has reached saturation. Further exploratory work is proposed, ideally to the point that no new information is being added to the data set (Robson 2011), though as each building project is likely to be unique, the difficulty of this goal is recognised. A second limitation relates to the observations as to when façade decision-making occurs within the RIBA Outline Plan of Work. These observations are based on the interviewees' general building experience (so are not for specific buildings) and, therefore, while they can be considered as indicative, they cannot be used to draw definite conclusions as to the points at which decision-making might occur in a project. Future work could involve recording façade decisions for specific buildings throughout the project life. Despite its limitations, this study's findings are valid in their own right as they provide an insight into façade decision-making in today's construction industry, and thus, will aid in the generation of theory for the larger study in question (Davis 2006).

RESULTS AND DISCUSSION

Interviewee sample group information

Thirteen semi-structured interviews were conducted with personnel involved in façade selection, which were categorised by the following roles: client (2), design team (2), consultant (4), building control (1), contractor (2), and façade specialist and supplier

(2). Ten interviews were conducted face-to-face, while three were conducted by telephone. Eleven interviewees met this paper's definition of a 'construction professional'. The two interviewees within the 'façade specialist and supplier' category, which did not possess membership to a construction professional body, were however retained in this study's main data set, due to their clear role in the cladding supply chain (Du and Ledbetter 2006). The interviewees' experience related to buildings in the UK. The interviewees' general experience according to building type, height in metres (m) and number (no.) of storeys, is shown in Table 1.

Table 1: Interview sample group experience: building type, height and number of storeys

Role	Position	Building type	Height (m)	Storeys (no.)
Client	Head of Estates Operations	C	≤ 30	4-8
Client	Energy and Environmental Manager	C	≤ 30	4-8
Design team	Chartered Architect	R	5-8	2-3
Design team	Senior Architectural Technologist	R&C	≤ 100	≤ 23
Consultant	Learning and Development Manager / Project Manager	C	≥ 28	≥ 8
Consultant	Chairman - Europe, Middle East and Africa	C	75-100	≤ 26
Consultant	Project Manager	R	≤ 48	2-20
Consultant	Regional Director	R&C	9-12	3-4
Building control	Principal Building Control Surveyor	R&C	≤ 18	2-4
Contractor	Director	R	12	4
Contractor	Senior Project Manager	R&C	≤ 72	3-24
Façade specialist and supplier	Senior Sales Executive	R&C	4.8	2
Façade specialist and supplier	Director of Business Development	R&C	7-70	3-18

Building type: R = residential; C = commercial (e.g. denoting one or more of the following: education, office, retail, health, stadia, hotels); R&C = residential and commercial.

How the façade decisions are being made and the influential roles

When asked about how the decision-making was carried out, the interviewees made little mention of decision-making tools. Two interviewees: client (1), and façade specialist and supplier (1), mentioned whole life cost analysis, while one consultant mentioned life-cycle cost analysis in relation to the decisions made by owner-occupiers. Another consultant mentioned simulation software in relation to assessing façade designs with the purpose of trying to influence the client to increase the level of insulation. A few of the interviewees felt that the construction industry is changing and that the days when the architect was at the top are long gone. For some, the change was perceived to be a good thing, while for others, the reduction in project structure and in the quality of materials is considered to be a non-beneficial result of new methods of procurement, i.e. design and build. Despite comments about the changing industry, the interviewees still generally considered that architects were responsible for the initial façade decisions (reflecting the tendency for design and construction research to focus on the architect). Some interviewees (consultants, and façade specialists and suppliers) felt that they had no direct involvement in the façade decision-making, but tried to influence decisions where possible. The contractors try

to make façade decisions at a later stage (post-tender), if possible, for the purpose of achieving cost and time reductions in the overall build. The client and the planning officer are seen as having the most say in façade decision-making, with the planning officer appearing to play a very 'commanding role', in which the interviewees opinion differed. Most of the interviewees expressed frustration at the time scales involved in the planning process, while two interviewees' responses were clearly divergent. One interviewee perceived that planners lack experience and knowledge in key areas such as material longevity, yet have inordinate power to block façade proposals made by experienced architects. Conversely, the other interviewee felt that planners should not act any differently to how they already do, as it was perceived to be correct that they work to preserve the integrity of a geographical area. The number of different roles participating in façade decision-making, in just this small sample alone, suggests that the 'traditional' project roles described in BS6100-1:2004 (BSI 2004: 74-75) should be amended to enable it to better reflect the complexity of today's construction industry.

When the façade decisions are being made

To investigate when façade decisions are generally being made, the interview sample group were asked to state, at which stages in the RIBA Outline Plan of Work, they had observed façade decisions taking place. These observations reflect the interviewees' general building experience and therefore, are only indicative in nature. Eleven interviewees responded with a total of 29 observations (Figure 2).

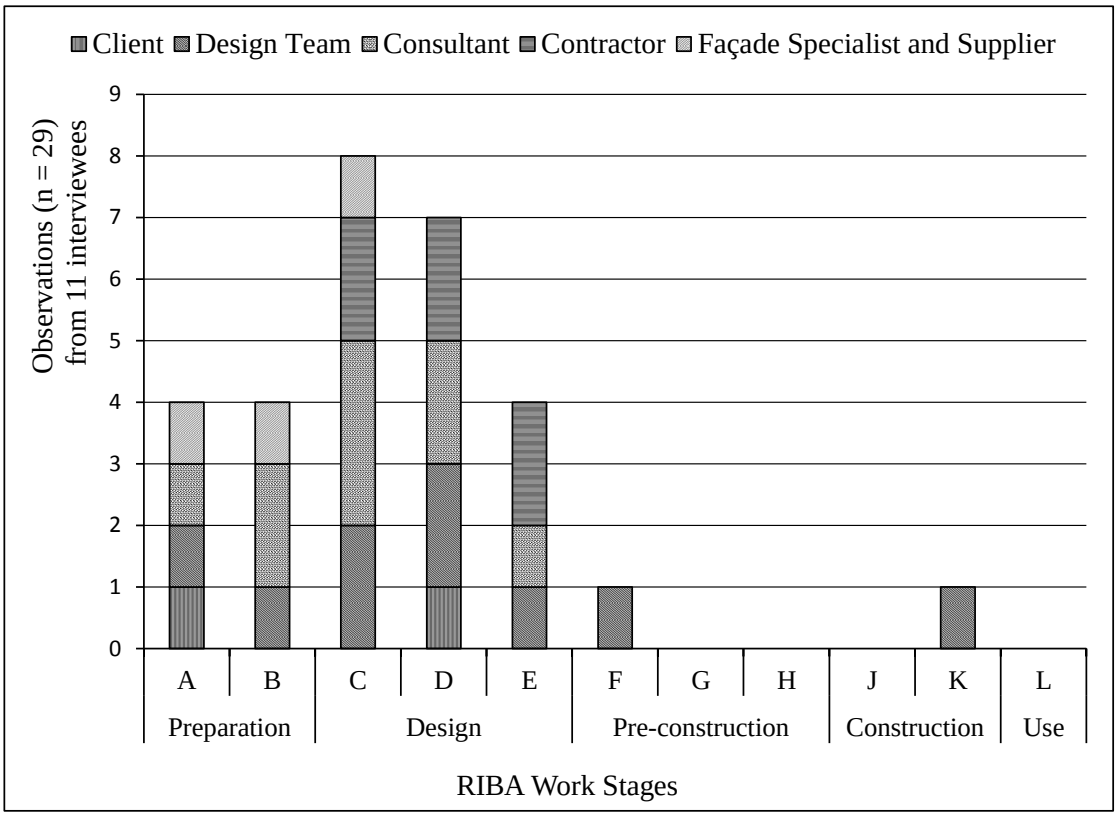

Figure 2: RIBA Work Stages in which façade decisions were observed

Two interviewees: building control (1), and façade specialist and supplier (1), were in roles that did not result in observing the RIBA Outline Plan of Work, and the fact that only 2 interviewees do not have exposure could be said to reinforce that it is "the most widely used model of building design" (Austin *et al.* 1999: 281). The results show that the majority of the observed façade decision-making occurs during the Preparation

(Stages A-B) and Design (Stages C-E) stages of a project. The design team and consultants observed decision-making at multiple stages, while the clients made unconnected observations, with one observing them in Stage A and one in Stage D. The façade specialist and supplier observed decision-making in the early project stage, reflecting their admission that they aim to influence decisions at an early stage to aid project success. The contractor observations slightly overlap the façade specialist and supplier, while their subsequent decisions hint at post-tender value engineering.

Problems perceived in the façade decision-making and suggested solutions

The problems that the interviewees perceived as occurring in façade decision-making are shown together with their suggested solutions, in Table 2 (listed alphabetically in order of 'Problem Theme'). Cost is a key factor in making good decisions, but not simply the total cost of procuring the façade. Other important cost factors include: paying adequate fees at an early stage in the design process to ensure that the right decision is made by the right people; and analysing the expected payback in terms of energy saving, but accepting that it might not 'win' the business case, in the face of less tangible gains, e.g. occupier satisfaction, maintaining the company brand. Collaborative working appears to be another way in which the perceived problems in façade decision-making can be improved. This collaboration can be among many roles and in varying combinations: architect and planner; lead architect with colleagues from the design team; client and consultant; or indeed, a whole project team of construction professionals collaborating at a project workshop dedicated to the façade.

Table 2: Problems perceived in the façade decision-making and suggested solutions

Problem Theme	Perceived Problems	Suggested Solutions
Business case	Justifying the re-cladding of buildings; short-term view when making façade decisions	The driver is not always cost; benefits can come from other areas, such as managing the company brand, attracting customers and retaining staff; use whole life cost analysis
Energy Efficiency	The client needs the building as energy efficient as possible; increasingly stringent standards	A business case for refurbishment may see aesthetics as secondary to performance (though some architects may not think this way); evolution - embrace the changes
Fees	Making the wrong decision; having to value engineer at a later stage to reduce costs	Paying fees up-front so that the client gets the right advice and the right decision; paying for a full consultant team at the start, so that a quantity surveyor is involved from the outset
Planners	Façade material rejected for not being local enough; planning approval delayed due to other complications; planners lacking knowledge in material durability; planners lacking an understanding of the architects' design intent	Get the planner on-board early in the design stage; produce options; produce a mock-up of the façade for the planner to review; increase the number of project design workshops purely devoted to façades; create a project checklist of façade design issues; take time to consider the options; no one system will fit all projects; better training
Quality	Façade system must be well built; design and build procurement allows flexibility for the contractor to cut corners; material faults; led by aesthetics rather than function; installation standards; buildability; maintenance in-use	25-year guarantee; collaboration to make a proper informed decision; pay for a full design team up-front so that full details are already produced when the job goes to tender; increase the number of project design workshops purely devoted to façades; Clerk of Works' role important to installation quality; craftsmanship - need to go back to grassroots
Specialist advice	Lack of choice in the façade specialists available	The specialists mentioned were all deemed of excellent quality, but where a job is small, may only provide off-the-shelf options

CONCLUSION

This paper has sought the opinions of different participants in the façade selection process, to explore and discover the current state of façade decision-making in today's construction industry in the UK. It has focused on façades on multi-storey buildings, due to the increasing prominence of multi-storey buildings as a result of the global trend towards urbanisation. The decision-making observations against the RIBA Outline Plan of Work indicate that certain participants might tend towards decision-making at different times in the project process. Architects are shown as leading the initial façade decisions; with consultants, and façade specialists and suppliers influencing these decisions where possible. Contractors are shown as attempting to make decisions at a later stage, post-tender, to potentially achieve cost and time reductions. The final façade decisions are made by the client, with planners giving ultimate approval. Very few decision-making tools were revealed as being used: namely whole life cost analysis, life cycle cost analysis and simulation. Further exploratory work is proposed to further define the roles participating in façade decision-making; and to investigate specific projects, with the aim of producing higher resolution as to what decisions are being made, and when.

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COMPARISON OF THE GREY MODEL AND THE BOX JENKINS MODEL IN FORECASTING MANPOWER IN THE UK CONSTRUCTION INDUSTRY

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Accurate forecasts of manpower in the construction industry are very important for the government, educational institutions and individual construction firms in their manpower planning. Although many good forecasting models have been developed, they require a sufficient amount of good-quality data to produce accurate results. Grey systems theory developed by Deng has become popular due to its ability to deal with systems in which some information is unknown. Grey models require only a limited amount of data to estimate the behaviour of unknown systems. This paper compares the grey model with the Box-Jenkins model in the forecasting of manpower in the UK construction industry. A GM (1, 1) grey model is proposed to forecast construction manpower one quarter ahead using manpower data from the Construction Statistics Annual published by the Office for National Statistics covering 72 quarters from 1991 Q1 to 2008 Q4. Within this period, two sets of manpower data were used: the total manpower available for employment (labour supply) and the total number of employees in employment (labour demand). An Excel programme was formulated to execute the forecasts using the grey model. An SPSS programme was used to conduct autoregressive integrated moving average (ARIMA) forecasts (Box-Jenkins model). The minimum mean absolute percentage error (MAPE) forecasted by the grey model for the total manpower and total employees time series was 1.52% and 2.14%, respectively, whereas the MAPE forecasted by the ARIMA model was 1.61% and 2.33%, respectively. Given the small forecasting error, it is concluded that both the GM (1, 1) model and the ARIMA model can accurately forecast manpower in the UK construction sector, but that the GM (1, 1) model performs slightly better than the ARIMA model.

Keywords: manpower forecast; Grey Model; Box-Jenkins Model.

INTRODUCTION

The construction industry is characterised by a workload that fluctuates cyclically. These cyclical fluctuations in workload in turn create fluctuations in labour supply and demand. Consequently, labour supply and demand in the construction sector are rarely in exact equilibrium: there is always either a labour shortage or a labour surplus. Labour shortages results in the hiring of unskilled labour, overtime work to maintain

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Ho P.H.K (2012) Comparison of the Grey Model and the Box Jenkins Model in forecasting manpower in the UK construction industry *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 369-.379

original programmes, and increased wages to maintain existing labour and attract new workers. In contrast, labour surplus results from the dismissal of skilled labour. The recruitment and training of skilled workers is costly (Uwakweh and Maloney, 1991). Accurate forecasting of the workforce is thus very important in the construction industry to maintain the correct balance between labour supply and demand.

Forecasting models for construction manpower can be classified into different types or levels: national aggregate manpower models, occupational manpower models, regional manpower models, regional manpower models by occupation (Briscoe and Wilson, 1993), company manpower models and project manpower models. Each of these models requires different input data and forecasting approaches. However, the transience of manpower, the reliance on self-employment and problems with estimating the informal labour market reduce the reliability of employment statistics in the construction sector (CLR-GB, 2008). As such, accurate manpower forecasting at any level is a challenging task for government, educational institutions and individual construction firms alike.

Many good statistical models have been developed for forecasting manpower. However, most of these models require the input of a sufficient amount of suitable data. If there is insufficient data or if the data is sufficient but does not follow certain patterns, then the forecasts may not be reliable or accurate. Given the potential limitations of existing statistical models, this study introduces a grey model for forecasting national aggregate labour supply and demand in the construction industry based on a limited amount of data. To demonstrate the accuracy of the grey model, its forecasting results are compared with those forecasts obtained with the Box-Jenkins statistical model.

PREVIOUS MANPOWER FORECASTING MODELS

A wide range of statistical models of varying degrees of complexity is available for forecasting manpower. These models can be grouped into five broad approaches: the exponential smoothing approach, single-question (linear or non-linear) regression approach, simultaneous-equation regression approach, autoregressive integrated moving average (ARIMA) approach and vector autoregression (VAR) approach (Gujarati and Porter, 2009). Many studies have attempted to use these models to forecast the aggregate labour supply and demand, some of which are reviewed here.

Based on the neoclassical labour economics theory, several employment functions have been developed to forecast labour demand in the short run. The optimal employment functions so derived usually incorporate a lagged adjustment mechanism, and the inputs can only be adjusted gradually towards their desired levels. One of the most seminal employment functions is that proposed by Ball and St. Cyr (1966):

$$\log E_t = a_0 - a_1 t + a_2 \log Q_t + a_3 \log E_{t-1}, \quad (1)$$

where E = the level of employment, t = the time trend and Q = the construction output. The coefficients α_0, α_1, α_2 and α_3 are estimated by the regression method, which captures explanatory rigour and uncovers the causal links amongst the variables. However, the inclusion of a lagged dependent variable means that the parameter estimates may be biased and the sampling variance underestimated. The regression model is also unstable over time.

Econometric models also derive the supply and demand employment functions from labour economics theory. By identifying appropriate reduced-form equations, the relevant coefficients are then estimated by either the ordinary least-squares (OLS) or

two-stage least-squares (2SLS) methods. For instance, Black and Kelejian (1970) employed the 2SLS method to estimate a quarterly model of US labour demand and supply and wage adjustments. The parameters estimated from an econometric model are dependent on prevailing policy at the time of estimation, and will change if there is a policy change.

The ARIMA model (or the Box-Jenkins model) focuses on analysing the probabilistic properties of time series data (i.e. it lets the data speak for itself). Unlike single- and simultaneous-equation regression models, the ARIMA model is not derived from any economics theory. Wong *et al.* (2005) applied the model to forecast five construction manpower time series in Hong Kong: employment level, productivity, unemployment rate, underemployment rate and real wages. Their results showed the mean absolute percentage error (MAPE) in the predicted employment level, productivity, unemployment rate, underemployment rate and real wage values to be 12.8%, 6.6%, 7.4%, 7.5% and 2.2%, respectively. Depending on the patterns of the data, it is well recognised that the ARIMA model achieves a better forecasting performance than single- and simultaneous-equation regression models.

The VAR model resembles simultaneous-equation modelling in that several endogenous variables are considered together, but each is explained by its lagged values and the lagged values of all other endogenous variables in the model. By examining a wide range of variables with the cointegrating regression method, Briscoe and Wilson (1991, 1993) formulated the following long-run labour demand specification for the UK engineering sector.

$$E_t = a + b(Q_t) + c(RW_t) + d(H_t) + e(ROP_t) + f(BR_t), \quad (2)$$

where E = the employment level, Q = the construction output, RW = the real wages, H = the average hours worked, ROP = the real oil prices, BR = the bank rates and t = the time trend. Due to the small degree of freedom, the over-parameterized VAR model was then simplified into a restricted error correction (EC) form.

$$\triangle E_t = a + b_0(\triangle Q_t) + b_1(\triangle Q_{t-1}) + c_0(\triangle RW_t) + d_0(\triangle H_t) + e_1(\triangle ROP_{t-1}) + f_0(\triangle BR_t) + g_1(\triangle E_{t-1}) + g_2(\triangle E_{t-2}) + (EC_{t-1}).. \quad (3)$$

Briscoe and Wilson found that the dominant variables were output, real wages and the lagged dependent variable.

Most statistical forecasting models require a large amount of data in order to achieve a reliable conclusion. For instance, Box and Jenkins (1976) stated that 50 to 100 observations are necessary to ensure adequate power for model testing, although other studies have shown that the minimum number of observations is more likely to be between 100 and 250 (Yaffe and McGee, 1982). The foregoing literature review clearly indicates the need for a manpower forecasting model that can produce accurate forecasts with a limited amount of input data.

GREY MODEL

Grey systems theory, originally developed by Deng (1982), is a generic theory that deals with problems with small samples or poor data. It looks for realistic patterns based on the modelling of a small amount of available data. Several types of grey models have been developed over the years. Probably, the most popular predicting model is the single-variable first-order grey model, abbreviated as GM (1, 1). The GM (1, 1) modelling algorithm can be summarised in the following steps, details of which can be referred to Liu and Lin's (2006) book.

Step 1: Assume that $x^{(0)}$ is the original raw data sequence with n samples:

$$x^0 = \left[x^{(0)}(1), x^{(0)}(2), \ldots\ldots, x^{(0)}(n)\right] = [x^0(k)]; \quad n \geq 4, \tag{4}$$

where the superscript (0) represents the original data and negative data values are not allowed. The task here is to forecast $x^{(0)}(k+1)$ (i.e. one sampling time ahead).

Step 2: In the grey system, the original sequence $x^{(0)}$ is transformed into a new sequence $x^{(1)}$ using a first-order accumulated generation operator (AGO). The main function of the AGO is to discover the potential regular pattern or trend of the original data sequence through the accumulation of data so that the prediction can be more accurate. The new sequence $x^{(1)}$ is the AGO sequence of $x^{(0)}$, which is defined as follows.

$$x^1 = \mathrm{AGO} \cdot x^0 = \left[\sum_{k=1}^{1} x^0(k), \sum_{k=1}^{2} x^0(k), \ldots\ldots, \sum_{k=1}^{n} x^0(k)\ \right] \tag{5}$$

where

$$x^1(1) = x^0(1)$$

$$x^1(2) = x^1(1) + x^0(2)$$

$$x^1(3) = x^1(2) + x^0(3)$$

…….....

$$x^1(k) = x^1(k-1) + x^0(k) \tag{6}$$

Step 3: The sequence $x^{(1)}$ is then modelled by a first-order differential equation (whitening equation) as follows.

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b, \tag{7}$$

where $dx^{(1)}/dt$ is the derivative of the function x, x is the background value, and the parameters a and b are the development coefficient and grey input, respectively.

Step 4: In order to handle the discrete data sequence which is not continuous and differential, Equation (7) is generalized into the following grey differential equation.

$$x^{(0)}(2) + az^{(1)}(2) = b$$

$$x^{(0)}(3) + az^{(1)}(3) = b$$

……..

$$x^{(0)}(k) + az^{(1)}(k) = b, \tag{8}$$

where $z^{(1)}(k)$ is the generated sequence of the consecutive neighbours of $x^{(1)}$ given by

$$z^{(1)}(k) = \alpha x^{(1)}(k) + (1-\alpha)x^{(1)}(k-1); \ \ \alpha \in [0,1] \text{ and } k = 1, 2, \ldots\ldots, n, \tag{9}$$

where α is the generation coefficient, which depends on whether $z^{(1)}(k)$ places more emphasis on new or old data. When $\alpha > 0.5$, the generation of $z^{(1)}(k)$ is said to have emphasis more on new data, whereas when $\alpha < 0.5$, $z^{(1)}(k)$ is said to have emphasis more on old data.

Step 5: In order to provide a solution for Equation (8), the parameters a and b can be solved by the traditional least-squares error method as follows.

$$\hat{a} = \begin{bmatrix} a \\ b \end{bmatrix}^T = (B^T B)^{-1} B^T Y, \tag{10}$$

where

$$Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ x^{(0)}(4) \\ . \\ . \\ x^{(0)}(n) \end{bmatrix}, B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ -z^{(1)}(4) & 1 \\ . & \\ . & \\ -z^{(1)}(n) & 1 \end{bmatrix}, \hat{a} = \begin{bmatrix} a \\ b \end{bmatrix}. \quad (11)$$

Step 6: Setting the initial value $\hat{x}^{(1)}(1) = x^{(0)}(1)$ and t = 1, the solution to Equation (7) is given approximately by

$$\hat{x}^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a}\right) e^{-ak} + \frac{b}{a}; \quad k = 1, 2, 3, \dots, n, \quad (12)$$

where $\hat{x}^{(1)}(k+1)$ is the predicted value of $x^{(1)}(k+1)$ at time (k+1) and $\widehat{\ }$ denotes the forecasted value.

Step 7: By using the inverse accumulated generation operator (IAGO) which is an inverse operator of the accumulated generation, the forecasted value $\hat{x}^{(0)}(k+1))$ can be obtained by:

$$\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k). \quad (13)$$

Step 8: The metabolic GM (1, 1) model is used by inserting $x^{(0)}(n+1)$ and deleting $x^{(0)}(1)$ in the sequence $x^{(0)} = [x^{(0)}(2), \dots, x^{(0)}(n), x^{(0)}(n+1)]$ because the value of new data is greater than that of old data. As the system develops, older data are deleted and newer data added so that the modelling sequence is constantly renewed to reflect the latest characteristics of the system.

Step 9: The overall accuracy of this forecasting model can be measured by its means absolute percentage error (MAPE):

$$\text{MAPE} = \frac{1}{n}\sum_{k=1}^{n} \frac{|x^{(0)}(k) - \hat{x}^{(0)}(k)|}{x^{(0)}(k)} 100\%; \quad k = 1, 2, \dots, n, \quad (14)$$

where $x^{(0)}(k)$ and $\hat{x}^{(0)}(k)$ are the actual and forecasted values, respectively, and n is the number of forecasts.

RESEARCH METHODOLOGY

Based on a limited amount of data, the metabolic GM (1, 1) model is used to forecast the aggregate labour supply and demand in the UK construction sector. The Box-Jenkins (ARIMA) model is used to perform the same forecasts based on the same datasets. The results forecasted by the two approaches are then compared based on the means absolute percentage error (MAPE). Amongst several statistical models, the ARIMA model is chosen for the comparison purpose for two reasons. First, in many cases, the ARIMA model produces more reliable and accurate forecasts than the exponential smoothing model, single-question regression model and simultaneous-equation regression model. Second, same as the grey model, the ARIMA model does not rely on the input of other external data so that these two approaches can be directly compared on the same base.

The manpower data is based on the Construction Statistics Annual published by the Office for National Statistics. It contains a total of 72 quarterly datasets, covering the first quarter of 1991 to the fourth quarter of 2008. Within this period, this study

examines two sets of data: the 'total manpower' time series and the 'total employees' time series. The manpower time series represents the total amount of labour available for employment (i.e. the labour supply), whereas the employees time series represents the total amount of labour in employment (i.e. the labour demand). All of the data were adjusted to reduce seasonal fluctuations. Figures were occasionally revised due to differences in the definitions and coverage from the original series. This created certain fluctuations in the time series that would affect the accuracy of the forecasts.

EMPIRICAL RESULTS AND DISCUSSION

GM (1, 1) Model

One of the major advantages of the GM (1, 1) model is that it only requires the input of a few data for model building. The sample number determines the amount of memory in the model. Generally, when a series is very random, a larger sample number produces a lower MAPE. In contrast, if the series moves smoothly up and down, then a smaller number produces a lower MAPE. The optimal sample number is that which produces the lowest MAPE. To achieve the lowest MAPE, a search method was employed to find the optimal sample size. Different sample sizes were used to build the models, forecast the number of workers one quarter ahead, compare the differences between the actual and forecasted numbers and finally calculate the absolute percentage error of each forecast and the overall MAPE. Table 1 presents the MAPE of forecasts based on sample sizes of 4, 5, 6, 7, 8 and 9.

Table 1: MAPE of forecasts based on different sample sizes

Time series	MAPE of forecasts based on					
	4 data input	5 data input	6 data input	7 data input	8 data input	9 data input
Total manpower	1.95%	1.74%	1.66%	1.75%	1.81%	1.98%
Total employees	2.44%	2.47%	2.64%	2.89%	2.95%	3.11%

As can be seen in Table 1, the results demonstrate that the grey model requires few input data and indeed, a larger amount of input data does not produce more accurate results. Based on the minimum MAPE, the optimal sample sizes for the total manpower and total employees time series are 6 (1.66%) and 4 (2.44%), respectively.

The coefficient α in Equation (9) depends on the relative reliance on new versus old date in the accumulated generation process. Again, the optimal coefficient is that which produces the lowest MAPE. Based on the identified optimal sample sizes, a search method was used to find the optimal coefficient. Table 2 presents the MAPE of forecasts based on α values ranging from 0.50 to 1.00.

Table 2: MAPE of forecasts based on different α values

Time series	MAPE of forecasts based on					
	α=0.50	α=0.60	α=0.70	α=0.80	α=0.90	α=1.00
Total manpower (6-data solution)	1.66%	1.62%	1.59%	1.56%	1.54%	1.52%
Total employees (4-data solution)	2.44%	2.35%	2.27%	2.21%	2.17%	2.14%

As shown in Table 2, using a larger α value reduces the MAPE of forecasts in both time series. This indicates that the value of new data is greater than that of old data in

the forecast. The optimal coefficients for the total manpower and total employees time series are both equal to 1.

Based on the optimal sample size of 6 data for the total manpower time series and the optimal α value of 1, the first six actual values were used to build the GM (1, 1) model and to forecast the seventh value (i.e. one quarter ahead) according to Equations (4) to (13). The seventh forecasted value was compared with its actual value. The absolute percentage error was then calculated according to Equation (14). The same calculation procedure was repeated until the end of the last set of data. As each forecast required a large number of calculations, an Excel program incorporating Equations (4) to (14) was used to manipulate the calculations. The dataset comprises 72 data. After deducting the first 6 data for model building, the remaining 66 data were used to evaluate the accuracy of the ex-post forecasts. The same forecasting method was used with the total employees time series to produce similar forecasts. Table 3 shows a comparison of the actual and forecasted values for one quarter ahead, together with its absolute percentage error, for the total manpower and total employees time series.

Table 3 shows that the MAPE of the overall forecast for the total manpower and total employees time series is only 1.52% and 2.14%, respectively. The respective maximum absolute percentage error (MaxAPE) is 7.19% at 2000 Q1 and 6.98% at 2002 Q1. These relatively larger errors are due to irregular movements of the time series at those periods. With few exceptions, the error for most forecasts is very small. Therefore, the actual and forecasted values are in a very good agreement as shown in Figure 1.

Table 3: Actual and forecasted values for one quarter ahead from the grey model

Year	Quarter	Total manpower time series			Total employees time series		
		Original value	Forecasted value	Absolute % error	Original value	Forecasted value	Absolute % error
1991	Q1	1 777	-	-	1 094	-	-
	Q2	1 723	-	-	1 057	-	-
	Q3	1 667	-	-	1 019	-	-
	Q4	1 626	-	-	994	-	-
1992	Q1	1 579	-	-	962	975	1.37%
	Q2	1 533	-	-	932	948	1.75%
	Q3	1 494	1 508	0.93%	909	915	0.69%
	Q4	1 475	1 470	0.37%	890	894	0.44%
1993	Q1	1 432	1 444	0.83%	873	878	0.62%
	Q2	1 409	1 414	0.36%	852	863	1.33%
	Q3	1 403	1 391	0.87%	831	843	1.42%
	Q4	1 398	1 380	1.27%	803	820	2.12%
1994	Q1	1 394	1 377	1.20%	795	791	0.46%
	Q2	1 379	1 385	0.46%	784	782	0.23%
	Q3	1 390	1 379	0.77%	778	780	0.21%
	Q4	1 375	1 382	0.48%	766	773	0.89%
1995	Q1	1 394	1 375	1.38%	773	762	1.37%
	Q2	1 362	1 385	1.72%	749	769	2.62%
	Q3	1 362	1 373	0.78%	743	750	0.94%
	Q4	1 382	1 359	1.64%	750	732	2.38%
1996	Q1	1 392	1 371	1.54%	758	748	1.31%
	Q2	1 354	1 383	2.11%	741	762	2.77%
	Q3	1 355	1 374	1.40%	741	743	0.27%
	Q4	1 378	1 359	1.40%	739	734	0.70%
1997	Q1	1 399	1 361	2.72%	767	739	3.67%
	Q2	1 361	1 385	1.79%	754	768	1.92%
	Q3	1 384	1 384	0.01%	806	765	5.14%
	Q4	1 392	1 386	0.45%	839	805	4.03%
1998	Q1	1 447	1 386	4.21%	901	861	4.45%
	Q2	1 426	1 429	0.20%	906	918	1.28%
	Q3	1 419	1 450	2.19%	921	931	1.05%
	Q4	1 418	1 439	1.52%	912	924	1.34%
1999	Q1	1 429	1 426	0.18%	933	918	1.66%
	Q2	1 409	1 417	0.55%	899	931	3.57%
	Q3	1 418	1 414	0.27%	897	905	0.91%
	Q4	1 403	1 416	0.92%	885	882	0.31%
2000	Q1	1 514	1 405	7.19%*	930	883	5.04%
	Q2	1 491	1 477	0.96%	963	929	3.54%
	Q3	1 493	1 512	1.29%	976	983	0.69%
	Q4	1 535	1 523	0.78%	983	990	0.73%
2001	Q1	1 518	1 548	1.95%	974	989	1.53%
	Q2	1 523	1 523	0.02%	970	976	0.64%
	Q3	1 546	1 534	0.76%	946	966	2.10%
	Q4	1 557	1 546	0.67%	968	942	2.66%
2002	Q1	1 594	1 554	2.52%	1 032	960	6.98%*
	Q2	1 629	1 594	2.14%	1 048	1 045	0.27%
	Q3	1 631	1 635	0.23%	1 036	1 074	3.68%
	Q4	1 599	1 652	3.29%	994	1 042	4.80%
2003	Q1	1 619	1 632	0.81%	994	985	0.89%
	Q2	1 559	1 619	3.88%	985	976	0.91%
	Q3	1 590	1 570	1.28%	988	984	0.38%
	Q4	1 613	1 569	2.72%	1 002	984	1.75%
2004	Q1	1 659	1 596	3.80%	1 034	1 004	2.86%
	Q2	1 682	1 642	2.37%	1 049	1 042	0.66%
	Q3	1 762	1 699	3.58%	1 080	1 063	1.57%
	Q4	1 754	1 764	0.59%	1 062	1 088	2.49%
2005	Q1	1 760	1 789	1.67%	1 067	1 073	0.60%

	Q2	1 811	1 791	1.09%	1 102	1 060	3.82%
	Q3	1 830	1 818	0.68%	1 113	1 107	0.55%
	Q4	1 799	1 832	1.83%	1 089	1 128	3.58%
2006	Q1	1 827	1 831	0.20%	1 131	1 092	3.48%
	Q2	1 815	1 836	1.15%	1 103	1 125	1.98%
	Q3	1 836	1 818	1.00%	1 120	1 118	0.15%
	Q4	1 866	1 828	2.01%	1 168	1 110	4.98%
2007	Q1	1 810	1 864	3.00%	1 095	1 178	7.62%
	Q2	1 857	1 835	1.18%	1 123	1 110	1.16%
	Q3	1 914	1 851	3.27%	1 154	1 095	5.15%
	Q4	1 859	1 894	1.87%	1 096	1 168	6.53%
			MAPE	**1.52%**		**MAPE**	**2.14%**

***** *Maximum absolute percentage error.*

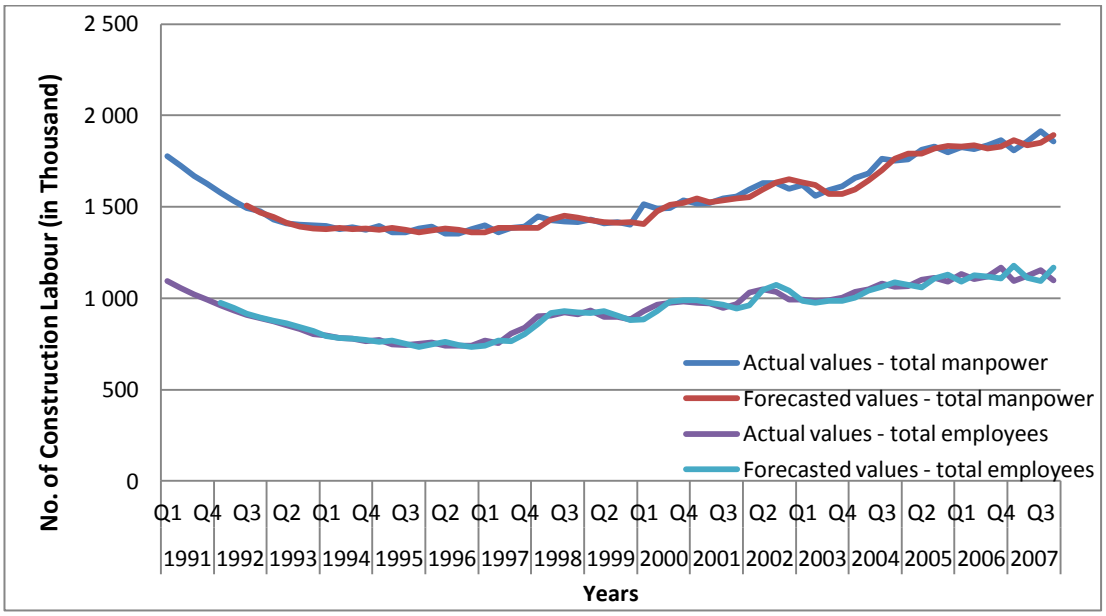

Figure 1: Actual and forecasted values for the total manpower and total employees time series from the grey model

ARIMA Model

The ARIMA approach consists of four steps: identification of the model (tentative choice of p, d, q), parameter estimation for the chosen model, diagnostic checking and forecasting, details of which can be found in Box-Jenkins' seminal book 'Time Series Analysis: Forecasting and Control'. The SPSS programme was used to find the fitted values based on the same data as that used in the grey model. The best models for the total manpower and total employees time series were found to be ARIMA (0, 1, 3) (0, 1, 1) and ARIMA (0, 1, 0) (0, 0, 0), respectively. The model parameters are shown in Table 4.

Table 4: ARIMA Model Parameters

Time series			Estimate	SE	t	Sig.
Total manpower	Difference		1			
	MA	Lag 3	0.490	0.119	4.116	.000
	Seasonal Difference		1			
	MA, Seasonal	Lag 1	0.648	0.120	5.386	.000
Total employees	Constant		0.030	3.409	0.009	.993
	Difference		1			

Table 5: Model Fit Statistics

Model	Stationary R-squared	R-squared	RMSE	MAPE	MaxAPE
Total manpower	0.449	0.967	31.233	1.613	5.678
Total employees	-2.895E-16	0.951	27.907	2.331	6.878

According to Table 5, the MAPE of the overall forecast for the total manpower and total employees time series is 1.61% and 2.33%, respectively, whereas the respective MaxAPE is 5.68% at 2000 Q1, and 6.88% at 1998 Q1. As with the grey model, the actual and forecasted values for both time series are in very good agreement.

Comparison of the GM (1, 1) Model and ARIMA Model

Table 6 shows a comparison of the forecasting accuracy of the GM (1, 1) model and ARIMA model. The MAPE values forecasted by both models are between 1.52% and 2.33%, which is very small. Hence, both the GM (1, 1) model and the ARIMA model can be considered to be able to accurately forecast labour supply and demand in the UK construction sector.

Table 6: Comparison of the forecasting accuracy of the GM (1, 1) model and ARIMA model

Time series	MAPE of forecasts based on GM (1,1) model	ARIMA model	Difference
Total manpower	1.5%	1.6%	0.1%
Total employees	2.1%	2.3%	0.2%

It is also observed from Table 6 that the GM (1, 1) model performs slightly better than the ARIMA model, although the differences are only 0.1% and 0.2% for the total manpower and total employee time series, respectively. As the ARIMA model is well recognised as one of the most reliable forecasting approaches, the results demonstrate the reliability and robustness of the grey model in forecasting short-term construction manpower.

CONCLUSIONS

As shown in Figure 1, labour supply in the construction industry has always been greater than labour demand over the past 20 years. In other words, the UK construction industry is demand led rather than supply led. Hence, it is more important to focus efforts on the forecasting of labour demand rather than labour supply.

Contrary to the general belief that it is difficult to make an accurate labour forecast, the above results empirically demonstrate that both the GM (1, 1) model and the ARIMA model can accurately forecast labour supply and demand in the UK construction sector. Besides the robustness of the models, one of the main reasons is that the data was fairly stable over the period of analysis as indicated in Figure 1. As

the overall MAPE values are only around 2%, there should be little concern about the forecasting method itself.

Based on sample sizes of only 6 and 4 data for the total manpower and total employees time series respectively, the GM (1, 1) model produced a slightly more accurate forecast then the ARIMA model. This demonstrates that the GM (1, 1) model can handle a time series with a small sample size. The model may thus be equally, or even more, suitable for forecasting other detailed manpower models such as the occupational manpower model, regional manpower model and regional manpower by occupation model. This would be a promising area for further research.

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TIME SERIES ANALYSIS FOR THE PREDICTION OF RC MATERIAL COMPONENTS PRICES IN EGYPT

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Reinforced concrete (RC) as a construction material is widely used in the Middle East and particularly Egypt. Prices of the RC material components usually comprise an important portion of construction project costs. Prices of RC materials have witnessed significant changes and fluctuations over the past 15 years in Egypt, leading to severe impacts on the running projects' costs and to the failure of various projects as well as legal consequences on contracting companies. Factors affecting steel and cement prices (the major cost contributors to RC) have been related in previous literatures to cost of the production process, raw material prices, energy prices, macroeconomic variables, and industry related factors. Time Series Analysis involves the use of historical data to predict the future outcomes and the associated risks. Thus, the objective of this paper is to apply Time Series Analysis to better predict the prices of RC material components in Egypt. Prices of steel, cement, sand and crushed stones were collected for the period from 1997 to 2010. The collected data was divided into two sections based on the economic growth within the studied periods. A computer-based analysis was conducted using ForecastX and SPSS software to apply the Time Series analyses and detect trends, stationarity, and seasonality. Results indicate that the outputs on applying the Time Series models in both programs were nearly identical. Furthermore, the predictions for the last quarter of 2009 and the first two quarters of 2010 were compared to actual past prices as a way to validate the analyses. A reasonable degree of prediction accuracy was concluded for all materials, and in particular cement, although the global financial crisis in 2008 was found to negatively affect the predictive capability of the model. Time Series Analysis in general, although being a good prediction technique in stable economic and industry conditions, cannot predict sudden macroeconomic or other events, and therefore, future research is required to tie in input variables of material costs based on leading cost indicators and to explore how the effects of sudden events can be realized and hopefully predicted, if possible.

Keywords: reinforced concrete, time-series analysis, material prices, Egypt.

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Bassioni, H; Elmasry, M.I; Ragheb, M and Youssef, A. A (2012) Time series analysis for the prediction of RC material components prices in Egypt *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 381-390.

INTRODUCTION

Construction projects sometimes fail to achieve their time, quality, and budget goals, partially due to the failure of the contractors to analyze and assess unanticipated dangers (Ghosh and Jintanapakanont 2004). Material prices in developing countries comprise the majority of construction costs and are also known to have high variability, as opposed to developed countries. Reinforced Concrete (RC) as a material is very popular worldwide and especially in the Middle East and comprises a large portion of material costs. Forecasting of material costs, and in particular RC, is an important function for effectively managing projects in terms of more accurately estimating, tracking and controlling projects. Time series analysis is a well-established technique that has been utilized successfully in many domains for forecasting processes (Hwang and Liu 2009). The objective of this paper is to apply Time Series Analysis, as a prediction technique, to the prices of RC materials. The analysis introduced herein is limited to the prices in the period from 1997 to 2009 which can be divided into a stable economic period from 1997 to 2002 and a growth economic period from 2006 to 2009. The analysis was differentiated by the status of the economy as it is believed that the Time Series model can perform differently in each period. The following sections discuss international prediction of material prices, forecasting with Time Series Analysis, data collection and analyses, validation of results and finally conclusion and recommendations.

INTERNATIONAL PREDICTION OF MATERIAL PRICES

Considerable amount of research has been conducted worldwide to identify the explanatory variables of building price indices such as Tender Price Index (TPI) in the UK, Hong Kong and Singapore, and in less cases the Construction Cost Index (CCI) in the USA (Ashuri *et al.* 2012). Unemployment level, construction output, industrial production, and the ratio of price to cost indices in manufacturing were used by Akintoye *et al.* (1998) as leading indicators for the TPI. In addition, time series historical data on economic, energy and construction market variables was used to explain variations in the CCI, using the parameters of gross domestic product, crude oil price, housing starts and employment level (Ashuri 2012).

In more specific terms of predicting RC prices, Walker (2006) pointed out that time-series analysis of cement prices should be performed on a month to month basis rather than day to day. The direct factors affecting cement prices in Europe were found to be: kiln fuel; electricity for materials handling and grinding; EU allowances for carbon emissions; cost of limestone; variable labour costs. Indirect factors were found to be: capacity utilisation; management of supply; impact of sea-freight cargo rates; locational variations in the intensity of competition. Hagimura *et al.* (1998) applied time series analysis to the process of cement production using modern control theory. Padhan (2012) fitted a Seasonal Autoregressive Integrated Moving Average (SARIMA) model to the production of cement in India. Pereira (2011) examined the time series of rebar prices in Brazil and concluded the existence of a long-run relation between prices of raw materials, international prices and domestic prices, and thus assist in predicting future prices of domestic rebars. Chou and Huang (2010) analysed the relationship between forward freight agreements and steel price index using the Vector Autoregressive Moving Average Model (VARMA).

FORECASTING WITH TIME SERIES ANALYSIS

Forecasting techniques range from simple to complex, and include the use of executive judgment, surveys, time-series analysis, correlation methods, market tests and simulation (Smith III *et al.* 1996). Wilson and Keating (2007) defined time series forecasting as the use of a technique to forecast future events based on known past events. Time Series Analysis explicitly recognizes the order in which experimental data are observed, as well as the statistical dependence of observed data (Abdelhamid and Everett 1999). The advantage of the time series method compared to other predictive methods, such as regression and neural networks, is that the other methods require future values of input variables that are not readily available, whereas, univariate time series analysis has been identified as the most effective way of carrying out work to develop predictive models for construction costs (Ahsuri and Lu 2010a). Therefore, univariate time series analysis was chosen in this paper as the research methodology due to its requirement of just one input variable for creating and calibrating models. Brockwell and Davis (2002) pointed out that time series analysis follows a standard procedure in sequence: examine the main features of data series; check dependency in data; choose a model to fit the series; diagnose the constructed model; and forecast and update data. Four major factors affect time series analysis: trend; seasonality; cycles; and irregular movements, whereas, seasonal component is concerned with the periodic fluctuation in the series within each year (Farnum and Stanton 1989). Simple Moving-Average (SMA), Holt Exponential Smoothing (Holt ES), Holt-Winters Exponential Smoothing (Holt-Winters ES), Auto-Regressive Integrated Moving-Average (ARIMA), and Seasonal ARIMA are some of the well-known time series approaches (Ashuri and Lu 2010b). The SMA is properly employed when there is no trend or seasonality present in the data (Wilson and Keating 2007). The Holt ES method is recommended to handle time series data that display trends (Brockwell and Davis 2002). Winters (1960) generalized the Holt ES method and developed the Holt-Winters Exponential Smoothing. A third-factor called seasonal smoothing is presented into time series analysis and is an estimated value of seasonal growth rate reflecting the seasonal pattern of time series data (Wilson and Keating 2007). ARIMA is built upon Auto-Regressive (AR) and Moving-Average (MA) approaches. ARIMA is recommended to model time series data displaying nonstationary behaviours (Box and Jenkins 1970).

DATA COLLECTION AND ANALYSIS

All the prices of concrete components (which are steel, sand, crushed stone – mostly used in Egypt - and cement) were obtained from the Central Agency for Public Mobilization and Statistics (CAPMAS 2010). Data was obtained in quarterly periods from 1997 till 2009. Raw materials are heavily used in the construction industry and their costs greatly affect the construction sector, which in turn both affects and is affected by the economy in terms of its indicators such as Gross Domestic Product (GDP). For example, the prices for Portland cement (50 kg package) from 1997 till 2008 for each quarter time series are shown in Figure 1. Prices of sand were also collected for the same period in terms of cubic meters, crushed stone in terms of cubic meters and 16 mm and 10 mm steel reinforcing bars (rebars) in tons.

Furthermore, experiences in developed countries have shown that construction investments and activities increase with the state of economic development of the country (Ali 2005). To assess the effect of economic activity or status on prices, the Gross Domestic Product (GDP) in Egypt was considered. GDP is the market value of

all final goods and services produced within a country in a given period of time (Edgmand *et al.* 2001). Real GDP shows how the economy's overall production of goods and services changes over time, which is taking into consideration inflation (Colander C. 2006). Bade and Parkin (2007) explained that real GDP has been considered as the primary measurement of growth. Figure 2 shows the nominal and real GDP for Egypt in the period from 1996 to 2008.

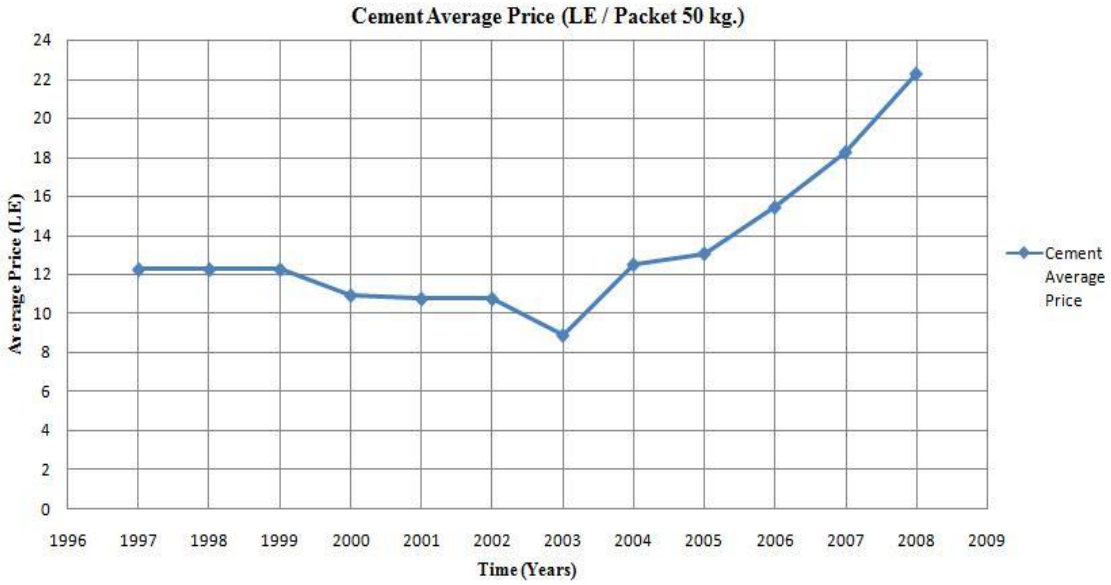

Figure 4: Cement Average Annual Price in Egypt 1997 - 2008 (Source CAPMAS 2009)

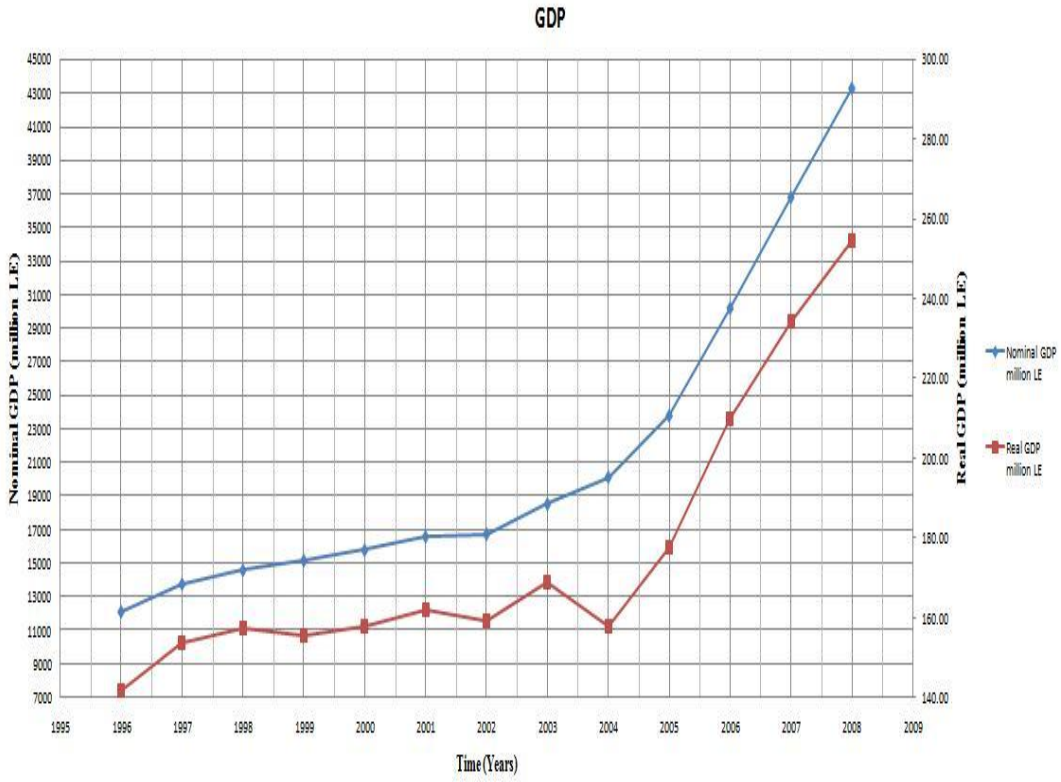

Figure 5: Nominal and Real GDP in Egypt 1996 - 2008 (Source CAPMAS 2009)

The period from 1997 to 2002 showed relative economic stability. A small downturn in 2004, probably due to inflation from the floating of the Egyptian currency (ECISC

2009), was succeeded by economic growth through the period from 2004 to 2008. Therefore, the analysis was conducted in two discrete periods; the first was an economic stable period from 1997 to 2002, and the second, an economic growth period from 2006 to 2009. The interim period was excluded due to abnormal economic situations that could distort the analysis. Two different kinds of programs, namely, SPSS (Statistical Package for Social Science) program and ForecastX program are used to apply time series in order to find out materials' trends.

Cement prices analysis

The cement price data was entered into SPSS software and the results of the time series analysis for the economic stability period (1997-2002) are shown in Figure 3. Different sets of data are used in the software to follow specific patterns relying on their behaviour. Upon testing the pattern that guide the data of this case, ARIMA model was the closest pattern that could give an interpretation for the set of data used. The model type was ARIMA(0,1,0). ARIMA stands for "Auto-Regressive Integrated Moving Average." A nonseasonal ARIMA model is classified as an "ARIMA (p,d,q)" model, where: p is the number of autoregressive terms; d is the number of nonseasonal differences; and q is the number of lagged forecast errors in the prediction equation (ARIMA 2010). The fit statistics produced an R2 – coefficient of determination 0.861, an estimate of the proportion of the total variation in the series that is explained by the model (Farnum and Stanton 1989). The value of MAPE – Mean Absolute Percent Error, an expression of percentage of relative error in order to introduce a unit free scale of evaluation (Farnum and Stanton 1989), was 3.047% which is considered a good fit as it is below 10% (Ashuri and Lu 2010a). The ForecastX software fitted a Holt-Winters model with an alpha of 0.95, beta 0.45 and gamma of 0.02, where alpha is the level of smoothing, beta the seasonal parameter, and gamma the trend parameter and the three factors are the smoothing constants factors (Wilson and Keating 2007).

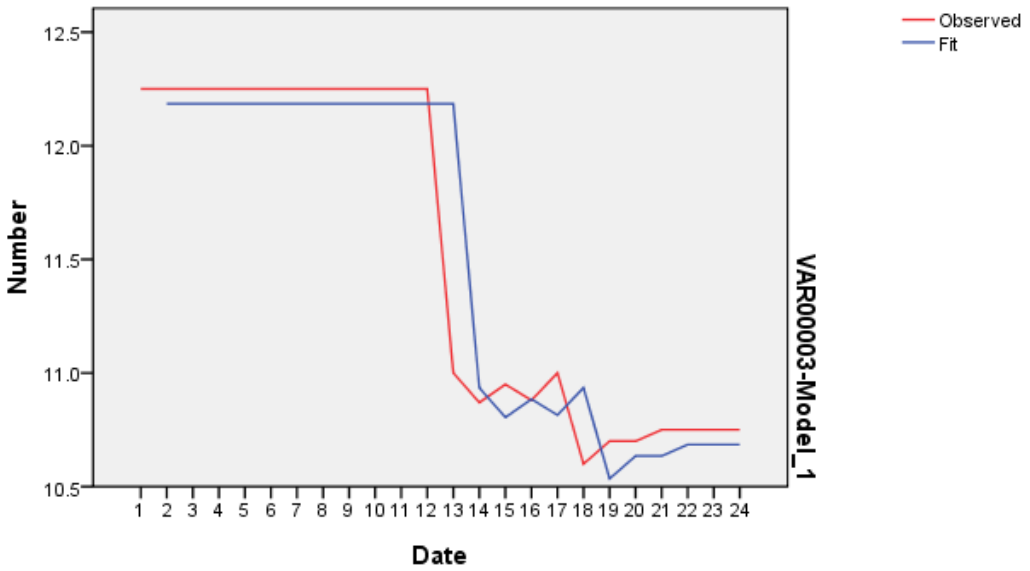

Figure 6: SPSS Observed and fit values for cement prices for economic stability period

The analysis was also conducted on ForecastX software, and results shown in Figure 4. The fitted model was Holt-Winters with an alpha value of 0.13, a beta value of 0.61 and gamma of 0.81. The fit statistics produced an R^2 of 0.9514, and a MAPE of 2.76%, which show good fitness of the model. The software produces lower and upper 95% confidence limits (Wilson and Keating 2007). SPSS analysis of the same period

fitted a Holt model with an R^2 of 0.949 and MAPE of 3.047%. The Holt model is quite robust and has an easy to use projection procedure. The method allows data to be modelled by a local mean, a local trend and a local seasonal factor which are all updated by exponential smoothing. Seasonal effect may be additive or multiplicative, while a non-seasonal version is also available. The model is usually suitable for a series with a linear trend and no seasonality (Chatfield and Yar (1988). Holt's exponential smoothing is most similar to an ARIMA model with zero orders of auto regression, two orders of differencing, and two orders of moving average (Farnum and Stanton 1989).

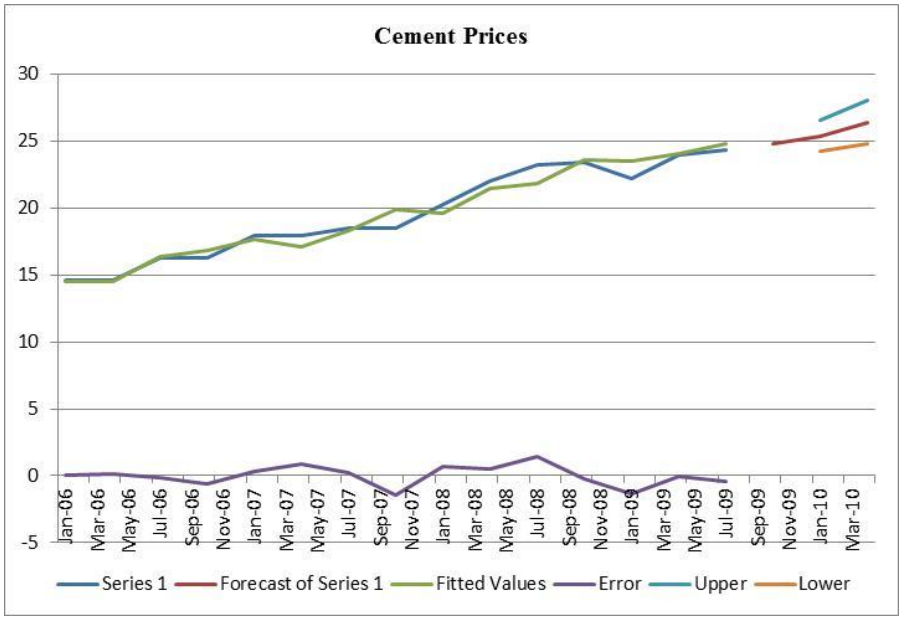

Figure 4: ForecastX observed and fit values for cement prices in economic growth period

Crushed stone and sand prices analysis

For the economic stability period, the crushed stone analysis on SPSS revealed a simple model, which is a model with a constant percentage rate for growth or decline that can be exponential in nature and has neither trend nor other pattern except random movement in the graph with its only smoothing parameter being level (Sorensen 2006). The ForecastX software detected a Holt-Winters model for both the stable and growth economic periods. The model detected for the economic growth period by SPSS was a Holt model, whereas the model detected by ForecastX was Holt-Winters.

A simple model was detected for sand prices in the economic stable period. ForecastX results for the same periods fitted a Holt-Winters model. As for the economic growth period, the fitted model for sand prices was the Brown model. Brown and Forsythe (1974) defined Brown's linear trend as the model that is appropriate for series in which there is a linear trend and no seasonality. Its smoothing parameters are level and trend, which are assumed to be equal. Brown's model is therefore a special case of Holt's model. Brown's exponential smoothing is most similar to an ARIMA model with zero orders of autoregression, two orders of differencing, and two orders of moving average, with the coefficient for the second order of moving average equal to the square of one-half of the coefficient for the first order. The model fitted by ForecastX for the same period was Holt-Winters.

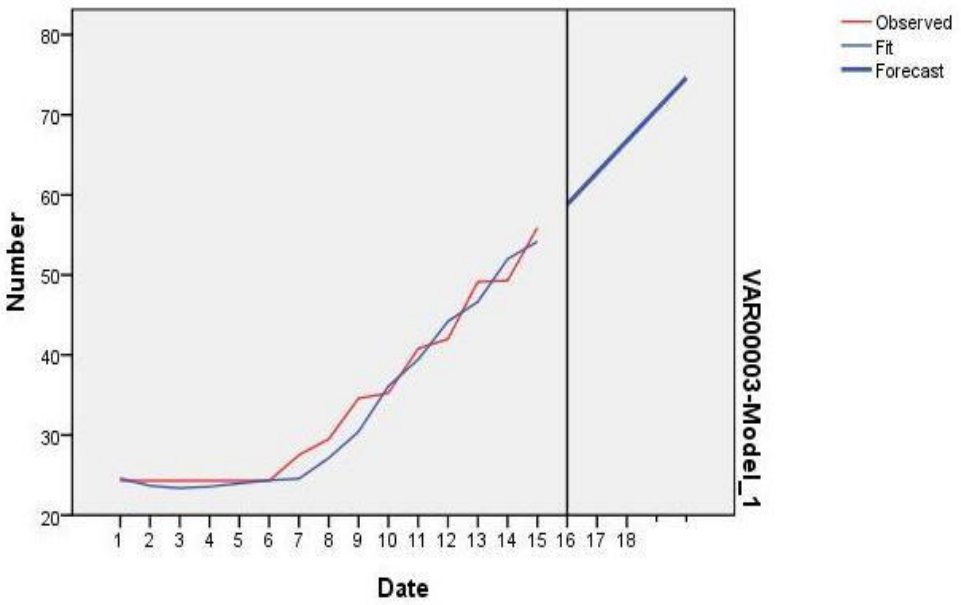

Figure 5: SPSS observed and fit values for crushed stone prices 2006-2009

Steel prices analysis

The fitted model for steel prices by SPSS in both the stable and growth economic periods was the simple model. The trend of the model in the growth economic period was horizontal, as shown in Figure 6, which although reports a simple model, shows inability to predict price values. This can be contributed to the unexplained variability in steel prices in Egypt in that period and the general public conception of price fixing, although no formal charges had been proven. ForecastX, on the other hand, fitted the stable economic period to the Holt-Winters model and the growth economic period to an exponential smoothing model. However, the plot shows inability to predict price values.

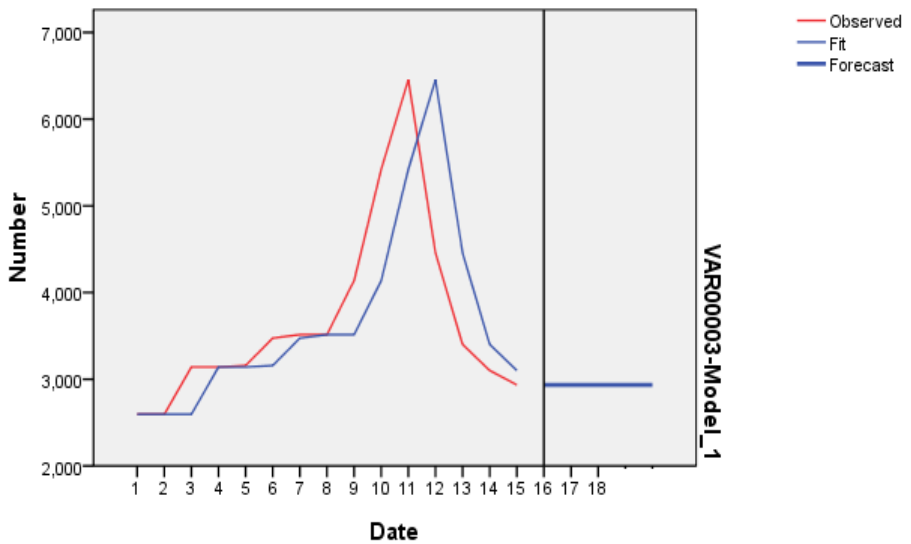

Figure 6: SPSS observed and fit values for steel prices in economic growth period

VALIDATION AND RESULTS COMPARISON

Validation is the process of determining the degree to which a model or simulation is an accurate representation of the real world from the perspective of the intended uses of the model or simulation. To validate the results of this research, a comparison

between the two methods results and the actual data, which was published by CAPMAS (2010). CAPMAS substituted wholesale prices reporting with retail prices reporting from 2007. Thus the actual wholesale prices for 2010 were calculated from retail prices with a correction factor. Table 1 shows the predicted values by both software and comparison with the actual prices. The difference between the results of the software are negligible and in the range of 1%. In light of the high variations of material prices in Egypt, the time-series average predictions were mostly in a range of 10% of the actual prices. The percent deviation for quarterly prices was the least for cement, and showed considerable variability.

A factor that might have impacted the average percent deviation is the global financial crisis in the second half of 2008. The crisis sparked off in the United States and spread to Europe and the rest of the world including Egypt, although not with the full effect as that in USA and Europe. Building and construction growth dropped from 15.4% before the crisis to 9.3% after the crisis (Abu Hatab 2009). A drop in growth can cause surplus in supply versus demand, and thus lower prices. This can explain the negative % differences in predicted vs. actual prices in Table 1. The unpredictability of the steel Time Series model can be attributed the positive % deviation in the validation. It can be concluded that, albeit Time Series Analysis is a good prediction technique, as shown in the high fit values in the analysis, it cannot accurately predict sudden events (wild cards) such as macroeconomic changes.

Table 1: Validation of RC Material Prices' Prediction in EGP

Material	Period	Predicted SPSS	Predicted ForecastX	Actual	% Dev. SPSS	% Dev. ForecastX	Avg. % Dev. SPSS	Avg % Dev. ForecastX
Cement	Oct. 2009	25.53	25.4	24.9	-2.53	-2.01	-5.13	-4.23
	Jan. 2010	26.27	26.43	25.24	-4.08	-4.71		
	Apr. 2010	27.02	26.32	24.84	-8.78	-5.96		
Crushed Stone	Oct. 2009	58.81	57.26	56.3	-4.46	-1.71	-13.98	-9.73
	Jan. 2010	62.76	63.94	53.19	-17.99	-20.21		
	Apr. 2010	66.72	59.9	55.84	-19.48	-7.27		
Sand	Oct. 2009	28.23	28.45	27.68	-1.99	-2.78	-8.51	-8.18
	Jan. 2010	29.58	30.58	26.65	-10.99	-14.75		
	Apr. 2010	30.94	29.42	27.49	-12.55	-7.02		
Steel	Oct. 2009	2933.61	2949.53	2935	0.05	-0.50	8.37	7.36
	Jan. 2010	2933.61	2976.31	3085.4	4.92	3.54		
	Apr. 2010	2933.61	3010.49	3672.9	20.13	18.04		

CONCLUSION AND RECOMMENDATIONS

The accurate estimation of concrete material prices is an essential practice, especially in developing countries where high price fluctuations can negatively affect projects' success and even viability. Factors affecting steel and cement prices (the major cost contributors to RC) have been related in previous literatures to cost of the production process, raw material prices, energy prices, macroeconomic variables, and industry related factors. A Time Series Analysis was conducted on the material components of RC in Egypt in the period from 1997 to 2009, in a univariate manner because other

predictive techniques require future input variables that are not readily available to estimators. The analysis was differentiated for a stable economic period and a growth economic period. The outcomes of the Time Series model can be different in both periods and thus caution should be taken in the times of economic change or status switching. The results were verified using two distinct software: SPSS and ForecastX for the Time Series Analysis. The fitted Time Series models where used to predict the prices along 3 quarters and compared to actual prices to validate the models. A reasonable degree of prediction accuracy was concluded for all materials, and in particular cement, although the global financial crisis in 2008 was found to negatively affect the predictive capability of the model. Time Series Analysis in general, although being a good prediction technique in stable economic and industry conditions, cannot predict sudden macroeconomic or other events. High variability in construction material prices, and in particular RC, in developing countries poses high risks to domestic and international developers and contractors, thus making it increasingly important to utilize prediction tools, such as of this paper, in cost estimating and bidding. Further research is required to tie in input variables of material costs based on leading cost indicators and to explore how the effects of sudden events can be realized and hopefully predicted, if possible.

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HEALTH AND SAFETY & RESPECT FOR PEOPLE

INCONSISTENT, INCOMPLETE AND INCIDENTAL: SITE SAFETY CULTURE FROM A CONSTRUCTIONIST PERSPECTIVE

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Safety culture is a common concept within both academia and industry, where large UK contractors have made significant efforts to improve the safety culture and consequently the safety of their sites. Although from either perspective, 'safety culture' itself is not yet fully emergent. Academic research has sought to identify and measure safety culture on sites, however such a quantification of culture is something that may not ultimately be possible. Grounded in social constructionism, this study instead sought to explore and examine safety culture in practice. This epistemology enabled the exploration of culture through the discursive patterns and constructional frameworks that surround safety on sites, themselves constructed through shared social practices and resources. Data was collected from five UK construction projects, all over £20m in value, and included site safety signage, safety talk and various safety documents. Discourse analysis, followed by triangulation of the key themes and representations, revealed considerable variation in the constructions of safety on sites. Safety culture was found to be inconsistent, incomplete and incidental; relating to a variety of different realities in a variety of different contexts. This variation not only has significance for the practices of large contractors in their desire to develop safety culture on sites, but also the direction of further academic research. Recommendations for practice were generated, in order to facilitate further improvements in safety on sites.

Keywords: discourse analysis, safety, safety culture, social constructionism.

INTRODUCTION

Working on UK construction sites is frequently perceived to be a dangerous activity, a perception understandably grounded in the high level of industry accidents and fatalities; construction is currently the third most dangerous occupation in the UK (HSE 2011a).

Unsurprisingly, this situation is not tolerated by the UK government or by the UK construction industry itself. Focus on improving the safety record of the industry has

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Sherratt F; Farrell P and Noble R (2012) Inconsistent, incomplete and incidental: Site safety culture from a constructionist perspective *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 393-402.

been continuous, and supported by academic research, considerable efforts have been made to improve safety within the industry. Most recently, safety culture has become a key concept in the management of safety on sites, despite on-going debates about its manifestation in practice.

This paper presents the findings of a wider research project which sought to examine the social construction of safety on large UK construction sites. The aim of the research was to provide deeper insight for practitioners of safety management of the associations and understandings of 'safety' amongst the site-based workforce. Building on precedent from other social constructionist studies (Gergen and Gergen 2004; Wiggins and Potter 2007), a deeper understanding of safety within the site environment has the potential to inform recommendations of different practices and interventions to produce change and improve safety management on sites.

CONTEXT

'Safety culture' has recently come to the forefront of pro-active safety management in the construction industry. There has been a sea change amongst larger contractors since the safety summit of 2001 (Chevin 2007), and the concept of a safety culture has been adopted on a significant scale by those seeking to improve safety on their construction sites (Ridley and Channing 2008). Seen by industry as a natural progression after the implementation of Safety Management Systems (SMSs) within organisations, safety management then focuses on safety culture (Hudson 2007).

The original concept of safety culture had close links with the human factors theory of accident causation, and unsafe behaviours were frequently cited as evidence of a poor safety culture (HSE 2003). Indeed some have argued that the popularity of safety culture as a concept was due to the convenience for accident investigations to report 'poor safety culture' as the underlying cause (Baram and Schoebel 2007).

There are a large variety of definitions, models and processes which attempt to clarify, predict, develop or examine safety culture within the literature; for examples see ISOH (2004); HSE (2005); Ridley and Channing (2008); Mohamed and Chinda (2011); Maloney (2011); Wamuziri (2011). However, agreement as to what a safety culture actually is, how to measure it, or how to effectively develop one has yet to be definitively established within the construction arena (IOSH 2004; Wamuziri 2011). The quantification of safety culture is also attempted, seeking to measure safety culture through means such as surveys and questionnaires (Guldenmund 2007) which have developed the quantifiable construct of safety climate (Lingard *et al.* 2010).

Such variation within the definitions and models of safety culture within construction management research can be directly related to culture as a concept in the wider academic field; indeed there have been hundreds of different definitions of culture employed in psychology, anthropology and other disciplines (Toomela 2003). For example, culture can be defined as '… the beliefs of a society, represented through words and actions, ideas of what is held as important and expectations of acceptable behaviour' (Fulcher and Scott 2007: 14); or '… socially shared information that is coded in symbols' (Toomela 2003: 37); or Hofstede and Hofstede's (2005: 4) famous '… collective programming of the mind …'; or even the self-proclaimed 'plain speaking' definition: 'it's the way we do things around here' (HSE 2011b).

It would appear that all that can be stated with any certainty is the uncertainty of any consensus as to what safety culture is, how to measure it or, more practically, how to influence it. Academically, the concept of safety culture within construction is not yet

fully emergent. Although research has sought to identify and measure safety culture on sites, such a quantification of culture is something that may not ultimately be possible. The dissonance within current research suggests that safety culture itself may not be sufficiently coherent to enable such investigation, capture or modification.

However, academic debate has not prevented industry from embracing the concept, and the quest for a 'strong safety culture' can be identified through the adoption of certain processes and practices within the site environment. Wamuziri (2011) identified the following practices among others, as positive influences on safety culture: top down management commitment, worker engagement with formal and informal communications founded on trust, a no-blame culture to encouraging accident and near miss reporting and the use of programmes such as behaviour based safety. Some of these aspects are further supported through legislation, for example worker engagement is legislated for within the CDM2007 Regulations in a section devoted to such communications (HSE 2007) and the HSE also promote a specific Worker Engagement Initiative for the construction industry (HSE 2011b), to achieve a ‘ … step-change in the health and safety culture of the construction industry.’

The most prominent manifestation in practice of safety culture is found in the implementation of Safety Culture Programmes (SCPs). Such programmes seek to win the ‘hearts and minds’ (Worthington 2007) of all members of organisations, by the promotion of a caring attitude on sites (Illia 2006). The most prominent branded SCP in the UK is the Incident and Injury Free (IIF) programme, originally from the USA, and adopted in the UK by both Laing O’Rourke and LendLease. As Laing O’Rourke stated on its website, ‘IIF represents a step-change in attitudes to safety .. underlining the personal responsibility we each have to ourselves and each other’ (Laing O’Rourke 2011), a philosophy echoed by LendLease, who have commented that IIF requires ‘ .. individuals to take a personal stand … with a mindset intolerant of any injury or incident .. ’ (LendLease 2011). However, these programmes have not been without their critics, and the HSE have reported that there is little firm evidence of their success, despite positive reports about their implementation on large sites (HSE 2008). Whether these practices are effective or how they influence safety outcomes has been explored far less within academic research (Biggs *et al.* 2005) than the broader concept of safety culture itself.

METHODOLOGY

Culture is about people. Although research examining people and safety is high on the agenda within construction management, it is generally approached from a quantitative methodological position (Fellows and Liu 2008). However critics have argued that this has led to a field of research concerned with explanations of behaviour rather than understandings (Dainty 2008). Consequently, this study was grounded in social constructionism (Burr 2003; Gergen 2009), an interpretive approach which would enable an exploration and examination of safety and safety culture in practice.

Social constructionism sees the world as socially constructed by the people within it through systems and practices, and for various reasons such as convenience (Gergen and Gergen 2004; Crowther and Green 2006). This challenges the concept that knowledge is a direct perception of reality; if the only realities are those which are constructed by individuals or societies in specific contexts (Gergen 1999), they are therefore in constant flux; there can be no such thing as an objective reality or fact (Burr 2003). Furthermore, if there is no objective reality (Gergen 1999) the 'culture' of that reality certainly cannot be established objectively, definable or measurable

perspectives of safety culture become defunct. Rather, realities are constructed by language in the form of discourses, which include talk and text, shared practices and resources (Potter and Wetherell 1992).

However, an examination of the discourses of safety can be seen as an examination of culture, the context of the discourses. Discourses are shaped by shared cultural resources from the immediate community (Augoustinos *et al.* 2006), and culture can therefore be seen as the network of discourses that socially construct the world (Gee 2011). This study, in its focus on safety within the site environment, will inevitably enable some illumination of how safety is constructed within this cultural context; the 'safety culture' of the sites.

Data was collected from five UK construction projects, all over £20m in value, and included images of site safety signage, audio recordings of conversations discussing safety and various hard copy safety documents. The talk data was transcribed using the Jefferson system (2004), and was inputted, along with the digital images of site signage, electronic copies of the PowerPoint induction presentations and scanned copies of the hard copy documents, into NVIVO8.

Data collection, coding and discourse analysis (Augoustinos *et al.* 2006) was a concurrent process, enabling a method of constant comparison to be employed. Through this approach new data was analysed and constantly compared as it was gathered to the existing data analysis library in order to illuminate themes and patterns, or indeed anomalies. This interpretive approach necessitated multiple and repeated passes of the coded data (Taylor 2001) which enabled the researcher to explore the discourses of safety within the data until no new patterns emerged and saturation had been reached (Flick 2009). Examination both within and between the data sources was undertaken during the analysis, which was intrinsically linked to the coding process through shared development. There is no predetermined protocol when performing coding and analysis within this approach (Peräkylä 2007; Gibbs 2007) and the coding was driven by the data to be as inclusive as possible to allow major themes, ideas and interpretations to be identified. The most prominent of these were then developed through further passes of the data and a variety of lenses (Potter and Wetherell 1992). This analysis ultimately produced a detailed, explicative narrative, which explored the data sources in turn, identifying and examining the most prominent, or master, discourses of safety as they developed from the data.

FINDINGS

Safety on UK construction sites was found to be highly chimeric, demonstrated by the variety of discourses of safety identified within the data, as well as the variety and disparate nature of the discourses themselves. Due to constraints of space, the findings presented within this paper explore only one of the discourses of safety identified within the study as a whole, that of 'safety as practice'. This master discourse was thought to be highly relevant with regard to safety culture, and eminently demonstrative of the findings of the study overall in terms of the understandings of 'safety' on sites.

Representative examples from the data have been included within this section in order to demonstrate the development of the discourse of 'safety as practice' from the data. This discourse was itself highly diverse, and two opposing representations readily emerged from the data; safety as 'entity', totally disassociated from practice, and safety inherently bound up in practice. Both were also associated with various relationships

between safety and practice, safety positioned as a negative influence on practice and practice as a negative influence on safety.

The talk of a main contractor's male site operative discussing a recent safety programme that has been introduced on the site is highly illustrative:

36. R: yeah=[it has but (0.2)] erm (0.8) some↑times its (0.2) it just
37. I: [what od'ya thinko]
38. R: stops the jobs half the time some of it, dun[nit?]
39. I: [yeah]
40. R: you know when some of the stuff gets to:o (02.) carried away
41. really I think (0.8) when it's just common sense at some of the
42. ti[me]=

Rather than explore recent changes in terms of accidents or with regard to safety practices, the speaker instead positions safety as a hindrance to work practice. Safety is constructed as an entity rather than inherently linked to any specific practices or tasks; and is positioned by the speaker as a behemoth with the power to actually stop work. This construction is then developed into safety practices, although these remain distinct from site practices and are themselves belittled by the speaker as beyond 'common sense'. There is no consideration of consequences in terms of accidents or incidents if safety impositions were not in place, nor of the possible good these safety practices may be performing, rather these safety is positioned as directly hindering work practices.

In drawing on the discourse of safety in practice through the negative within his talk the speaker has constructed a version of reality where production is king. Safety practice, although arguably not actually too onerous when considered within the scope of site work, is accorded the status of a considerable hindrance when positioned within a production-driven reality.

This is further illustrated through the talk of a subcontractor's operative below:

113. R: = probably fall into the same bracket as everyone else in that
114. respect whereas .hhhh er:: where yeah-in- (0.2) doing the job
115. where its unsafe and you c-can find little shortcut ways round
116. things I suppose it's just (0.4) jumping in the room you
117. shouldn't be in for two minutes which's got li:ve parts in
118. (0.2) and you know you can be in th-in and out of there in two
119. minutes=you're job's done (0.2) the alternative might've been
120. two or three days sorting stuff out (.) to get in that job
121. (0.4) I just find er::: (0.4) the ↑hassle of safety [is t]he=

Here, the speaker again positions safety in practice, and initially develops a detailed scenario where safety is violated in order to achieve production. This scenario is then contrasted to the correct and safe procedure in which the speaker positions time as the key variable, and contrasted 'two minutes' with 'two or three days' in order to justify the behaviours within the scenario. This scenario construction serves to position

‘everyone’ as justified in behaviours which value time and consequently production against safety, and the speaker ultimately positioned production as the ultimate goal.

Through the negative discourse of safety as practice, the speaker not only segregates safety from production, but actually places it in direct competition. The potential consequences of the safety violation, which in this speaker’s own scenario could potentially be death, are not explored and the construction of the event does not entertain the fact that the individual concerned could come to harm. This construction of safety as practice juxtaposed with production was common within the data, safety was referenced as either entity or practice, yet both were ascribed the power to stop or delay work to the detriment of those concerned. There was no extrapolation of the consequences of safety in terms of positive influence, such as accident mitigation or improvements in process.

In contrast, the discourse also developed around the influences of site practice on safety. An example can be seen in the talk of a main contractor’s supervisor below:

97. R: Well if you go down to the root cause of that it comes back to
98. the subcontractor nature=the subcontractor all he’s interested
99. in is earning money (1.2) I mean yo-=especially now where
100. rates are going down he’s got the pressure on him even more to
101. generate money (0.8) to keep his family basically.
102. I: Yeah
103. R: It all comes down to earning money doesn’t it? (1.0) the bottom
104. line

The speaker here was discussing unsafe behaviours on sites. The discourse initially establishes the subcontractor as 'other', positioned almost as a different species, with a distinct ‘nature’. This nature is then developed as the justification for subcontractor behaviours within the site environment and the lack of participation in safety in practice, with some sympathy. Despite the continued distinction between subcontractor and management supervisor, the speaker’s construction of the subcontractor is accepting of the subcontractor’s own concerns; considerations of the economy and family are then developed to further justify this inherent ‘nature’ and consequential action. The participation of subcontractors in safety in practice is constructed here as inherently bound up with money, or rather the traditional payment processes of sites. In this particular text, it is the site practice of payment on price that was positioned as the negative influence on safety.

Acknowledgement and validation of this relationship between safety as practice and site practice could also be located within the site induction presentations, which also developed associations with responsibility for safety. In one induction data source, the text of the MS PowerPoint slide reads "In conducting your works please note: Nothing you do is so important that the time cannot be taken to do it SAFELY!". This entire text was personally directed towards the audience though the use of ‘your’ and ‘you’, and constructed a direct association with their behaviour and safety. Safety was bound up with practice, the use of ‘time’ and ‘important’ positioned it firmly within the reality of productivity, yet also challenged the association with reference to safe working practice.

DISCUSSION

The discourse of safety as practice developed some significant insights into the safety culture of large UK construction sites. The constructions of safety as entity disassociated it from the social, engagement or interaction with the site environment unnecessary for its existence or function, which has significant consequences in terms of practice. Separation from the social sets safety apart from the quotidian interactions of sites; although present, safety is not necessarily engaged with everyday practices and work processes. This is in sharp contrast to the aims of Safety Management Systems and safety culture programmes of the industry, which seek to instil safety within all aspects of the construction site environment, and embed safety principles within all work practices (HSE 2007).

The opposing representation of safety as inherent in practice fulfilled the aims of the safety programmes far more satisfactorily, with safety bound up as an inherent part of practice, embedded within the actions and interactions of the site. Safety as practice was incorporated within a wide variety of specific work practices and processes as well as more general social interactions on sites.

These two developments within the master discourse of 'safety as practice' reflect variety in the individuals of the site and their own personal social constructions of safety, and therefore indicate significant variation within the safety culture. Although it could be suggested that safety as entity is a simple rhetorical manifestation of reference to an abstract concept, it is equally suggestible that it is the associations of ownership and responsibility that are important here and have actually directed the rhetoric. Indeed, as evidenced by the legalese that permeated the texts of the documents of safety, it actually is, to some extent, somebody else's problem, articulated through a language far remote from the 'muck and bullets' of the site itself.

The discourse of 'safety as practice' was also bound up with the activity of safety as work practice and safety as safe practice, which were themselves found to negatively interrelate through the negative influences of safety on site practice and the negative influences of site practice on safety. Indeed the practice of safety was frequently constructed as a direct challenge to the practice of work and sought to prioritise safety within the work environment, as promoted by safety management systems (Lingard and Rowlinson 2005). Safety as practice was seen as interfering with the work of the site, and was placed in direct competition to positive production, either abstractly or through development of detailed scenarios.

However, the constructions of safety as a negative influence on practice were challenged by constructions of practice as a negative influence on safety. Within the site environment, common processes within construction site management, such as payment on price (Spanswick 2007), the perpetual pressures of time and money (HSE 2003) were seen as negative to the positive implementation of safety in practice; either safety must be sacrificed for production or production sacrificed for safety. These two constructions also developed through the hierarchical positions of main contractors and subcontractors, although both also acknowledged the potential influences of these pressures on the other, and the negative effect of safety on practice was rarely constructed outside of a context of production and pressure. Safety was not negated for and because of itself; rather it was very much discursively associated with practice.

This association was also addressed directly by site safety management, whose prioritisation of safety within the construction site place was often made in direct

contrast to the values of production. The recipients of the site inductions were given the direct instruction to value safety above production and productivity. Ongoing tension between productivity and safety is a recognised aspect of construction site life (HSE 2009) and its manifestation within the discourse of safety as practice has served to further highlight its scope of influence.

CONCLUSIONS

The literature indicates no consensus within construction management as to what safety culture is, how to measure it, or how to develop one. Indeed, the debate and discussion around culture within academia as a whole suggests that safety culture may not actually be sufficiently coherent to enable investigation, capture or modification. This examination of just one of the master discourses of safety identified by the wider study, that of 'safety as practice', supports this suggestion. When considered with relation to safety culture, a highly complex and mutable construct develops. The paradoxical constructions of entity or practice and the shifting challenges and realities in which the discourse operates, suggest that safety culture can be described as inconsistent and incomplete. That safety culture is so closely bound up with practice and work, further suggests it is incidental in nature, an accompaniment to the main focus of the sites; production and practice.

A change of definition is arguably required to develop safety culture into a relevant and applicable construct for the site context, or a change in terminology is required to position safety on sites within a construct more reflective of its turbulent existence.

However, beyond semantic debates, this discursive approach to safety on sites has also increased understanding of safety within this context. How safety is approached and considered by those who work on the sites should be considered by those who develop and implement Safety Management Systems and Safety Cultural Programmes for sites. For example the inherent inclusion of safety within work practice is arguably necessary, beyond the practice of safety itself, rather than positioning it as an 'add-on' to work activities. Furthermore, safety management must also drive change at the corporate level. The impact of corporate decisions at tender stage can be found in the talk at the site level, and their employment as justification for the common safety violations due to time and money is in direct conflict to the development of safety in practice. In order to develop a safe site, these factors need to be considered and addressed in context to eliminate their influence on un-safety.

It is also suggested that further research to fully explore the social constructions of safety within the site environment is carried out, to develop more robust associations to increase knowledge and understanding of the inconsistent, incomplete and incidental safety culture found there. Such research can also inform the production of positive interventions in order to assist in the improvement of safety management practices on sites.

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EXPLORING HUMAN ERROR THROUGH THE SAFETY TALK OF UTILITIES DISTRIBUTION OPERATIVES

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Cable strikes form a significant safety challenge for the construction industry's utilities sector. Such incidents can and do result in both death and injury for the workforce, as well as costing companies millions of pounds in associated damages and compensation costs. Despite specialised tools, processes and training programmes, cable strikes still occur on a regular basis. The majority of cable strikes are, like many incidents within the construction industry as a whole, attributed to human error. However, current thinking has suggested that human error is itself a symptom, rather than a cause, and theories have developed to position the incident-causing human error action as the final link in a much longer chain. This paper presents an exploratory study which sought to examine this theory within a specific context; the construction utilities sector and cable strike incidents. Seven interviews were undertaken with operatives within their work environments, which gathered talk around general safety and cable strike incidents. A thematic approach enabled patterns within the transcribed data to be extracted and contextualised within industry practice. Findings indicated that operatives assigned a variety of different causalities to their experiences of incident occurrence, which were then used to construct a taxonomy of the causal factors of cable strikes from the operatives' perspective. These factors were then analysed within the industry context to construct potential 'causal chains' which are able to link the site incidents to management policy. This study, although exploratory, suggests that application of the systems theory of human error is highly applicable to the construction industry, and that the focus of safety management and safety management research should look beyond operatives on the front line to seek further improvements in safety performance.

Keywords: accidents, human error, safety, utilities.

INTRODUCTION

The construction industry is one of the most dangerous in the UK; it accounted for 27% of all fatal workplace accidents in 2010/11, making it responsible for almost a third of all deaths at work (HSE 2011). Significant and inevitable hazards which affect

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Patel M; Sherratt F and Farrell P (2012) Exploring human error through the safety talk of utilities distribution operatives *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 403-412.

construction companies and more specifically the utilities installation and maintenance companies, are underground services. Services within the ground include high/low voltage cables, street lighting cables, water, gas, telecoms, drains and sewers. However, for the purposes of this study, concern is focused on incidents involving the electricity network, subsequently termed 'cable strikes'. The hazards and risks associated with this specific type of service are extremely serious, both to the health and safety of the workers and approximate public, alongside the financial repercussions of a cable strike (Stancliffe 2008). Indeed considerable efforts are ongoing to examine the underlying causes of accidents and incidents within the construction industry as a whole (HSE 2009a), and the utilities industry has developed its own innovative solutions to mitigate these incidents, such as air shovels and vacuum excavators (ODA 2011; ADP 2012).

However, incidents still occur and utility safety training has recently focused on the human factor in terms of behaviours and attitudes to safety in the workplace (Industry Today 2011). Theories of human error have seen significant developments since Heinrich's (1980) study laid the majority of blame for incidents at the feet of operatives, and a systems approach now positions the human factor within the context of influential industry practices and processes. This study seeks to explore, from the site level upwards, the systems that potentially influence the behaviours and attitudes of the utilities installation and maintenance operatives as they carry out their works in this hazardous environment.

LITERATURE REVIEW

The Utility Context

An estimated 4 million holes are dug by utilities companies annually in the UK, a figure which does not include the many excavations carried out as part of ongoing construction projects (Stancliffe 2008). The precise number of cable strikes and subsequent injuries as a result of these excavations is more difficult to source due to parameters within the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (HSE 2012a) and the Electrical Safety, Quality and Continuity Regulations 2002 (as amended) (HSE 2012b). However the utility distribution industry does make its own estimations, for example Industry Today (2011) puts the figure at 60,000 strikes annually that are reported, whilst industry insurer Zurich (2007) claims an average of 12 deaths and 600 serious injuries per year are attributed to cable strikes.

Despite a lack of clarity in the figures, the potential severity of the consequences of cable strikes is not in dispute. Damage to underground services can cause fatal or severe injuries (HSE 2005) as well as the potential for fire or explosions, and these risks are not just to the workforce but also the general public. Even non-fatal shocks can cause severe and permanent injury (HSE 2010). Flash burns may occur as a result of arc formation; burns may be extensive and lower the resistance of the skin so that electric shock may add to the ill effects. Temporary blindness can also occur due to burning the retina of the eye (Hughes and Ferret 2007). Alongside the human costs, the financial repercussions can be severe. A recent case examined an accident in which an employee received life threatening 60% burns after striking a high voltage cable with a hydraulic breaker on London's Crossrail project in 2008. In addition to the disabling injuries received by the operative, the employing company was fined £55,000 with £30,000 costs (Prior 2012).

Such financial repercussions are commonplace within the industry, and insurer Zurich publish its own 'best practice guidelines for construction companies' to avoid underground cable strikes. Zurich (2007) warn that whilst insurance may cover the repair and legal costs for claims, it will not cover the costs of incident investigation, loss of contracts, insurance excesses, penalties and reduced bonuses. Indeed, the fines that can result from a utility service disruption often drive the total cost of the event even higher (Utiliquest 2010).

With regard to human safety, the HSE have published detailed guidance for best practice in the form of Guidance Booklet HSG47 'Avoiding Danger from Underground Services'. HSG47 outlines the dangers which can arise from work near underground services and gives advice on how to reduce the risk (HSE 2005). HSG47 requires detailed inspections prior to any excavation to ensure that all utilities are identified and safe systems of work employed to detect the presence of underground plant and services. Safe systems of work are a fundamental feature of HSG47 and include all aspects of the work; planning, utility drawings, cable locating devices and safe digging practice.

Flyn *et al.* (2000) note that in industries where significant hazards exist, there is considerable attention paid to safety assessment, and this is evident within the utilities industry. Safety management systems, as established by the HSE in its guidance documentation, 'Successful Health and Safety Management' (HSE 2006) can be found within larger contractors of the industry. Its implementation looks to provide structure to the legislative and other safety management requirements of organisations, and articulate their practical implementation on sites (Howarth and Watson 2009). For example, Enterprise (2012), one of the UK's largest utility installation and maintenance contractors promotes its own safety programme 'TargetZero', launched in 2003 '… with the belief that all accidents and incidents can be prevented …' as well as establishing a safety management team to ensure full employee training, personal ownership of health and safety in addition to meeting all legislative requirements.

However, cases brought to court reveal that the HSE Guidance and company procedures are not necessarily followed in practice. For example, HSE inspectors examining the Crossrail incident found that no effective lines of communication had been established, appropriate training in digging techniques had not been provided, key safety documentation showing the cable was not to hand at the work location, and although the site had been scanned no markings had been made to show the locations of buried cables. As this incident happened in a busy London street, the HSE inspectors felt it was '… completely foreseeable that cables would be present …' (Prior 2012). Following an incident in 2002, the HSE (2002) voiced a warning to the construction industry to ensure safe working practices are followed when working near buried electrical cables. This followed an incident where an employee suffered burns to the face and neck as a result of striking a live 11kV electricity cable and the employer fined £10,000, yet the investigation concluded that had the method statement actually been followed in practice '… this was a preventable accident.'

Theoretical explanations for these behavioural challenges to procedures can be found within the management structures and payment systems of the utilities sector. In keeping with the practices of the construction industry as a whole, a large proportion of utilities work is subcontracted both by the operating companies to contractors, and also from contractor to contractor due to the fluctuating workload (Lingard and Rowlinson 2005), resulting in potentially elongated supply chains and highly

fragmented delivery systems (Loosemore *et al.* 2003). The utility industry subcontractors are paid on a price per metre basis as an incentive to increase productivity, facilitated by the ease with which outputs can be measured and rewarded (Harris *et al.* 2006). However, this practice has been found to encourage operatives, who are also paid on price, to work as fast as possible to make the most money in a day or shift. As speed often means cutting corners and taking risks, safety is often sacrificed (Spanswick 2007). In a work scenario where painstaking preparation through the use of Cable Avoidance Tools, followed by careful and precise excavation using hand tools or mini diggers is essential for cable avoidance, a payment structure based on speed of installation appears somewhat incongruous.

Indeed, recent developments in training have shifted in focus from technical to behavioural. The online 'cable avoidance evaluation' assessment for operatives has been developed by a utilities industry training provider, to establish knowledge, confidence and attitudes rather than just technical knowledge to enable evaluation of skills gaps and training needs (Industry Today 2011). Such an approach acknowledges the people in the process, and their influence and participation within cable strike incidents; indeed, a human influence can be identified in the case studies noted above. Consideration of the human element as a causal factor in accidents and incidents is not uncommon within the construction industry as a whole (HSE 2009a) and associated behaviours such as inaccurate assessments, bad decisions and poor judgements are often judged the root cause of incidents (Perrow 1999; Dekker 2006).

Theories of Human Error

Traditionally, 'blame' was allocated to individual workers through their 'error' in terms of poor behaviour or inadequate risk perception. This approach is based on the work of Heinrich (1980) and his seminal examination of accidents at work, which drew the conclusion that 88% of workplace injuries were due to unsafe acts on the part of operators. Although this study has since been criticised for the choices made in data selection and classification that may have led to this high figure (Woodcock 2007), human error is still seen as a major cause of accidents within construction (Wilson 2007; HSE 2009a). Indeed one HSE report (2003a) found that worker actions and behaviours contributed to over 70% of the accidents investigated, and such high estimations are not uncommon within industry (Wilson 2007).

However there has been a paradigm shift in the overall positioning of human error within the accident context, and the view that work related accidents and injuries are a direct result of carelessness and unsafe behaviours has become outdated (HSE 2007). The systems theory of accident causation has challenged this approach. This theory, also known as the 'new view', states that 'Human error is the effect, or symptom of deeper trouble … that it is systematically connected to features of peoples' tools, tasks and operating environment.' (Dekker 2006: 15). It states that people make incorrect assessments or take incorrect action as a result of failures in the systems which have created situations which dictate a certain course of action (Perrow 1999; Dekker 2006). It is no longer accepted that the system will work correctly if not for the behaviour of some 'bad apples', rather there is a need for safety to be instilled at all levels of the organisation (Dekker 2006), including management, who may unwittingly create latent failures within the system through the choices they make in boardrooms (Reason 1990; Kletz 2001). Cultural influences have also been suggested to affect people working within complex systems, and therefore can influence safety

in terms of acceptance of authority, need to conform to the social groups within organisations as well as organisational culture itself (Strauch 2004).

This systems approach has also been acknowledged within construction industry research. The HSE (2009b) commented that although inappropriate actions and behaviours did contribute to incidents on sites, they were in the majority founded on weakness inherent within site management processes. The report found indications that causal factors were operating from well beyond the physical location of construction sites. For example, contracting strategies commonly employed within industry and the levels of responsibility and accountability at higher levels of management were indicated as contributory factors to accidents on sites. The report clearly categorises these 'mezzo' factors, such as inappropriate procurement systems and supply chain arrangements, and also 'macro' factors, such as potentially immature corporate systems and inappropriate enforcement, as areas of latent influence that directly affect construction sites.

Awareness of these higher level factors was also demonstrated in the findings of the earlier HSE Study (2003a), which articulated the potential links between site based causal factors and underlying issues such as design or client influences. However, as Chaplin (2006) noted in his report for the Main Contractors Group examining organisational ‘safety stressors’ and the relationship to accidents within the UK construction industry, accident investigation findings will vary depending on the focus of the investigating team. A focus on human error will seek behavioural causes as opposed to a systems approach to safety. Chaplin identified time based pressure, lack of attention to procedures, and production pressures as the key systemic root causes of accidents on UK sites, whilst also suggesting that personal behaviour and competence were significant human factors, highlighting workplace culture as a key area of concern.

However, despite the use of a systems theory approach within construction safety research (HSE 2009a) to date there has not been in-depth application of the theory to accidents at site level. The HSE has called for research to improve understanding of the links, the systemic connections, between accidents on sites and project factors such as project stage, size of contractor and type of works in progress (HSE 2003b). More commonly, the potential causes of systemic failures with relation to safety are examined solely at the mezzo and macro level, with failures at site level labelled as active (Lingard and Rowlinson 2005) rather than latent, and which retains association with human error, rather than completing the theoretical chain.

METHODOLOGY

This study employed a qualitative and interpretivist approach (Creswell 2003; Flick 2009) in its desire to seek out the subjective experiences, understandings and attitudes of operatives. Semi-structured interviews were employed as the exploratory tool (Gillham 2005), and were undertaken with a sample of convenience consisting of seven members of a utilities distribution operational workforce. The interviews employed open questions to enable probing where appropriate (Fellows and Lui 2008) and facilitate development of talk around safety.

Whilst this small sample size and selection process does not allow for generalisation, it does provide insights as to the perspectives of operatives with regard to safety, cable strikes and the potential causes that lie behind them, and indeed reached a level of saturation within the data (Kumar 2005). These initial interviews were carried out to

start to bring the picture into focus (Fellows 2008), rather than take the finished photograph, and the findings will be used to inform and develop further lines of inquiry and research in this area. It can also be argued that given the peripatetic nature of utilities distribution, the operatives' experiences, perceptions and attitudes are likely to be common within the industry as a whole.

The interviews were digitally recorded, transcribed verbatim and subsequently coded, to highlight themes, consistencies, inconsistencies, patterns and irregularities (Silverman 2001; Langdridge 2005) when the data was viewed through the lens of the literature. Attention was given to the causal factors as developed through the operatives' talk, and the connections and interactions described between them. These factors were further analysed to enable the development of causal chains, sparked by the initial thematic associations from the data, and developed within the context and understanding of industry practices.

FINDINGS

A prominent and overarching finding was that all the operatives were aware of the safety risks and hazards associated with their work and the safety procedures in place to manage and prevent them. However, all but one of the operatives interviewed had struck a cable in the course of their work. Interestingly, the majority could not articulate why the cable strike had occurred, and were reluctant or unable to speculate as to any underlying or contributory causes. Indeed, this was further associated with the proverb 'accidents will happen'; that accidents cannot be avoided, all risk cannot be removed, and cable strikes are an inevitable part of the work.

Therefore, in order to explore potential causal factors further through a systemic lens, the operatives talk was analysed as a whole to draw out the most prominent themes that developed through indirect discussions of the causal factors of cable strikes, rather than seeking direct explanations for incidents the operatives had been involved with. These findings are illustrated in Figure 1 below:

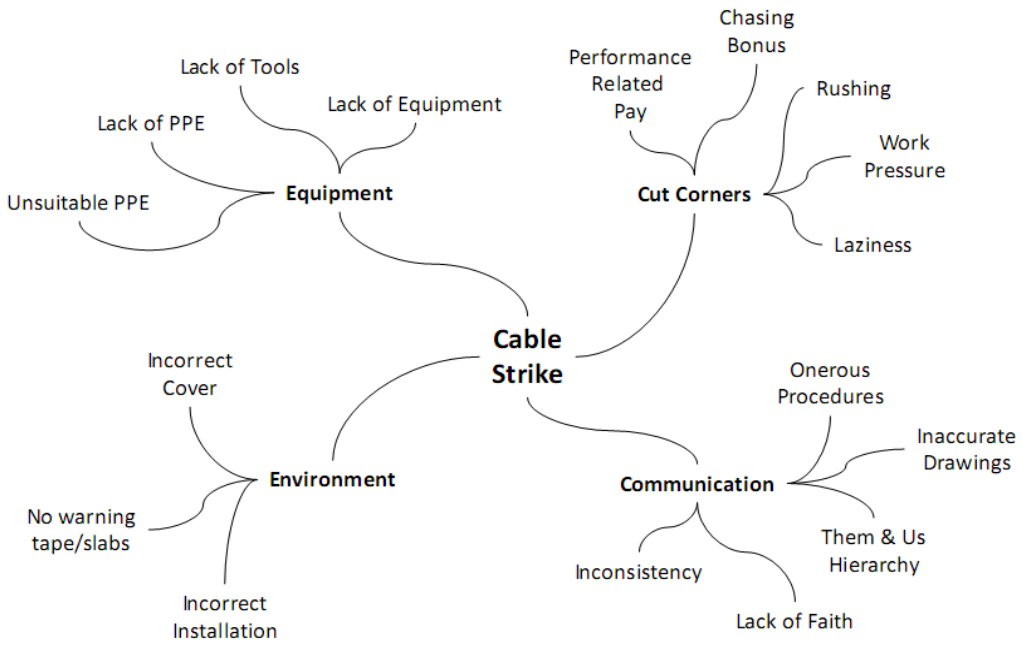

Figure 1: Causal factors of cable strikes

Analysis of the data enabled the identification of four distinct causal factor 'categories'; equipment, environment, cut corners and communication. Both 'equipment' and 'cut corners' were closely associated by operatives with money, and more specifically the management's money. Lack of expenditure for the correct provision of work equipment was a common criticism and the availability of tools and equipment was directly associated with an increase in risk within work practices. Methods of payment, either by rate per metre laid or the provision of a bonus for work completed within a specific timescale, were also associated by the operatives with an increase in risk and the potential for incidents. Although the hazards of the work were clearly articulated and understood, the operatives positioned these two factors directly in competition with safe working practices, including simply taking the time to follow procedures. It was argued that there was no motivation to work in the correct manner when incentives encouraged another route.

Money also constructed a barrier between the site and managements teams, which further developed through the talk within the category of 'communication'. The operatives felt there was a lack of communication and management knowledge and understanding of the site environment and actual requirements needed to follow the policies and procedures they had set down. Management were criticised for making poor decisions regarding work practice when alternatives were available, as well as developing 'onerous' procedures. The operatives also felt that when they raised problems or concerns they did not appear to be addressed, such as near miss data requested by management but not revisited either through feedback or demonstrable changes in practice.

The final categorisation of 'environment' laid the blame for incidents on the previous workforce who had not followed their own procedures in installing or maintaining their utilities, however these operatives were operating within the context of all the other potential causal factors which could have resulted in their own poor work performance.

Reference to the literature and the wider discussions around safety as experienced by the operatives in their daily work enabled the mapping of these site level causal factors, connecting the site incident to the macro and mezzo factors higher up the causal chain. An example of one such chain can be seen in Figure 2 below:

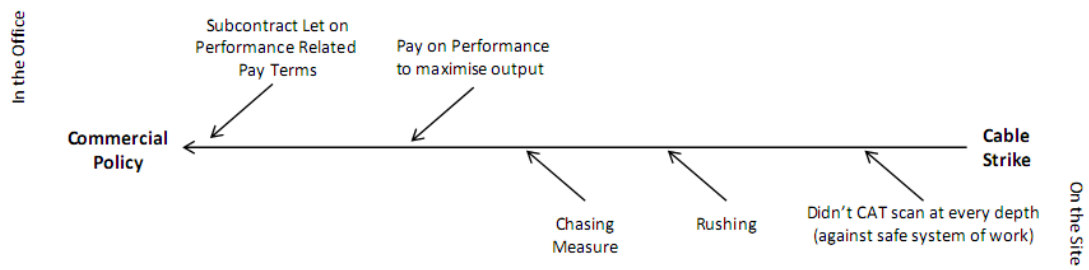

Figure 2: Causal Chain Example

Although highly simplistic in structure, this illustration demonstrates the chain of factors that connect commercial policy directly to a cable strike within just five links of the chain. The flow of influence from site to office, or rather office to site, can be clearly identified from the data provided by the operatives and the associated management practices. The contributory links in the chain, represented as arrows, are

shown on contrasting sides to reflect the fragmented nature of the communication between the site and the office, as articulated by the operatives. Overall, the development of the causal chains through the analysis inevitably led to the commercial policy of the company as the key causal factor at the final link. In reality, this policy will be the product of many other factors, however it has been employed here as a symbol of management practice and as a direct challenge to the health and safety policy that will inevitably sit beside it.

DISCUSSION AND CONCLUSIONS

When the utility operatives' talk around safety was analysed, the 'system' with relation to human error and accident causation became immediately apparent. The categorisations of the data demonstrated the close association between safety and the management system under which the operatives were working, as evidenced through the provision, or rather lack of provision, of equipment, the lack of communication through comprehensive information or the implementation of onerous procedures, and payment structures that fundamentally contradict safety processes in practice. This reference to management and the hierarchy in which the operatives are working can be seen as a manifestation of the system, in which operatives on site form the very last link in the chain. Indeed, a strong critique of the communication between operatives and management was that raising issues '… up the chain …' did not bring any action or feedback.

The resignation of the operatives that cable strikes are an inevitable part of their work could be considered to be the result of a lack of understanding of the systemic causal factors operating within their daily lives. Alternatively, this resignation can be seen as a clear comprehension of their current situation; should the system continue to operate as it does, the inevitability of cable strikes as a daily occurrence will indeed remain inherent within it. The latter is further supported by the repeated emphasis of communication, money and management as prominent causal factors, the operatives demonstrating the system in practice, and constructing their own causal chains behind the safety incidents they witness on a regular basis.

However, one prominent anomaly within the data as a whole was the consideration of laziness or apathy as a causal factor. Whether this was a misconception on the part of the operatives who voiced this causal factor, or indeed the manifestation of an unavoidable 'human factor' could not be further explored within the scope of this study. Its presence within the data was an interesting challenge to the systemic theory of human error, suggesting a fundamental human characteristic, uninfluenced by the systems in which it was operating, and itself worthy of further research.

This study, although exploratory, suggests that the systems theory of human error is highly applicable to the utilities sector, and indeed the construction industry on a wider scale. The focus of safety management and safety management research should look beyond operatives on the front line to seek further improvements in safety performance higher up the causal chain. More extensive research is recommended to develop the application of the systems theory of human error within this context.

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THE USE OF EXPERIENCE AND SITUATED KNOWLEDGE IN ENSURING SAFETY AMONG WORKERS OF SMALL CONSTRUCTION FIRMS

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Techniques used by small construction firms with regards to site safety have been found to differ considerably from those of large construction firms. Workers of small construction firms adopt a 'common sense' approach and eliminate procedures that the workers deem bureaucratic rather than practical. This paper is based on a PhD research project which aims to critically investigate 'good' health and safety practices undertaken by workers of small construction firms and in particular explores the informal ways of managing health and safety. The East Midlands region of the UK was chosen for the study of good practice due to a steady decline in accidents and injuries over the past decade. The research is being conducted with a qualitative approach to gain rich data on site practices and workers perceptions. The findings of a pilot study suggest that workers of the small firms use situated knowledge and experience when dealing with health and safety matters. Experienced workers tend to quickly and informally assess potential risks and subsequently manage their work environment so as to prevent injuries or accidents from happening in collaboration with their co-workers. Specific good practices emerging from the research include verbal and non-verbal communication such as gestures with eyes and hands, vital on-the-job training for new workers and insightful guidance by the leaders in order to attain safe work environments. The aim of this project is to create a foundation for further research into the good practices of small construction firms as the area is currently understudied. Much of the literature in the field focuses on problems and issues with health and safety rather than good practice.

Keywords: accident prevention, tacit knowledge, common sense, small firms.

INTRODUCTION

Construction sites are some of the most dangerous workplaces (Conchie and Burns, 2009). Large and small construction firms implement different approaches to accident prevention and building good safety environment on site (Gillen *et al.* 2004: 235).

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Aboagye-Nimo E; Raiden A; Tietze S and King A (2012) The use of experience and situated knowledge in ensuring safety among workers of small construction firms *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 413-422.

Dissimilarities between organisations stem from differences in management style, training, risk management, site arrangements and use of safety equipment (ibid). In the UK, 92% of the construction workforce is employed by small firms (Edwards, 2011). As they represent such a large proportion of the industry, their safety practices are constantly under scrutiny by policy makers and researchers (Loosemore and Andonakis, 2007). It has been found that the owners of small firms (who usually 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 health and safety practices, other workers in the firm tend to work likewise (Hinze, 2004). Trust and supportive environment amongst workers have also been found helpful in developing safety culture as workers believe they can rely on their colleagues during risky situations and this demonstrates that workers have genuine concern for each other's safety (Conchie and Burns, 2009; Mohamed, 2002).

This paper is based on a PhD project which focuses on the 'good' practices of small construction firms in the East Midlands region of the UK (see Aboagye-Nimo *et al.* 2011). This geographical area was chosen as a focal point of research because of a reduction in accidents and injuries over the last decade. Indeed, this unexpected decline in reported accidents and injuries sparked the interest in the project late 2009.

The Health and Safety Executives' (HSE) records (excerpts of records in Table 1) show the steady decline in accidents from 2001 to 2010. Most importantly, the figures reveal that smaller injuries that kept workers out of work for more than three days (+3 day injuries) have reduced from 10904 to 8049 over the nine year period. This is -2855 point difference, despite a temporary surge 2002/3-2003/4. However, figures for major injuries and fatal injuries have gone down too (-97 and -14 points respectively).

Table 1: HSE records on workplace accidents in the East Midlands (HSE, 2011)

	2001/2	2002/3	2003/4	2005/6	2006/7	2007/8	2009/10
Fatal injuries	23	17	17	11	12	8	9
Major injuries	2175	2153	2488	2293	2295	2238	2078
+3 day injuries	10904	11110	11047	10092	9683	9194	8049

While some may attribute this reduction in injuries to the fall in economic activity, a close look at construction output in the region suggests that this is not the case (see Table 2 below).

Table 2: Construction output trends in the East Midlands (Construction Skills, 2010)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
%change	10	17	26	12.2	24.3	-7.1	-10.9	-27.1	-9.3	15.5

Construction industry in the East Midlands experienced its' lowest level of output during the peak of the global financial crisis in 2008 (-27.1% percentage point change). 2009-2010 indicate recovery to almost as high a figure as shown for 2002 when the economy was known to be more stable. For the same period (2008/9-2009/10), Table 1 shows a notable decline in both smaller injuries that kept workers out of work for more than three days (+3 day injuries) and major injuries - only small increase in fatal injuries is noted.

This paper discusses the use of situated knowledge in achieving good health and safety practices in order to prevent accidents on sites. It begins with a literature review on knowledge management in small construction firms, with a specific focus on tacit

knowledge and common sense approach to safety. This is followed by a section on research methods and an in-depth discussion on the research findings and conclusion.

KNOWLEDGE MANAGEMENT

Knowledge is a known source of organisational advantage in projects and this has led to a great deal of interest in how organisations create, transfer and apply knowledge (Sole and Edmondson 2002: S17). The characteristics of organisational knowledge can be summarized as follows: (i) it is situated in the system of ongoing practices, (ii) it is relational and mediated by artefacts, (iii) it is always rooted in a context of interaction and it is acquired through some form of participation in a community of practice, and (iv) it is continually reproduced and negotiated, and hence it is always dynamic and provisional (Gherardi and Nicolini 2000: 330). This indicates that knowledge is contextual and hence the importance of the situation and actors involved in its management cannot be overlooked. Organizational knowledge can be viewed as a form of distributed social expertise in the sense that the knowledge-in-practice is situated in the historical, socio-material and cultural context in which it occurs (Tsoukas, 2003; Sole and Edmondson, 2002).

There are two types of knowledge: explicit and tacit knowledge (Polanyi 2009: 23). Explicit knowledge can be articulated and recorded. Tacit knowledge cannot be operationalized in this manner - it is displayed or manifested in what people do (Tsoukas 2003: 1). Workers of small firms use many forms of tacit (and explicit) local knowledge. Technical know-how, working practices and the values of workers contribute to site safety. Less experienced workers have to acquire such knowledge via training, work experience and leadership. Teaching of safety techniques (explicit knowledge) can be done on the job through demonstration and practice and in the classroom (Ngowi 1997: 289). The former has been found to be more effective (Laukkanen 1999: 60), as learning events can incorporate both explicit and tacit knowledge. When workers observe relevant instances and commit them to memory and subsequently compare them to other situations, they draw their own conclusions and this influences future performances hence creating a more effective learning experience (Gherardi and Nicolini 2002: 193). This lends support to encouraging multiple modes of knowledge conversion (as noted above after Little *et al.* 2002).

With regard to knowledge transfer (from person to person), the essential instrument of mediation is communication (Ciborra and Lanzara, 1990). On construction sites, communication takes different forms including verbal, paraverbal, non-verbal and/or actions (Bust *et al.* 2008: 586). That is, what is said; how it is said; non-verbal body language and the way things are done.

‘Common sense’ in construction safety

Common sense approach to safety on site has been employed by workers of small construction firms for quite some time (Vassie *et al.* 2000: 36). However, recently, common sense and safety have been connected in higher level (political) discussions about health and safety too, as impractical bureaucratic requirements have been found to be taking over the safety measures which actually prevent accidents (Lord Young of Graffham 2010; Davis, 2009). Since the commissioning of Lord Young’s ‘Common Sense Common Safety’ report in 2010, researchers, policy makers and industry practitioners have been compelled to rethink their views on the state of safety issues in the UK. The Lofstedt report 2011 recommends that many HSE regulations need reconsideration - health and safety systems will be ineffective if businesses

continue to over-comply with health and safety regulation due to fear of civil litigation (Department for Work and Pensions, 2011).

But conceptually common sense in safety lacks clear definition. Common sense in everyday language is defined as "the basic level of practical knowledge and judgement that we all need to help us live in a reasonable and safe way" (Cambridge Advanced Learner's Dictionary, 2008: 278). Application of this definition to health and safety on a construction site is problematic. Practical knowledge and judgement on site requires complex interaction of explicit and tacit knowledge gained through training, experience, guidance by leaders, experiential learning in new situations and from experts and experienced workers who have preceded us (Gherardi and Nicolini 2002: 192). People without extensive situated knowledge may stand right next to danger and not notice it (Baart 2009: 953). Situated knowledge is knowledge specific to a particular situation (Sole and Edmondson, 2002). What is 'reasonable' must be shared knowledge (whether explicit or tacit) among the workers on site so that they can create and maintain earlier-mentioned trust and supportive work environment.

In summary, we have discussed tacit knowledge and common sense as two emergent themes in contemporary literature on construction safety but little is known about the good practices that use tacit knowledge to ensure workers' safety. As part of improving safety practices in the construction industry, this research seeks to identify and encourage good practices of small construction firms that incorporate the use of tacit knowledge. The research methods adopted for the empirical investigation follows.

RESEARCH METHODS

This research sought to acquire rich data in order to explore the use of situated knowledge in accident prevention in-depth. Our interests were not in measuring the overall health and safety performance of the sites visited, but rather, to gather qualitative insights into the views and behaviours of the workers and specific practices they employ in order to manage health and safety. Collection of rich data requires direct contact with operatives on site (Pink *et al.* 2010). Hence, within an overall interpretivist ideology, semi-structured interviews and non-participant observations were used to collect qualitative data. These methods allowed for the study of the research participants in their natural work situations (Saunders *et al.* 2007: 600) and gave a voice to the workers of small construction firms with respect to their good practices.

The PhD research is based on a case study of five construction sites. This paper presents the findings of a pilot study; case study 1 conducted on a University campus in the East Midlands over summer 2011. The interviewees included the site manager and three of his site operatives. Areas covered in the interview included accident prevention, knowledge management, risk management, individual perceptions and supportive environments. Collection of the interview data was done with the aid of a digital audio recorder with interviewees' consent. The researcher transcribed the interviews verbatim. The non-participant observation was carried out on site with great care and aim for minimal researcher influence, with the site manager's consent on behalf of the site operatives. This method sought to reveal hidden or unconscious practices (e.g. different forms of communication) that may not have been discovered during the interviews. Field notes were compiled after site visits via thorough recollection of the day's accounts.

A thematic analysis was used to give the researcher a bird's eye view on emerging patterns in the data (see Aronson, 1994). In addition, a thorough thematic coding of the information (transcribed interview data and field notes from observations) was carried out with the assistance of QSR NVivo 9. This qualitative data analysis software eased the storage and organisation of data (i.e. interview transcripts, observation notes, personal comments, relevant literature and personal reflections), helped facilitate the coding process and helped the researcher draw out patterns and refine the research ideas, and hence assisted in efficient data retrieving and handling.

We develop critical discussion of the research findings in relation to the literature on tacit knowledge and common sense below.

THE PILOT STUDY - FINDINGS AND DISCUSSION

The project, the workers and work environment on site

As alluded to above, the site for the pilot study was located within a University in the East Midlands. The project included the renovation of a foyer, student union offices, a bar area and an entertainment hall together with the construction of a new beer garden. There were 15 craftsmen on site, including carpenters, bricklayers, electricians, plumbers and labourers. Four workers were interviewed on the site: the site manager, John; skilled labourer, Rick; and two general labourers, Mark and Ben. The interviewees had been working in the construction industry for 14, 30, 20 and 1 years respectively and had different levels of work experience. Age-range of the workers spanned from early 20s to late 50s. The workers wore casual clothing (e.g. jeans/trousers and t-shirts) and similar high-visibility vests. A sense of 'comradeship' was recognisable in their conversations and interactions with each other as they were observed waiting for a concrete truck to offload materials.

The interviewees mentioned that they currently work or had previously worked with many different workers on sites as a result of project requirements. John who was in charge of bringing in subcontractors explained that he hired firms or workers on the basis of their pricing and/or expertise in a specific area (pointing out some electricians on site who he hired on the basis of price). John explained that his team had a site orientation programme that has been designed to work for everybody and this arrangement was also supported by an open discussion about what could be done to help any newcomers. He clarifies that:

*"*You need to be able to do your own job as well as working with other people with your health and safety in place*"*.

This echoes the importance of supportive working environment discussed in the literature (after Conchie and Burns, 2009; Mohamed, 2002) but also 'fitting in' safe working practices with the demands of the operational schedule. As the 'need to be able to do your job' is prioritised in the quote, it is indicative of functional/ pragmatic line, which could also reflect notions of common sense. There is an implied emphasis on workable solutions for 'health and safety in place' that allow for 'the job' and 'working with other people' to flourish in the foreground.

Rick, the skilled labourer, with 30 years of experience in the construction industry and having moved around numerous different sites, explained that through his years of working he had learnt the valuable lesson that once you arrived on a new site, it is advisable to familiarize yourself with the workers on site in order to receive support and prevent accidents. Ben supported Rick's statement by adding that he and his co-workers do their best to help other workers that come to work with them. It could be

sensed that the interviewees make genuine efforts to help workmates on site. An observation confirmed this when one of the electricians (new on the site) received help from one of the workers in moving scaffold to a desired location with 'a simple head nod'. These instances in the data support Mohamed's (2002) concept that workers showing genuine concern for each other's well-being improves the ties between workmates and this leads to a better safety culture. There is also an indication of 'communication by action' (after Bust *et al.* 2008: 586) in how the nod of the head results in useful and preventative action by the workers. This form of communication relies on the workers' awareness of what is going-on on site and ability to read cues in their fellow workers behaviour to produce collaborative action. It is based on tacit knowledge, which out of situation would be worth little, yet here is very valuable indeed.

Contrary to the shared view of his workmates, Mark, a general labourer who boasted of years of work with a multi-national construction firm, said he would rather work to the standards of other workers he was working with if it meant getting the job done. This supports the above-mentioned prioritising of the 'job completion' as the primary goal, but alarmingly, is also indicative of flexing health and safety standards where the situation may allow this. Beyond this reference to getting the job done, the interview with Mark as a whole suggested that he was not fully committed to his current team on site, as he constantly talked about the time he used to work with a large firm on large construction sites. Notions of trust and supportive work environment did not register with Mark in the way that Conchie and Burns (2009) and others argue that small construction firm workers believe in team work and feel they can rely on each other in risky situations instead of working alone.

Tacit and explicit knowledge

As much as respondents said they saw some importance in training in a classroom based setting, they all insisted that the process could not be compared to training received from the job and what could be learnt through experience. Some of the key statements made by the respondents with respect to on-the-job training included:

"*Experience told you they're not safe. Somebody new on site might not see them… It's like driving a car. You can't sit in a classroom until you get into a car.*" (Rick)

"*I don't think you can replicate anything in the classroom that happens on site. I think you can only be made aware of risks in the classroom.*" (John)

"*Yeah, [Construction Training] is hands on.*" (Mark)

"*…onsite training because when you get into it, you know what you've done wrong… you don't get the experience [in the classroom] they just give you answers.*" (Ben)

All the above statements suggest that only the basics can be explained or taught in the conventional way. Clearly, it is tacit knowledge that helps develop competent and safety aware workers.

In contrast to this emphasis on tacit knowledge, John, the site manager, described one recent industry initiative in terms of the Construction Skills Certification Scheme (CSCS): each operative on a construction site is required to hold a CSCS card, which is obtained through a classroom based test. John was concerned that this type of practice was rather creating situations of risk as new workers on site potentially only hold the [explicit] knowledge delivered through the formal training and assessment system. He mentioned that obtaining the certificate was very easy. He had passed his

test in around four minutes and noted that this was not because he was smart but because the questions were "*ridiculously easy*". It may be that the test was easy for him given his valuable site experience during which he would have acquired both explicit and tacit knowledge through practice.

Ben also reflected on this issue and noted that even though he had his CSCS card before getting on site one year ago, his knowledge had grown considerably through experience at work. He is now more aware of his surroundings and what could go wrong as well as how to prevent situations from going wrong. Clearly, he has acquired tacit knowledge since joining the experienced workers on site. He also added that he has now learnt the personal protective equipment (PPE) required for specific activities. The latter specifically depicts his improvement in situated knowledge as he is now able to assess situations and determine how to protect himself against potential dangers.

A setting for explicit knowledge versus tacit knowledge is evident. John points out that explicit knowledge can be used to pass the CSCS test and thus gain access to working on site but that this will not be sufficient in practice in order to prevent accidents. Rick, Mark and Ben seem supportive of John's stance highlighting the importance tacit knowledge in learning safe work practices.

Knowledge transfer: verbal and action-based communication

Verbal communication is regarded by the interviewees as the most effective means of getting one's point across while on site. John, the site manager, stated:

*"*I think verbal [communication] is the most important thing through the job*"*.

However, Mark, one of the general labourers, expressed a preference for more posters on site, to serve as reminders. Here again, as with regards to the supportive work environment above, he referred to his time with the multi-national organisation, noting that they used to have many more posters than the small site where he was interviewed. This lends support for our earlier deduction that he is not fully integrated into the life of a small construction site.

Rick, the skilled labourer, explained that if people are to see something going wrong, the best thing is to do whatever it takes to warn the other person including shouting from the top of a scaffold. He reflected on the this type of support in terms of 'looking out for one another'; he needs to warn his colleagues as he could be faced with a similar situation one day and would expect a colleague to help him out. Also, Rick stated that on a small site workers got to know each other well, unlike on large sites where workers may operate in different parts of the site day to day and hence not know each other personally. The ability to communicate amongst the team on the basis of their established relationship was valued greatly. Mohamed's (2002) idea of workers relying on each other to prevent unwanted incidents is again confirmed.

Two site observations were made with regards to non-verbal communication: one occurred when two workers, Bob and Derek, were carrying a movable scaffold and approaching a cable which presented a potential trip hazard. Bob was in clear view of the cable and he looked down to the cable and then looked back up at Derek. Derek then automatically followed Bob's line of sight and noticed the cable and hence was able to avoid it. The other site event related to workers pouring concrete from wheelbarrows. They knew exactly when to poor the concrete the moment the workers casting the concrete in place lifted their head up to them. This collaboration was observed for about an hour and no miscommunication or safety compromise occurred.

These observations show that even though workers continuously talked about verbal communication, body language and actions also play an important role in communicating effectively in difficult situations whereby verbal communication may be restrained for example because of noisy environments (Bust *et al.* 2008). They present good examples of 'tacit knowledge in practice' the workers put to use on site; good practices they may not be consciously aware of and hence would not think to discuss in interviews without a probe. Clearly this type of action-based collaboration is very important in accident prevention but easily remains hidden due to 'common sense'-ness of the practice.

Common sense

As discussed in the literature section, common sense as a concept is somewhat problematic in the context of accident prevention on construction sites. Firstly, it lacks definition, and, as it is based on tacit knowledge people are likely to interpret it differently. This was evident in the interviews and site observations in that some workers referred to it in terms of 'you should know it' -type of information and basic site rules and practices as common sense, where others believed that is was more concerned with intuitive and personal input.

For John, the site manager, common sense refers to a worker's ability to employ PPE and other forms of protection when working as situations change and new potential hazards emerge. The following example helps illuminate this:

As part of the formal site risk assessment, steel toe cap boots were found inadequate for the current site because the project required nails and hence a worker could step on a nail and get injured. Although it is beyond the HSE's PPE requirements, and an added expense to the workers, the labourers and craftsmen on site agreed to wear steel mid sole boots as opposed to the steel cap toe boots as a preventative technique. The ease in which the agreement was reached was facilitated by the workers' common sense about the work environment on a construction site; namely the falling of spare nails during work.

Rick, the skilled labourer, used the term common sense with reference to learnt knowledge about safety practices, referring to a situation where scaffold may be missing railings. All workers operating on a scaffold are given explicit knowledge about the nature and structure that particular scaffold should look like. But rather than connecting with learnt experience, or inspection of explicit knowledge, Rick stated that "*[a worker] automatically knows something is not safe*." However, consider a situation with a scaffold structure where only few but crucial safety railings are missing together with a newcomer on site. The missing safety railing may prove undetectable for the newcomer or be associated with the design of the scaffold, especially if the equipment comes from a supplier with signed documentation which states all safety checks had been carried out. To Rick such an error in judgement would be incomprehensible, but he was unable to explain why or how the 'automatically' works. As external and independent researchers, we are in the position to deduce that his 30 years of experience on site had led him build this valuable 'common sense'.

Interestingly, Ben, the worker with the least experience amongst the interviewees (only 1 year) did not refer to common sense during the interview. He did talk about continuous learning with regards to safe practices and acquiring new knowledge. This can be attributed to the fact that he had not yet internalised the safety culture on site, or moved to transfer of explicit to tacit knowledge as suggested by Little *et al.* (2002).

To him, many practices were still conscious processes rather than 'obvious' or 'automatic' as described by the workers with extensive experience above.

CONCLUSION

We have discussed tacit knowledge and common sense in accident prevention on a small construction site in the East Midlands. The key findings support literature in that interpersonal relationships play a significant role in creating safety aware culture on small sites, aiding workers' understanding of each other and building supportive work environment. Curiously, one worker with extensive previous experience from larger sites operated by a multi-national construction firm, expressed much less commitment towards such personable and collaborative approach. This strengthens our curiosity about the differences in the ways in which small and large sites operate; hence the later stages of the research project will investigate this in more detail.

The findings also suggest that workers of the small firms use situated knowledge and experience when dealing with health and safety matters. The respondents viewed initiatives based on explicit data, such as the CSCS card, critically. Experienced workers tend to quickly and informally assess potential risks and subsequently manage their work environment so as to prevent injuries or accidents from happening, in collaboration with their co-workers. Specific good practices emerging from the research include verbal and non-verbal communication such as gestures with eyes and hands, on-the-job training and insightful guidance by the leaders in order to attain safe work environments. Much of this relies on to tacit knowledge.

The qualitative research methods employed for the pilot proved useful in uncovering this tacit knowledge. The observations in particular revealed much useful information which the respondents did not think to report, as they considered it 'common sense'. Four other case studies are currently being developed on this model toward final presentation of the PhD thesis.

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A REVIEW OF COMPLIANCE WITH HEALTH AND SAFETY REGULATIONS AND ECONOMIC PERFORMANCE IN SMALL AND MEDIUM CONSTRUCTION ENTERPRISES

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Small and medium enterprises (SMEs) constitute over 90% of construction businesses and are vital to construction industry operation. Health and safety regulations in the UK compel all organisations, regardless of their nature or size to comply with health and safety rules. However, there is evidence that the risk of suffering an occupational accident in SMEs is higher compared to large enterprises. For every 100,000 workers in the European Union SME sector there are more than 4100 accidents involving over three days absence; while the same rate is 3088 in large firms. In terms of cost, SMEs spend more to remedy (considering costs of rectification work, fines, prosecutions and sentences) adverse health and safety incidents. Fundamentally, the high cost of human capital and the destabilising effects of health and safety make the financial performance of SMEs exposed to greater uncertainties and risks. Indeed SME financial performance is often worse than for large firms. Various attempts by previous research work to substantiate the relationship between compliance with safety and financial performance of SMEs seems elusive. The research question is; does compliance with health and safety enhance SME financial performance? It is argued that SME commitment to health and safety spins off into many aspects of business performance and thus they simultaneously also benefit from better profitability. The paper is based on a literature review and an appraisal of HSE prosecutions in the period 2007 - 2011. It is a supplementary study and part of an ongoing PhD that seeks to appraise the effects of investment in health and safety in the UK construction industry.

Keywords: compliance, financial performance, health and safety, SME

INTRODUCTION

Arguably, the nature of small and medium enterprises (SMEs) makes these types of businesses vulnerable to adverse health and safety incidents. Arocena and Nuez (2010: 1) stated that 'the economic adversity and risk of suffering an occupational accident in SMEs is higher than in larger enterprises. The annual data for every 100,000 workers in the European Union SME sector are more than 4,100 accidents involving over three days absence; while the same rate is 3,088 in larger firms'. In the UK, Philips (2011)

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Arewa A.O. and Farrell P (2012) A review of compliance with health and safety regulations and economic performance in small and medium construction enterprises *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 423-432.

referring to the Health and Safety Executive (HSE 2006) stated that, 82% of all reported health and safety injuries in the construction industry occur within SMEs and in some cases, these figures rise to 90% of fatal accidents at work. Moreover, the HSE (2005: 23 - 24) asserted that, SMEs are less likely to comply with health and safety regulations due to fears that, compliance with health and safety regulations will not enhance their economic performance.

The former Department for Business Enterprise and Regulation Reform (BERR 2008: 17) now the Department for Business, Innovation and Skills (BIS) stated that, compliance with health and safety regulations boosts economic performance of organisations. The BERR (2008: 6) claimed that 'SMEs spend approximately six times more per employee than large firms, to comply with preventative health and safety requirements, and such expenses are likely to have an adverse impact on their economic performance'. Similarly, a study conducted by the HSE (2003: 2) highlighted a disproportionate cost of compliance with health and safety between SMEs and large companies. The study revealed that, ‘it costs SMEs on average £341 per employee, per year to comply with health and safety compared to £37 per employee, per year for large organisations’. A research study conducted in mid 2000 by the Federation of Small Businesses (FSB 2006: 3) shows that, on average it costs SMEs £598 per employee per year to remedy non-compliance with health and safety rules and regulations and is widely considered to have adverse effects on SME financial performance compared to large firms. Head and Harcourt (1997) highlighted the direct and indirect cost of accidents; direct costs are visible and include insurance compensation and medical charges. Indirect costs are hidden, and include for example lost labour time, cost of repairs and costs of replacing injured workers.

Furthermore, findings by the FSB (2011) suggests that, the disproportionate cost of compliance with health and safety between SMEs and large firms seems to be much higher in recent times, due to high cost of insurance and other economic factors. Philips (2011) asserted that, SMEs are less likely to overcome adverse safety incidents due to cost of insurance and other punitive costs. In this regard, it could be argued that a single untoward safety incident has the potential to substantially destabilise or liquidate SMEs, due to the high cost of human capital coupled with the fact that most SMEs do not have the volume of work elsewhere in their organisations to compensate losses incurred. Thus, the HSE (2005: 6) claimed that, there exists a variety of economic perspectives about compliance with health and safety by construction SMEs. The HSE (2002) affirmed that, most often than not, an economic viewpoint about compliance with health and safety is usually linked to limited access to finance which is deemed a major constraint to SME's growth.

Recent data from the HSE (2011) about prosecutions involving health and safety fines, court sentences and other related health and safety breaches by construction firms show that, on average there is significant difference between magnitude of fine (penalties) or sentences issued to SMEs when compared to large firms for similar non-compliance with health and safety offences. In terms of number of fines, the HSE (2011) data reveals that, SMEs incurs more fines than large firms, in a ratio of 6:1. Arguably, the high number of fines linked to SMEs attests to the fact that, they dominate most construction work and perhaps prove that this category of firms lacked well trained health and safety personnel. Thus, Dorman (2000) affirmed that, there is need to bear in mind that most SMEs are financially fragile compared to large firms probably due to their institutional and financial (market oriented) failures and constraints.

In line with this argument, some schools of thought are of the view that, SMEs are supposed to receive lesser punitive fines and sentences for health and safety breaches or offences due to their fragile economic performances (HSE, 2005). On the other hand, allowing SMEs to settle for smaller fines or sentences for health and safety breaches or offences because of their fragile financial status or in times of turbulent economic circumstance may be considered a licence to SMEs not to comply with health and safety regulations; because fines associated with non-compliance with health and safety are mainly considered the major driver to improve performance (HSE 2005: 3). Though, it should be mentioned that not all SMEs are financially fragile. Bingham (1999) in an article titled 'Better safe than sorry' stressed that, 'those fines regardless of the size of firms contain a message. The days of being thumped for a few grand for health and safety breaches have gone'.

LITERATURE REVIEW

Definition and role of SMEs in the construction industry

The phrase small and medium enterprise (SME) is often used to describe a range of enterprises, with traditional definitions often based on number of employees or turnover. In terms of a universally accepted definition of SME, it is quite difficult to give a simple or straightforward explanation to the phrase. According to BERR (2008: 13), SMEs can be defined based on sections 382 and 465 of the UK Companies Act 2006. This Act defines, 'a small company as one that has a turnover of not more than £6.5 million, a balance sheet total of not more than £3.26 million and not more than 50 employees'. While, a medium-sized company has a 'turnover of not more than £25.9 million, a balance sheet total of not more than £12.9 million and not more than 250 employees'.

Generically, SME businesses are heterogeneous in nature and they dominate a wide array of construction business activities, ranging from ventures such as artisan, joinery firms, tiling firms, painting works, plumbing, and brick laying businesses. The Organisation for Economic Co-operation and Development (OECD 2004: 14) states that 'SMEs are of particular importance to the construction industry; because they constitute more than 90% of all businesses in the industry'. BERR (2008: 11) stressed that, 'SMEs account for 83.7% employment and 67.4% turnover generation in the construction industry'. The European Agency for Safety and Health at Work (EASHW 2003) argued that, 'approximately 99% of construction firms in Europe are (SMEs); thus their involvement in the day-to-day running of construction businesses make SMEs more susceptible to adverse safety incidents when compared to large firms'. Hence, the nature and characteristics of SMEs require a unique approach in all aspects of economic evaluation, especially ascertaining whether compliance with health and safety enhances financial performance

SMEs and formal health and safety compliance management systems

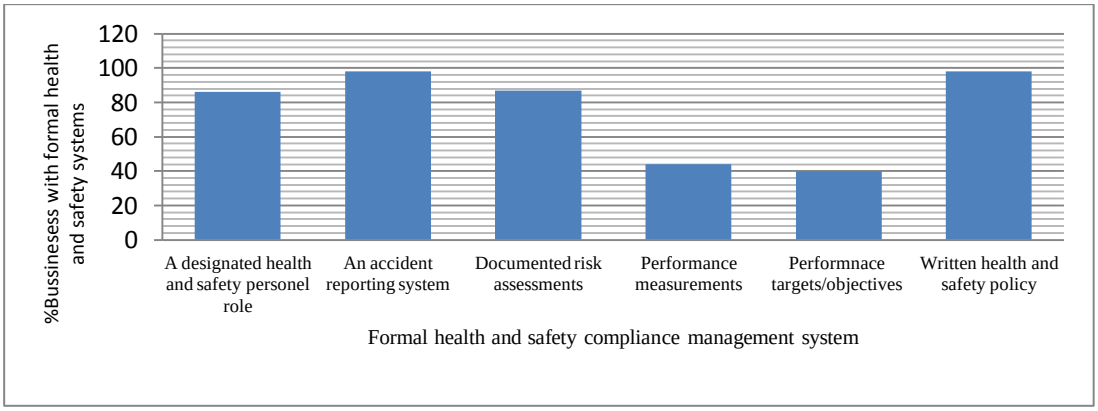
The phrase 'compliance with health and safety' has no specific definition. It is often used to mean an orthodoxy of health and safety rules and regulations. For example, in the UK, all firms have a legal responsibility for the health and safety of anyone affected by its business irrespective of their nature, size or volume of work. According to the UK Government Business Link (UKGBL 2012) compliance with health and safety is a legal responsibility of all employers to everyone affected by employers' businesses which entails:

- Carrying out thorough health and safety risk assessments.
- Drawing up a health and safety policies - for businesses with more than five employees.
- Ensuring workplaces meet minimum standards of conformity and cleanliness.
- Recording serious injuries, diseases or dangerous accidents in accident book.

The HSE (2005: 3) stressed that, 'different factors affect compliance with health and safety, but the main motivator for complying, or trying to comply with health and safety is the general fear of the law, liability (fear of being sued by clients) and threat from local workplace if non-compliance was not remedied'. The HSE (2003: 41) alluded that, research findings based on construction sites revealed that, the main factors motivating compliance with health and safety regulations by SMEs were legal obligation (67%), health and safety publicity (67%), and insurance costs (50%). Other factors are development of quality systems (50%), and supplier / customer / client pressure 33%. Conversely, the major reasons for non-compliance with safety by SMEs were identified as: lack of awareness of legislative requirements, inadequate knowledge on how to comply with safety obligations, money and poor management structures.

In addition, an HSE (2003: 5 - 6) study revealed that many businesses, especially construction SMEs, do not have formal health and safety compliance management systems in place. The study cited lack of knowledge on the benefits of complying with health and safety, small number of employees, low priority and time restriction as reasons for not developing formal health and safety management compliance systems. Findings from the HSE (2003: 36) claim that, 71% of SMEs compared with 84% of large firms agree to have formal safety system in place. Unfortunately, out of the 71% of SMEs that have formal safety systems in place, it was discovered that, their systems were often less comprehensive than large organisations. For example, the research went further to explain that, only 17% of SMEs include performance measurements in their formal health and safety compliance management systems compared with 71% of large companies. Figure 1 illustrates construction businesses percentage consideration for formal health and safety compliance systems.

Figure 1: Construction businesses percentage consideration for formal health and safety compliance systems; adapted from HSE (2003: 5)



The links between SME economic performance and compliance with safety

Taylor (2010: 136) opined that, non-compliance with health and safety leads to accidents, and workplace accidents have the potential to take 30% off company annual profits; also that failure to manage safety has a much larger social cost. Thus, the EASHW (2007: 9) claim that, 'it is reasonable ... exceptionally effective and efficient

for SMEs to comply with health and safety regulations; because it helps build better business performance'. Moreover, research work by HSE (2005: 5) 'shows that, 60% of companies that have health and safety related disruptions lasting more than nine days go out of businesses'. Therefore, since SMEs generally lack readily available credit and often have weak economic performance, it is essential for them to understand the economic benefits of improving and complying with health and safety rules to boost their financial status (Dorman, 2000: 13).

A study conducted by Elias *et al.* (2011: 3 - 34) that examined a total of 79 contractors of various sizes, found that the cost benefits of compliance with health and safety (commitment/improvement to safety) outweighs the cost of accidents or costs of safety in the event of adverse safety by a ratio of approximately 3:1 (62% benefit gain to 38% benefit loss). In addition, Ikpe (2009: 201) affirmed that, the benefits of accident prevention (that is compliance with safety regulations) far outweigh safety costs of accidents by a ratio of approximately 3:1. Philips (2011) findings suggest that, compliance with health and safety leads to substantial cost savings. While, Purvis (1999: 5) in an article titled, 'Safe firms have healthier profits' argued that 'British businesses need to understand that good health and safety management is worthwhile ... (if compliance with health and safety is) handled in the right way, it can be turned from a cost into a benefit'.

However, the EASHW (2009: 5) stated that compliance with health and safety is not usually viewed as a contributory factor to viability of SME economic performance. Young (2010: 25) asserted that, attempts to link compliance with health and safety to economic performance of SMEs is usually characterised by absurdity and confusion. Dorman (2000: 1) argued that, linking economic performance with compliance is relatively challenging because most firms lack foremost knowledge on how to set and measure key health and safety performance indicators. However, he also argued that, 'financial issues that arise from health and safety matters are purely issues of economics and can be used to measure the healthiness of business, since they stem from the workplace, which is an economic activity'. Thus, Koper *et al.* (2009) stated that 'compliance with health and safety should contribute significantly to performance aspects ... measured based on factors, such as overcoming absenteeism, overall cost reduction, productivity and profitability.'

EASHW (2009: 13) stated that, evaluating SME's compliance with health and safety with regards to their economic performance is demanding because of (a) the diverse nature of SMEs, (b) lack of formal safety knowledge, (c) the dynamic and flexible operations of SMEs (d) ability of such businesses to innovate because, such enterprises are more traditional in nature based on family involvement and rooted in local business environments, and (e) lack of accounting and performance measure knowledge. Nevertheless, the Construction Clients' Group (CCG 2008: 1 - 2) proposed table 1, to illustrate how key health and safety performance indicators can be measured.

Table 1 Health and safety KPI's adapted from CCG (2008: 1- 2)

Objective	UK KPI	Rationale for clients' interest and recommended action
1. Training and competency	a. Maintain: Average CSCS or equivalent H&S test card	Ensuring that the right and best people are employed to deliver projects
2. Minimise impact on neighbours and local communities	b. Maintain: 80% signed up to organisations that promote public and private sector clients best practice	Ensure that construction projects have minimum impact on neighbours, environment; respect for people, good welfare and safety standards
3. Proactive and sensible risk management of all health and safety risks	c. Increase: encouragement of firms that have overall risk register inclusive of design details key risks for the project team to manage	Ensure health and safety is incorporated into project risk registers
4. No incidents. Reduction of accidents	d. Reduce: the reportable injury frequency rate and numbers of days lost to ill-health year on year and target zero incidents	Minimise potential injuries and ill-health during construction, maintenance and demolition
5. Respect for people	e. Improve: increase access to occupation- ill-health support: measure employee satisfaction, staff turnover, sickness, working hours and training	Promote respect for people in projects so they are well motivated, productive, trained, treated fairly and enjoy their work
6. Maintain statutory compliance	f. Reduce: the number of prosecutions and enforcement notices from authorities by 10 % year on year	Set the tone that compliance is the minimum standard. Improve the image of the dangers associated with construction. Minimise unwanted disruptions to projects.

The Occupational Health and Safety Administration (OSHA 2009) maintained that, economic performance of SMEs in relation to compliance with health and safety can be assessed or measured using various methods. The EASHW (2009: 5) referring to the work of Warren (2005) proposed a logic model for measuring economic performance of SMEs with regards to compliance. Thus, a relationship can be deduced between compliance with health and safety and financial/social performance, using a set of determined factors such as inputs, activity outputs and outcomes made of flow processes, as illustrated in table 2. Aldana (2001: 296 - 320) argued that, linking SME compliance with health and safety and economic performance should take into account '... the number of accidents associated with SMEs, their poor financial performance and their lack of knowledge about occupational safety'. In this regard, Dorman (2000) stressed that, in order to have a better understanding on how to measure the economic performance of SMEs with regard to compliance with health and safety, 'it is imperative to promote effective compliance with health and safety culture within an organisation and the cost of health and safety should be made an economic internal variable and should be routinely visible'

Table 2: An examination of health and safety compliance input and economic performance outcomes for SMEs adapted from EASHW (2009: 6)

INPUTS	ACTIVITIES	OUTPUTS	OUTCOMES
Money	Training	Number of staff trained	Reduced sick leave
Staff	Investments	Number of investments undertaken	Higher performance/Productivity
Equipment	Maintenance	Number of equipment maintained	Increased profit
Supplies	Interventions	Types of interventions undertaken	Lower liabilities
Facilities			Healthier workforce
			Consistency in performance
			Better performance
			Fewer injures
			Increased output of goods and services

METHODOLOGY AND FINDINGS

This study research technique is based on a literature review and an initial appraisal of 2,646 prosecution cases on the HSE website (HSE 2011) leading to court sentences, and fines. The cases involved: civil engineering construction companies, building construction firms, specialised construction (demolition) firms, electrical installations companies, plumbing and heating firms and other types of construction specialist firms. This study restricted itself to 627 cases in the category of building construction (residential and commercial buildings development projects) in which 525 cases was deemed to be relevant to this study, as illustrated in table3.

Detailed analysis from data obtained shows that 64.57% (52.19% + 12.38%) of fines by volume between the years 2007 to 2011 were incurred by SMEs. Furthermore, SMEs incurred 71.25% (61.48% + 9.77%) of fines by amount of money. Therefore, considering SME's high cost of human capital, insurance costs and scope of work with regards to their marginal profitability, such uneven cost has the potential to jeopardise SME financial performance.

Table 3: Analysis of remedial costs for non-compliance with health and safety involving building construction firms in the UK 2007 - 2011, data used for this analysis were obtained from HSE (2011) data base.

Enterprise category	Number of HSE cases/ prosecutions between 2007 to 2011	Total costs of safety fines 2007 - 2011; £	Remedial cost of each accident; £	Percentage cases for each category by number	Percentage cases for each category by £s
Large firms	46	1,591,600	34600	8.76%	22.00%
Medium-sized	274	4,446,139	16227	52.19%	61.48%
Small	65	706,415	10868	12.38%	9.77%
Micro/individual	140	488,243	3487	26.67%	6.75%
Total	525	7,232,397	13776	100.00%	100.00%

Findings from table 3 show unanimity with other literature and confirm that SMEs are more susceptible to adverse economic performance due to non-compliance with health and safety regulations. The findings of Dorman (2000 p. 22), Smallman and John (2001), BERR (2008: 22) and Arocena and Nunez (2010: 414) are confirmed; there is need for SMEs to comply with health and safety because it reduces overall costs, improves availability of resources and heightens the effectiveness of their performance. In addition, research conducted by the HSE (2005) in relation to cost of safety revealed that, the amount of resources invested in health and safety has links with the size of firms. Large construction firms have the impetus to invest in health and safety (that is, they have well trained staff, better risk assessment structure and ability to purchase better working equipment/tools). Hence, there is that tendency for large firms to have better economic performance compared to SMEs.

DISCUSSION AND CONCLUSION

Findings from this study reveal that, remedial cost of non-compliance with health and safety tends to be higher per accident in SMEs than in large firms. SMEs are less knowledgeable on the need to invest in health and safety programmes. Moreover, most SMEs do not consider performance measurement as part of formal health and safety compliance systems. Dorman (2000) stressed that, it is imperative to promote investment in health and safety within small businesses and the cost of complying with safety should be made an economic internal variable and be routinely visible.

There is need for health and safety regulatory bodies to constantly and consistently echo the benefits of investment in healthy and safety to SMEs. It is therefore, recommended that more specific advice and guidance be developed to raise awareness among SMEs about the importance of investment in safety, performance target setting and evaluation in relation to compliance with health and safety rules and regulations (HSE 2003:49). Government may consider compelling SMEs to develop formal health and safety compliance management systems. There is evidence that the risk of suffering an occupational accident and the likelihood of adverse economic performance is greater in SMEs than in large enterprises.

Since safety management systems promote other facets of good management practice, such as advanced planning and clean places of work, there will spin off into worker motivation, efficiency, effectiveness and productivity. Safe companies are highly valued by clients, and there is also the potential to use evidence of robust safety systems as a vehicle to secure new work. It is argued that money spent on safety

management systems, alongside money invested in many other business systems that sensibly promote good practice, is money well invested, and will show returns in profitability. Many returns on investment are intangible, and the difficulty therefore is in measuring and convincing business leaders of the benefits, particularly in the SME sector.

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DETERMINANTS OF CONSTRUCTION FIRMS' COMPLIANCE WITH HEALTH AND SAFETY REGULATIONS IN SOUTH AFRICA

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The management of health and safety issues is very significant in the construction industry in South Africa in terms of accident rates and cost to contractors. The costs arise from both the cost of compliance with regulations and the cost of accidents and injuries. In spite of the fact that available evidence shows that construction-related accidents and injuries are on the increase in South Africa, many designers and contractors regard the cost of complying with regulations as unnecessary additional financial burdens. It is against this background that this study investigated the statutory regulations relating to health and safety in construction in South Africa and the level of compliance with the regulations and motivation for compliance by contractors. Data obtained from contractors in a questionnaire survey the Western Cape Province of South Africa were analysed using percentage scores and mean score analysis with the aid of the SPSS software. Although the validity of the findings is limited by sample size used in the survey, it is hoped that the findings will provide empirical basis for a more inclusive survey of H&S in the construction industry in South Africa.

Keywords: health and safety, regulations, enforcement & compliance, construction industry, South Africa.

INTRODUCTION

Construction industries worldwide are notorious for unacceptably high accident and fatality rates, both of which were noted by Ulang *et al.* (2010) and Sidumedi (2009) to be high in comparison to other industries. According to Odeyinka *et al.* (2005), construction workers are six times more likely to be killed at work than those in other industries. In South Africa, construction industry records show that work related deaths, occupational diseases and injury claims absorb a significant proportion of the

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Windapo, A and Oladapo, A (2012) Determinants of construction firms' compliance with health and safety regulations in South Africa *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 433-444.

Gross National Product (Benjamin and Greef, 1997) even though there are concerns that the reports in South Africa fail to capture the full number of accidents (van Huyssteen *et al.* 2009; Sidumedi, 2009). Construction health and safety has long been the focus of attention of many industry stakeholders and role players in South Africa. While it is acknowledged that many industry associations, professional bodies, contracting organisations and others have made significant efforts to improve health and safety within the construction industry, the Construction Industry Development Board (cidb) (2009a) noted that, overall, H&S is not improving commensurately and this has been a major challenge for building construction management. In addition, the Department of Labour (DoL) (2007) noted that even though H&S issues have seen some improvement over the years, the numbers of people that get injured or die are still high.

Warwick (2011), Baxendale and Owain (2000) attributed the accidents and fatalities associated with and reported in the construction industry to the non-compliance by contractors with H&S regulations on construction sites. The Occupational Health and Safety Act (OHSA) 85 of 1993 stipulate the steps to be taken in order to ensure a safe and healthy work environment for all employees on a construction site in South Africa (Hermanus, 2001) and contractors are obliged to comply with the requirements of the Act. In general, compliance means conforming to or being in accord with a rule/established guidelines, such as a specification, policy, legislation, standard or law, or the process of becoming so (Sarbanes-Oxley Act, 2002). Windapo (2011), Bettesworth (2011), MBAWC (2011) and cidb (2009b) noted that building contractors in South Africa do not comply fully with H&S regulations. It emerged from the MBAWC construction site survey conducted from 2007 to 2010 that the overall combined Health and Safety legislation compliance levels of the sites surveyed ranged from 91.9% to 93.77%. (MBAWC, 2011). Plausible reasons given for non-compliance with H&S legislation on construction sites are that some individuals are ignorant of the law, and in other cases they take chances, aware of the small likelihood that they may get caught or of the minor severity of the penalties when they are caught (Bettesworth, 2011). Other reasons are lack of knowledge and inadequate training of site workers (Smallwood, 2002; and Haupt and Smallwood, 1999); and the fact that contractors regard the cost of complying with regulations as an unnecessary financial burden (Windapo, 2011; Hinze, 1997).

This study was prompted by the prevalence of accidents and the lack of consensus among researchers on the key factors responsible for the level of compliance with H&S regulations in the South African construction industry. It examines the factors that affect the levels of contractors' compliance or non-compliance with OHSA regulatory requirements on construction projects. It also evaluates the perceived benefits of compliance with the regulations and its impact on construction project performance. The study is significant because knowledge of factors that affect contractors' compliance with OHSA requirements, perceived benefits of the OHSA regulatory requirements will help H&S policy makers in developing achievable and effective regulatory requirements.

FACTORS AFFECTING LEVEL OF COMPLIANCE

The factors affecting the level of contractors' compliance with H&S legislation have been identified by various authors. They are discussed in the following sections.

Management Commitment and Attitude to Health & Safety

According to Smallwood (2002), workers' actions are influenced by the workers' own mentalities, immediate supervisors, and by the site, middle and top management. Haupt and Smallwood (1999) determined that the most common issues with regards to non-compliance with regulations were that workers were never consulted about health and safety by management; when an instruction to perform a task is given there is no reference made to health and safety; the workers are seldom provided with personal protective equipment (PPE); programme, policy and rules are non-existent; there is no appointment of H&S representatives; inspections and meetings are never conducted; and the workers perceive the supervisors not to prioritise health and safety. Bailey (1997) found that the perception of employees about management's commitment to H&S has a significant impact on the safety outcomes.

Knowledge and Training

Haupt and Smallwood (1999) noted that lack of training is a major cause of non-compliance by workers with H&S legislation on construction sites. Workers that are not trained would not be knowledgeable or aware, and are consequently unable to properly comply with requirements (Smallwood, 2002); and will underestimate the inherent risks/hazards in their work (Haupt and Smallwood, 1999; McLeod, 2007). While Smallwood (2002) noted the widespread lack of understanding by workers when it comes to regulations and the requirements thereof, Haupt and Smallwood (1999) established that very few workers are actually aware of the requirements of OHSA. Smallwood (2002) opined that managers are unlikely to be committed to H&S legislation if their level of knowledge and awareness of H&S regulatory requirements are minimal.

Penalties for non-compliance

According to cidb (2009a), if potential losses relative to labour, materials, plant and equipment as a result of non-compliance with H&S regulations are cited by regulatory authorities, contractors will address H&S issues. However, corruption enables contractors to get away with minor and major misdemeanors and escape severe penalties.

Cost of compliance

Compliance with H&S regulations, according to Smallwood (2004), is an enabler and catalyst for enhanced performance relative to cost. Contractors are more willing to spend money on compliance where the financial costs of non-compliance (i.e. cost of accidents) are likely to be high. According to Windapo (2011), it is not surprising that contractors perceive regulations as an additional burden, which they have to conform with and which gives rise to unnecessary costs as Hinze (1997) views compliance with the OHSA regulations as costly. In an attempt to avoid these perceived additional costs, contractors tend not to comply fully with H&S regulations. Smallwood (2004) estimated that the cost of implementing H&S systems within a company is between 0.5% and 3% of total project costs, confirming the international literature which indicates that the total cost of implementing H&S systems is estimated to be around 5% of the value of completed construction, which is less than the total cost of accidents (CoA) on a project. Baxendale & Owain (2000) established that the costs of implementation of health and safety on small construction sites are higher than that of larger sites.

COMPLIANCE WITH HEALTH & SAFETY REGULATIONS

Perception is the way information is picked up to influence behaviour (Bridgeman and Hoover, 2008), and it is unique to individuals (McDonald, 2012). Thus, different people will have different perceptions of a given situation. Mcleod (2007) notes that there are a number of factors that influence the perceptual set and thus influence perception, and those factors are made up of expectations, emotion, motivation and culture. Therefore peoples' experiences and knowledge will influence their perceptions (Mcleod, 2007). A general underlying belief is that the majority of accidents are not caused by the carelessness of workers, but by failures in control, which is ultimately the responsibility of construction site management (Baxendale & Owain, 2000). The extent of this control depends largely on management's perceptions of the risks involved in the works. Risk perception is generally influenced by individuals' beliefs, attitudes, judgments and feelings (Akintoye & MacLeod, 1997).

The Benefits of Compliance

Higgins (2011**)** viewed compliance with H&S regulations as an investment in the light of the costs it can save. Lack of compliance with OHSA regulations, according to Sidumedi (2009), could result in increased project costs due to reworking as well as time overruns, while the injuries caused by accidents lead to additional unbudgeted costs (Sidumedi, 2009: Higgins, 2011). Bentil (1992) noted that firms which make safety a priority are able to reduce lost workday accidents. Smallwood (2002) opined that contractors gain more than reductions in workers' compensation (WC) and liability insurance premiums, workers' compensation rebates, and reductions in the indirect costs of accidents. Other benefits enumerated by him include enhanced morale of supervisors and workers, and increased attractiveness to clients as a result of perceived holistic quality.

Levels of Compliance

The level of contractors' compliance with H&S regulations is influenced by management/worker attitudes, knowledge and training, cost of compliance, severity of the penalties for non-compliance and the benefits of compliance (Bettesworth, 2011; Windapo, 2022; Smallwood, 2002; Haupt and Smallwood, 1999). MBAWC designed a system of grading the compliance of construction projects with the OHSA regulations in South Africa using elements of OHSA and the total points achieved on a project (Warwick, 2011). The system classifies the basic requirements of the OHSA regulations into 19 different elements ranging from Education, training and promotion to Plant and storage yards/site workshop specifics. The compliance levels achieved are classified into >95% (Comply with regulations), 90% - 95% (Acceptable but needs attention in the near future) and <90% (Unacceptable standards, needs urgent attention). A site must achieve an overall score of over 90% and have a disabling injury frequency rate (DIFR) of one or less in order to be awarded a five star grading.

Construction Project Performance and Compliance with H&S Regulations

Time, cost and quality are widely known measures of performance in the construction industry. However, in recent years, other indicators such as H & S, sustainability and client satisfaction have been included (Hapanova *et al.* 2006). In South Africa, standard performance with regards to H&S is generally deemed to be the mitigation of fatalities, lost time incidents, recordable incidents, doctor cases and near-miss accidents (CURT, 2005). According to Sidumedi (2009), H&S violations resulting in

accidents slow down the construction process and lead to poor time and cost performance.

RESEARCH METHODOLOGY, DATA ANALYSIS AND RESULTS

An internet-based questionnaire survey was conducted in the Western Cape Province of South Africa between May and September 2011 using the SurveyMonkey© . A combination of convenience and snowball sampling was used to obtain data from 53 contractors who agreed to participate in the survey, out of a total of 678 registered by cidb in the province. In addition, case studies of 4 construction sites were conducted using face-to-face and telephone interviews, and secondary data were also collected from MBAWC records. The case study sites chosen were from among those surveyed by the MBAWC for Occupational Health and Safety compliance grading and auditing. This allowed for drawing of links from perceptions and costs of compliance to the data collected by MBAWC. The study examined the main sub-clauses of the OHSA legislation that govern H&S in the South African construction industry. The data collected from the survey were analysed using frequency analysis, percentage scores and mean score analysis. The mean score was used to rank the factors that promote non-compliance with H&S rules and regulations. The mean score (MS) is given as follows (after Odeyinka *et al.* 2011):

$$MS = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{(n_5 + n_4 + n_3 + n_2 + n_1)},$$

where n_1 = number of respondents who answered "Very low"

n_2 = number of respondents who answered "Low"

n_3 = number of respondents who answered "Average"

n_4 = number of respondents who answered "High"

n_5 = number of respondents who answered "Very high"

Respondents' Distributions and Profiles

The background profile of the companies and respondents from which information was obtained is presented in Table 1.

Table 1: Profile of companies/respondents

Profile	Frequency	Percentage
Business Type (N=53)		
Private Company	24	45%
Close Corporation	21	40%
Public Liability Company	3	6%
Sole Proprietorship	3	6%
Multi-National Company	2	3%
Geographical spread of firms (N=53)		
Local	16	30%
Provincial	6	11%
Regional (located in more than one province)	11	21%
National	9	17%
International	11	21%
Age of company (N=53)		
5 year and below	5	9%
6-10 years	10	19%
11-15 years	12	23%
16-20 years	5	9%
21 years and above	21	40%
Number of Employees (N=53)		
Small (Less than 20)	12	23%
Medium (21-100)	19	36%
Large (More than 100)	22	41%
Position of respondent in the company (N=53)		
Owner	21	40%
Director cadre	11	21%
Managerial staff	16	30%
Technical staff	5	9%

Table 1 reveals that 45% of the companies surveyed were private companies, 30% and 21% are local and multinational companies respectively, 40% are more than 21 years and above in the construction business, 41% are large companies and 40% of the respondents are owners. The type of business, geographical spread, age and size of the companies surveyed and the status of the respondents is of relevance to the study because, the higher the position of the respondent, the older the organisation, its operational base and size, the more the respondents would have the necessary experience to be able to provide credible and reliable information.

Ranking of the Factors that Contribute to the Level of Contractor's Non-compliance with OHSA Regulatory Requirements

The study sought to find out the key factors perceived by contractors to contribute to the level of non-compliance with OHSA regulatory requirements.

Table 2:Factors contributing to level of non-compliance with OHSA regulatory requirements

Factors	Perception of impact*					No	Mean Item Score	Rank	Level of Contribution
	1	2	3	4	5				
Negligent attitudes of management	3	3	8	8	7	29	3.43	1	Average
Lack of knowledge	6	6	7	6	11	36	3.28	2	Average
Lack of training	1	5	8	5	4	23	3.26	3	Average
Cutting cost	2	12	4	7	5	30	3.03	4	Average
Non-severe penalties for non-compliance	17	3	3	4	5	32	2.22	5	Low

*1= very low, 2 = low, 3= average, 4= high, 5= very high

As shown in Table 2, the major perceived contributor to the level of non-compliance with OHSA regulations by contractors is the negligent attitude to H&S by management of construction companies. The H&S attitude of top management is particularly critical as it drives the overall attitude and H&S culture of the organisation. The least contributor is the non-severity of penalties for non-compliance. This implies that the severity and enforcement of penalties aid compliance.

Perceived Benefits of Compliance with OSHA Regulatory Requirements

The respondents were asked to indicate the perceived benefits that compliance with nine OHSA regulatory requirements (based on the average level of compliance attained in the MBAWC site audits) provides onsite. Table 3 shows that 70.3% of the respondents perceived that the major benefit of compliance with the OHSA regulatory requirements is a safe work environment.Only 30% and 29.3% perceive the benefits of compliance to be improved project performance (productivity and time) and reduction in costs of accidents (wages and medical expenses) respectively. 8.6% of the respondents perceive that there are no benefits in complying with the OHSA requirements.

Table 3: Perceived benefits of compliance with OHSA regulatory requirements

OHSA Requirements	Level of Compliance (%)*	Benefits						Total response
		None	No Penalties	Safe Work Environment	Reduction in COA**	Reduction in Admin Costs	Improved Productivity	
Cranes (Tower, Mobile & Gantry)	99.4	5	8	35	14	8	19	49
Demolition Work (Safety Requirements)	97.4	5	8	38	14	6	16	50
Transport & Material Handling (safety in use)	96.9	6	10	33	17	3	15	51
Admin Structure & Legal Requirements for H&S	94.3	5	17	31	11	9	11	50
Scaffolding, Formwork & Support (safety in use)	90.0	3	6	37	16	6	19	51
Site Plant & Machinery	89.9	2	5	33	16	5	14	50
Work Place Environment Health & Hygiene	88.8	6	8	37	8	2	13	51
Personal Protective Health & Clothing	88.1	3	5	39	19	4	15	51
Excavation (adequacy of side support, etc.)	82.5	4	6	36	18	7	14	51
TOTAL		**39**	**73**	**319**	**133**	**50**	**136**	**454**

*Source: MBAWC (2011) **COA-cost of accidents

Case Study Results

Four case studies - referred to below as Site A, Site B, Site C and Site D in Table 4- were undertaken. The stakeholders interviewed were contractors, quantity surveyors and health and safety consultants. The type and size of construction projects on the sites ranged from housing projects with a budget of less than R20mil (Site C and D, to a hospital project of R500m budget (Site B) as well as a multi-billion rand power station site (Site A). The interviewees were asked questions pertaining to the requirements of the OHSA and the effects they have on project performance. A few project specific questions were also asked on each site in order to establish whether the level of compliance with OHS requirements had an impact on health and safety performance and other performance parameters on a particular site. The interviewees were then requested to give their opinions on how the regulations in the OHSA Act could be improved.

Table 4: Summary of Case Study Interviews

Questions Posed	Site A	Site B	Site C	Site D
Is OHSA implemented on site?	Yes	Yes	Yes	Yes
Level of compliance with OSHA	High	High	High	High
Is the project running within time?	No	No	Yes	No
Is the project running within budget?	No	No	Yes	Yes
Has there been any report of accidents/ injuries?	Yes – Fatalities, accidents and injuries	Yes - Accidents and injuries	Yes – Minor injuries	Yes – Minor injuries
Reasons for non-compliance	Lack of knowledge; Cost mitigation – profit maximisation; Time consuming	Cost mitigation	Lack of knowledge; Cost mitigation	Lack of knowledge; Cost mitigation; Attitude/negligence
Effects of OSHA compliance on performance	Less accidents	H&S is costly but cost is justified; overall performance is improved	OHSA compliance is unnecessarily costly and time consuming	Quality is improved; time and cost are compromised
Benefits of complying with OHSA legislation	Competing on international standards; Penalties & loss in production due to accidents are avoided;	Increased productivity	Safe working environment	Workplace is safe and thus more productive; reduces accidents
Any improvements to existing OHSA legislation?	None	Adapt to suit individual project requirements	Adapt to suit individual project requirements	Adapt to suit individual project requirements, which is not practicable

DISCUSSION OF FINDINGS

The results of the questionnaire survey have given some indications of the main causes of noncompliance with H&S regulations and the perceived benefits of compliance. However, these results are based on a rather small sample size (about 8%), which limits the generalisability of the findings. To make these findings more meaningful, the four case studies were conducted to reinforce the survey findings. The case study results are discussed below.

Factors that affect the level of contractors' compliance with OHSA Legislation

The interview results (Table 4) show that negligent attitudes, lack of knowledge (ignorance) and/or understating of H&S regulations by construction site employees and the profit motive are the main causes of non-compliance. This is widely supported by the literature The interviewees believed that non-compliance because of cost mitigation is due to small contractors not including allowances for H&S requirements in their tenders as a deliberate strategy to win tenders.

Two of the interviewees stated that they did not comply with some of the requirements of the OHSA Act because they perceived them as unnecessarily expensive, time-consuming and unjustified for their particular site (housing projects). They added that most of the requirements of the OHSA regulations are more applicable to larger projects and would be better complied with if they were more project-specific.. Other interviewees stated that non-compliance by site operatives can be significantly attributed to negligence/worker attitude which is a product a risk-taking cultural background.

Perceived Benefits of Compliance with OHSA Regulatory Requirements

In addition to providing a safe work environment, the interviewees stated that compliance with H&S regulations also gives the firm a competitive advantage. This implies that increased level of compliance with OHSA requirements is an investment by contractors in the pursuit of corporate growth and profitability.

CONCLUSION

The health and safety regulations in the construction industry were enacted to safeguard lives and to improve the quality of construction products, including construction processes. However, contractors have been reported to be non-compliant with these regulations. This study examined the levels of compliance by construction firms with the OHSA regulatory requirements, the reasons for compliance and/or non-compliance, and how these affect the cost and performance of building/construction projects. The main reasons for non-compliance with health and safety regulations are the lack of knowledge and/or understanding of health and safety legislation requirements by lower management, smaller and sub-contractors and site operatives. Other significant reasons for non-compliance are the profit maximisation motive driven by the competitive nature of the construction industry, as well as negligence/attitude of the contractor. It emerged from the study that contractors benefit from a safe work environment, reduction in COA and improved productivity with increased level of compliance with OHSA requirements. This suggests that, although complying with the OHSA regulations involves upfront costs, the costs saved in the long run in preventing potential accidents outweigh the cost of compliance.

These findings are based on a survey using a relatively small sample size selected through convenience and snowball sampling. This limits the validity of the results. It is, however, hoped that this study will form the basis of a more inclusive survey of H&S in the South African construction industry in future.

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SAFETY IMPACTS OF ALCOHOL AND OTHER DRUGS IN CONSTRUCTION: DEVELOPMENT OF AN INDUSTRY POLICY AND CULTURAL CHANGE MANAGEMENT PROGRAM

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There is increasing concern about the impact of employees' alcohol and other drug (AOD) consumption on workplace safety and performance, particularly within the construction industry. While most Australian jurisdictions have identified this as a critical safety issue, information is limited regarding the prevalence of AODs in the workplace and there is limited evidential guidance regarding how to effectively and efficiently address such an issue. The current research aims to scientifically evaluate the use of AODs within the Australian construction industry in order to reduce the potential resulting safety and performance impacts and engender a cultural change in the workforce - to render it unacceptable to arrive at a construction workplace with impaired judgement from AODs. The study will adopt qualitative and quantitative methods to firstly evaluate the extent of general AOD use in the industry. Secondly, the development of an appropriate industry policy will adopt a non-punitive and rehabilitative approach developed in consultation with employers and employees across the infrastructure and building sectors, with the aim it be adopted nationally for adoption at the construction workplace. Finally, an industry-specific cultural change management program and implementation plan will be developed through a nationally collaborative approach. Final results indicate that a proportion of those sampled in the construction sector may be at risk of hazardous alcohol consumption. A total of 286 respondents (58%) scored above the cut-off cumulative score for risky or hazardous alcohol. Other drug use was also identified as a major issue. Results support the need for evidence-based, preventative educational initiatives that are tailored to the industry. This paper will discuss the final survey and interview results.

Keywords: alcohol, drugs, education, safety.

INTRODUCTION

While it is estimated that 640,700 Australian persons suffered a work-related injury or illness in 2009-2010 (ABS 2010), and 444 persons lost their lives as a result of a work-related traumatic injury in 2008-2009 in Australia (Safe Work Australia 2011),

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Biggs, H.C and Williamson A.R (2012) Safety impacts of alcohol and other drugs in construction: development of an industry policy and cultural change management program *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 445-454.

very little is known about what proportion of such accidents are directly attributable to the effects of alcohol and other drugs (AODs). This is despite AOD consumption being relatively prevalent within the Australian community (Holland, Pyman and Teicher 2005) and the clear link between such consumption and subsequent declines in cognitive and behavioural performance (Elliot and Shelley 2006). Nevertheless, the impact of employees' AOD consumption on workplace safety and performance is an on-going issue for Australian employees, particularly within the construction industry (Berry, Pidd, Roche and Harrison 2007). This documented concern is reflected in the increasing array of workplace policies being developed to improve construction site safety through addressing the issue of employee impairment. Improving workplace health and safety is particularly important for this arena given the current size, economic value and expanding nature of the Australian construction industry. It is argued that developing a nationally consistent, contemporary and collaborative approach across the construction workforce is needed to engender a cultural change in the workforce. Such an approach may take a similar form to the on-going initiative in securing a cultural change to drink-driving in our society where peer intervention and support is encouraged and appears integral to maintaining such change (Ferguson, Schonfeld, Sheehan and Siskind 2001).

The current research aims to scientifically evaluate the relationship between the use of AOD and the safety impacts within the Australian construction industry to engender a cultural change in the workforce - to render it unacceptable to arrive at a construction workplace with impaired judgement from AODs. A national approach across the Australian construction workforce - involving government representatives; employers and employees; unions; and other key industry stakeholders and experts will be adopted. An evaluation of the extent and nature of the problem, through an AOD consumption and behaviour assessment, will inform the development of an appropriate industry policy and cultural change management program. The study builds on the credibility and networks developed through the CRC for Construction Innovation's landmark achievements in safety including the Construction Safety Competency Framework (Dingsdag, Biggs, Sheahan and Cipolla 2006), Guide to Best Practice for Safer Construction (Fleming, Lingard and Wakefield 2007), A Practical Guide to Safety Leadership (Biggs, Dingsdag and Roos 2008) and the Safety Effectiveness Indicators (Cipolla, Biggs, Dingsdag and Kirk 2009; Biggs, Dingsdag, Kirk and Cipolla 2010).

AOD in the workplace: the Australian context

Anecdotal evidence from the infrastructure and building sectors highlights issues of drugs and alcohol and its association with safety risk on construction sites. Currently, there is no clear evidence on the prevalence and risk of AOD use among Australian construction workers. While there are several studies that offer consumption rates and patterns in various industry and occupational groups (Pidd, Boeckmann and Morris 2006; Banwell, Dance, Quinn, Davies and Hall 2006; Evans, Tait, Harvey and Newbury 2005; Davey, Obst and Sheehan 2000a), such industry-specific information is limited for a number of reasons (including small sample sizes with specific groups, when they were conducted and the amount of time that has elapsed since the research and methodological factors such as measurement variation). Such factors limit the degree to which these findings can be generalised across industries and the wider workforce (Pidd and Roche 2011). While many companies do maintain an AOD policy and associated procedures, there is still tremendous variety across different types of industries and within industries in regards to content and outcomes, and

questions remain as to what is the best approach. Importantly, there appears considerable merit in examining the feasibility and effectiveness of more contemporary approaches that extend beyond traditional workshops and education-based methods and embrace techniques similar to internet e-therapy which have demonstrated positive preliminary results (Klein, Meyer, Austin and Kyrios 2011).

Almost universal across the Australian construction industry is the adoption of the theoretical construct of organisational safety culture (Glendon 2003; Guldenmund 2000; Reason 2000). When considering predominant pathways to create behavioural change in the workplace, there are two main pathways to ensure compliance: (1) the extrinsic pathway, governed by systems and rules with rewards and punishments; and (2) the intrinsic pathway, establishing voluntary compliance via individual commitment to safety (Glendon 2003). For example, in the mining industry the extrinsic pathway with a legislative framework governing mining operations and the implementation of AOD policy and programs has resulted in a heavy focus on testing. However, within the construction industry across Australia, there is generally not as extensive or explicit AOD workplace legislation and there is also wide variability between organisations, sites and practices. In general the construction industry relies heavily on an educative approach built around the intrinsic motivation of individuals to operate safely when it comes to AOD use (Guldenmund 2000; Sully 2001).

There is now a national need to develop sound scientific research, based on a safety culture framework, to assist the industry in delivering appropriate, up to date and evaluated strategies and materials targeted at the unique needs and characteristics of the construction industry. It is proposed that the development of such educational initiatives should firstly be grounded in an accurate understanding of the aetiology, impact and consequences of AOD within the construction workplace. This should then be followed by the development and implementation of tailored and effective interventions designed to specifically target the extent and severity of the problem within the cultural and operating context of the construction industry. This paper will provide an analysis and discussion of data collected in phase 1 of the research, as outlined below.

METHODOLOGY

This project was approved by the QUT Human Research Ethics Committee and will be led by an Academic Project Leader in partnership with a senior Industry Project Leader from a major Australian construction company. The project team will collaborate with academic leaders and experts in applied research in the area and will be guided strategically by an Industry Steering Committee with membership comprising representatives from key government, industry and union groups. The project will be achieved through four phases:

Phase 1: National qualitative and quantitative assessment of the use of AOD

Participants

A survey method was adopted to gain a quantitative assessment of the use of AODs in the Australian construction workforce. It was expected that the survey (described below) would be distributed to approximately 500 employees at selected construction sites across Australia Operational sites were selected by the Industry Project Leader, in consultation with the respective regional and safety management team. All employees at the selected sites and corporate headquarters were invited to participate.

In addition to the survey, semi-structured interviews were conducted to gain some qualitative insights into the safety impacts of AOD in the workplace. Interview numbers were dependent on the availability of employees on the particular day of each site visit.

Measures

The World Health Organisation Alcohol Use Disorders Identification Test (AUDIT) was used. The AUDIT, while originally designed for use with clinical populations, has been widely used and validated in a variety of populations and contexts, including the workplace (Davey, Obst and Sheehan 2000a; Davey, Obst and Sheehan 2000b; Donovan, Kivlahan, Doyle, Longabaugh and Greenfield 2006; Lennings, Feeney, Sheehan, Young, McPherson and Tucker 1997; Neumann, Gentilello, Neuner, Weiß-Gerlach, Schu¨rmann, Schroder, Muller, Haas and Spies 2009; Younga and Maysona 2010). There are 10 items on the AUDIT which are classified into three domains. The first domain (Q1-3) measures the quantity and frequency of alcohol consumption and screens for possible risk of hazardous consumption. The second domain (Q4-6) examines abnormal drinking behaviour, which may indicate early or established alcohol dependence. The third domain (Q7-10) probes for negative consequences related to alcohol consumption. Each question is scored from 0 to 4, with a cumulative range of 0-40. A total AUDIT score of 8-15 indicates a risk of harmful consumption and is most appropriate for simple advice focused on the reduction of hazardous drinking. A total AUDIT score of 16 or more indicates a high risk of alcohol problems and suggests the need for brief counselling and continued monitoring. A total AUDIT score of 20 or above warrants further diagnostic evaluation for alcohol dependence. Although these thresholds were established on the basis of a study on a clinical population, they have also been widely used and validated in non-clinical populations, including those listed above (Babor, Higgins-Biddle, Saunders and Monteiro 2001).

Four additional questions were developed by the research team for the purpose of this study and were included in the survey. These relate to readiness to change (e.g. “do you think that you presently have a problem with drinking” and “in the next 3 months, how difficult would you find it to cut down or stop drinking?” and ‘other drug’ consumption (e.g. “when have you most recently used marijuana/cannabis” and “when have you most recently used ecstasy or meth/amphetamine type substances”. Demographic details were also included in the survey.

Structured interviews were also conducted across a number of roles within the company to identify major issues and themes. Interview questions centred on perceptions towards AOD use in the workplace (including perceived prevalence in the industry, how it affects you, your safety, performance and productivity, as well as that of your co-workers) and attitudes and perceptions towards existing AOD workplace policies (including knowledge of, perceived effectiveness and attitudes towards them as well as what could be improved).

Procedure

Corporate headquarters and operational sites of the industry partner organisation were visited to distribute the AUDIT survey and conduct structured interviews with both management and employees. The research team worked closely with the relevant operational site and safety managers in order to access employees most effectively on each site. The AUDIT survey was distributed in hard copy to employees during their breaks along with a Participant Information Sheet and a plain envelope to seal the completed survey in, before returning to the researcher. All surveys are confidential

and anonymous and are now kept in a locked office. The researchers clearly communicated this to employees and that participation is entirely voluntary, that no names are recorded and that the data remains with the researchers at the end of the project. The interviews took place at both corporate headquarters and operational sites in a private room. Detailed notes were recorded by hand during the interviews and later thematically analysed.

Phase 2: Development of an appropriate industry policy

A non-punitive, rehabilitative and educational approach will now be developed in consultation with employers, employees, and unions across the industry, with the aim being that the program will be adopted nationally for construction workplaces.

Phase 3: Development of a cultural change management program

Upon development of an appropriate industry policy, the Australian Government, lead industry associations and key stakeholder groups and the research team will initiate an industry-wide collaborative approach to reducing the risk of impaired performance on construction sites and increasing workers' commitment to AOD safety. Previous work by Biggs, Dingsdag and Roos (2008); Biggs, Dingsdag and Kirk (2009); Cipolla, Biggs, Dingsdag and Kirk (2009) and Dingsdag, Biggs, Sheahan and Cipolla (2006) provide a significant starting point for the developing a cultural change management program that is directly tailored to the construction industry.

Phase 4: Development of an implementation plan

An implementation plan will be designed and developed stemming from the initial data collected. This process will include the development of clear recommendations for industry use and will be educative in focus.

RESULTS

This paper reports the results from phase 1.

Participants

Final survey results are based on the completion of 494 surveys. All employees who were provided with a survey, at the selected sites, completed and returned it to the researcher on-site. The majority of respondents (n=464) were male, with a mean age of 35.7 years (SD=11.4). Most respondents (398) were employees; with the remaining 85 respondents employed as a contractor. The survey was distributed across all roles within the company with the majority of respondents classifying themselves as a tradesperson (155), a labourer (117), a plant operator (68), in an administration or engineering role (53) or as a supervisor (47). Surveys were collected across three states (Victoria, South Australia and Northern Territory). Interviews were conducted with ten employees across several roles in the company. Several less formal conversations were also had with employees on-site.

Survey: AUDIT results

Of a possible maximum cumulative score of 40, the 494 respondents recorded a mean score of 9.98. Scores ranged from 0 to 40 with a median score of 9. A total of 286 respondents (58%) scored above the cut-off cumulative score for risky or hazardous alcohol use of ≥ 8, with 185 respondents (65%) falling into the 8-15 scoring group, 58 respondents (20%) falling into the 16-19 scoring group and 43 respondents (15%) scoring 20 and above. Subsequent analysis focused on the three individual AUDIT domains that look specifically at consumption, dependency and alcohol-related

problems (see Table 1). The maximum score for Domain 1 is 12 (scores ≥ 6 indicating a risk of alcohol related harm. The maximum score for Domain 2 is also 12 (scores ≥ 4 indicating possible alcohol dependence. Any score in Domain 3 warrants further investigation.

Table 1: Mean AUDIT scores for each domain

AUDIT Domain	Mean (SD)	No. of respondents (and %) who scored at or above the cut off
Domain 1: Consumption	6.17 (3.1)	300 (61%)
Domain 2: Dependency	1.38 (2.1)	79 (16%)
Domain 3: Alcohol related problems	2.48 (3.1)	291 (59%)

Survey: Additional questions

Four additional questions were included in the survey regarding self-rated dependency and past other drug use:

Thirty-three respondents reported that they either possibly or definitely had a problem with drinking. A further 19 respondents reported that they were unsure. Over the next 3 months, 71 respondents reported that it would be either fairly difficult or very difficult to cut down or stop drinking. Of those who scored above the cumulative score for hazardous alcohol use (n=286), 212 respondents (74%) reported that they do not have a problem with drinking and 157 respondents (55%) reported that it would be either very easy or fairly easy to cut down or stop drinking. In terms of prevalence, a total of 292 respondents (59%) had used marijuana/cannabis in their lifetime, with 46 respondents having used it in the last year (15.8%). A total of 196 respondents (40%) had used ecstasy or meth/amphetamine type substances in their lifetime, with 62 respondents having used it in the last year (31.6%).

Structured interviews

The structured interviews identified a number of important issues. Firstly, links to reduced safety and productivity levels were confirmed by a number of those in safety advisory positions. Overall, there seemed to be a general lack of understanding and knowledge surrounding the physical and psychological effects of AOD use and how these effects might impair performance. This was despite the overall attitude that the use of AOD is detrimental to workplace productivity and safety. In terms of prevalence, AOD use was perceived (by those in safety roles) as a major issue that is only getting worse, particularly drugs because they are harder to detect as well as the changes that are seen in drug type ‘popularity’ and the increasing use of synthetics forms of illicit drugs. Prescription medications and other legal stimulants such as energy drinks were also identified by safety staff as a major concern.

While current policies and employer assistance programs were generally seen as effective, there was an overall support for the development of more comprehensive and tailored educational initiatives for employees and contractors within the construction workforce. In particular, the need for preventative programs – rather than focusing on the consequences of AOD use when it could be too late (i.e. testing people who are already at work). Specifically identified was the need to educate younger employees about “how to cope” with the lifestyle that can accompany a high-

salary, project-to-project, transient type work and "getting in early before we have to deal with the aftermath". Acknowledging the difference between 'career workers' and 'it's just a job workers' was identified as an important consideration in terms of how to communicate educational messages most effectively to employees. Several suggestions and feedback were offered for the more effective communication of AOD education to employees. These included the need for clear and simple visual hard copy brochures, fact sheets or posters, as well as videos about the physical and psychological effects and impacts of AOD. Training sessions (separate from the tool box talks and daily pre-starts) were identified as an appropriate opportunity to focus on a particular safety issue in a certain level of depth. There was also a positive response to the proposed development of a web-based resource – which would assist those who may find it difficult to seek help or advice about AOD at work. Indeed, job security was highlighted as a common fear regarding seeking help or advice about AOD at work. Finally, the use of a mentoring type initiative was suggested as a way of communicating knowledge, experience and advice to younger workers who may benefit from a more one-on-one approach with more experienced fellow workers.

Other issues included the importance of management support, maintaining a strong supervisor relationship with a strong commitment to preventing harm caused by AOD, and the consistent communication of policies and expectations right from the start of the project. Related to this was the importance of ensuring that sub-contractors are subject to the same policies and practices that company employees are subject to in their regular practices. Consideration of the culture of specific occupational groups was also identified as being important in that the nature and pressures of a job, with specific skills and hazards, can have a major effect on employees' lives and relationships. Finally, educating the therapists and counsellors that are made available to employees, about the construction industry was identified as something that could be of great value.

CONCLUSIONS

No known study has scientifically examined the use of AODs and corresponding safety impacts in the construction sector. As a result, there has been only limited adoption of nationally coordinated strategies that are supported by both employers and employees to render it socially unacceptable to arrive at a construction workplace with impaired judgment from AODs. Together, the objectives of this study are designed to contribute to a change in culture towards improving safety in the construction industry.

Results from phase 1 of this research indicate that as in the general population, a proportion of those sampled in the construction sector may be at risk of hazardous alcohol consumption. As general AOD use does not necessarily translate into workplace AOD use and impairment, these results do not tell us about when those in the 'at risk' group are drinking. A proportion of those 'at risk' will consume alcohol in private, in their own time, whereby their behaviour has no relevance to their performance at work. For others though, alcohol risk will translate into workplace risk. This evidence does not allow any accurate indication of what this risk might be. While many in the current sample appear to be at risk of hazardous alcohol consumption, a large proportion of these respondents claimed not to have a drinking problem. Many of these respondents also indicated that it would be fairly easy to cut back or stop their drinking behaviour. These results suggest that those who may be at risk are unaware that a problem may exist, further highlighting the need for

educational programs to increase knowledge and awareness of the effects of AOD. Other drug use (both illicit and licit) remains a huge concern with complex and contentious issues around detection and privacy. Taken together, results support the need for evidence-based, comprehensive and tailored responses in the construction workplace, and in the broad community, so that those who may be 'at risk' are provided with accessible and relevant information and/or help if and when necessary.

Results from phase 1 will now be used to inform the development of an industry policy and cultural change management program and implementation plan. This study is of major significance for Australia within the current context of harmonisation of industrial legislation in occupational health and safety and Federal and State Government investment to improving workplace safety and overall population health. This project will fundamentally contribute to a greater understanding of the impact of AODs in the Australian construction industry within a safety culture framework and, critically, bring together employer and employee groups nationally.

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EVALUATING THE ROLE AND EFFECTIVENESS OF TRAINING INTERVENTIONS IN IMPROVING THE OCCUPATIONAL HEALTH AND SAFETY OF YOUNGER CONSTRUCTION WORKERS: A LITERATURE REVIEW

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Younger construction workers (age 15-24) suffer occupational injury at a much higher rate than older workers, raising concern over the effectiveness of widespread health and safety (H&S) interventions, particularly the quality of education and training provided to young workers about workplace H&S. Based on a review of relevant literature, this paper examines H&S training interventions in the UK and discusses their potential effectiveness in improving the occupational H&S of younger construction workers. The literature review reveals that H&S initiatives for young workers have rarely been examined and evaluated. Without this knowledge and understanding, the development of sound intervention efforts particularly within the complex construction industry context is greatly impaired. Furthermore, education and training programmes may be insufficiently preparing young workers for hazardous work conditions. The paper notes that the traditional 'control-based' approaches, while well intentioned, are limited in their ability to improve H&S for younger workers. To be more effective, such interventions must do more than simply provide young workers with information and must recognise the diversity of development among young learners and the significance of learning within organisations as a social process. More participatory approaches must be adopted, in which younger workers are engaged and involved.

Keywords: health and safety, interventions, learning, training, younger construction workers.

INTRODUCTION

Many people suffer harm as a result of their engagement within the construction industry worldwide. This harm can take many forms, including death and serious injury, long term chronic health effects and deleterious impacts upon general wellbeing. For example, in 2009/2010, there were 42 fatal injuries in UK construction, a rate of 2.2 deaths per 100 000 workers (HSE 2011). In terms of ill health, the Labour Force Survey estimated that in 2010/2011, 79 000 people whose current or most recent job in the previous year was in construction, suffered from an illness (longstanding and new cases) which was caused or made worse by this job (HSE

Nyateka N; Dainty A; Gibb A.and Bust P (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) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 455-464.

2011). In addition, HSE have published figures that show that the industry significantly exceeds the all-industry incidence rates with respect to musculoskeletal disorders, occupational dermatitis, work related hearing loss, mesothelioma and asbestosis (HSE 2009).

Furthermore, changes in demographics and in education and training arrangements, which are resulting in greater numbers of younger workers (age 15-24) entering work (For example, the Young Apprentice Programme in the UK provides a construction qualification for 14-16 year old learners, and includes up to 40 days of work experience over the two year period), present significant H&S challenges to the construction industry. The work injury rates of younger workers have been reported to be significantly higher than those of older workers (Mowlam *et al.* 2010, Screenivasan 2001, Salminen 2004, Schulte *et al.* 2005). In addition, the physical nature of some trade sectors of construction work can result in an earlier age transition from trades to other roles within the industry, which impacts upon the supply of labour in those trades. It is therefore imperative that the occupational H&S of younger workers is taken seriously and managed carefully. Protecting the health of younger workers is critical to the future of an ageing workforce and also of great importance for young people themselves, for their overall management of life, health and well-being.

Research Aim and Objectives

Despite a plethora of different H&S initiatives over the past decades for improving occupational H&S performance within construction (such as, legislation, behaviour based interventions including, goal setting, feedback, training and reward schemes), ill health, injuries and fatal accidents rates remain unacceptably high and continue to be costly to the individuals, employers and whole society. H&S initiatives specifically for young workers have rarely been examined and evaluated. Without this knowledge and understanding, the development of sound intervention efforts particularly within the complex construction industry context is greatly impaired.

Therefore, the aim of this paper is to examine training interventions for younger workers and discuss their potential effectiveness in enhancing young workers' occupational H&S. In order to achieve the research aim, the specific objectives are as follows:

1. To review existing literature about the characteristics and learning preferences of younger workers
2. To explore and understand the context and underlying structures of the construction industry that impact upon H&S training initiatives
3. To examine the current H&S training methods for younger workers
4. To explore how messages about H&S are communicated in practice
5. To discuss the effectiveness of current H&S training interventions in communicating the message and enhancing younger workers' H&S

The research will address the following key questions:

- Why are younger workers at greater risk?
- What barriers, obstacles or challenges to training intervention success exist within the industry?
- Are the current training programmes appropriate, adequate or sufficiently preparing young workers for hazardous work conditions?
- What improvements/changes need to be made to training interventions?

Research methodology

An extensive review of relevant literature and data was conducted to give a clear understanding of the situation regarding the occupational H&S of younger workers and particularly the training methods available to them, as well as the issues and barriers that younger workers face.

LITERATURE REVIEW

Understanding younger workers vulnerability

Previous research around the world has consistently suggested that young people are at greater risk of workplace injuries compared to older workers (HSE 2002, Mowlam *et al.* 2010, Screenivasan 2001, Salminen 2004, Schulte *et al.* 2005). In a global literature review of occupational nonfatal and fatal injuries studies, Salminen (2004) found that the majority (56%) of 63 nonfatal studies reviewed showed that young workers had a higher injury rate than older workers, whilst 29 out of 45 studies on fatal occupational injuries indicated that young workers had a lower fatality rate than older workers. European statistics confirm that young people are more likely to suffer occupational injury than older workers. According to the European Statistics on Accidents at Work (ESAW), in 2003, 4.7% of young workers aged 18-24 years had an occupational accident with more than three days lost, compared to an average of 3.3% for the working population. In the United States, the U.S. National Institute of Occupational Health (NIOSH) estimates that 200 000 workplace injuries occur each year among youth (under age 19) (Loughlin and Frone 2004).

A number of reasons why young people are more at risk have been suggested. These include inexperience, physical and psychological immaturity and employers' lack of provision of appropriate training, supervision and safeguards (Screenivasan 2001, Mowlam *et al.* 2010). Wegman and Davis (1999) point out that unlike most adult workers, young people frequently move in and out of the labour market, changing jobs and work schedules as they respond to changes in labour market conditions, employers' needs and their own personal circumstances. This might mean that young people may not be at the same work place long enough to be fully trained, or the employer may not be interested in training them as they expect them to leave entry-level jobs.

Studies such as those by Breslin *et al.* (2003) and Chin *et al.* (2010) have identified that a large proportion of young workers do not receive occupational H&S training. Moreover, H&S training may be insufficiently preparing young people to identify risks and to advocate for safety in the workplace, contributing to higher accident rates (Chin *et al.* 2010). The study conducted by Zakocs *et al.* (1998) found that even when youth were provided with safety training, workers felt that the training was ineffective in preparing them for hazardous conditions. Runyan and Zakocs (2000) argue that the problem of worker injury among young workers requires attention to the diversity of development within the age group. The researchers note the need to structure training interventions to take account of cognitive differences among young workers as well as between young and adult workers.

In addition, the ability to engage in consultation with employers in relation to occupational H&S is likely to be particularly difficult among vulnerable worker groups, which include the younger, older, migrant and temporary construction workers. HSE (2009) define a vulnerable worker as "someone working in an environment where the risk of being denied employment rights is high and who does

not have the capacity or means to protect themselves from that abuse. As new and inexperienced workers who are often employed in low paid or part-time jobs on a temporary, casual or informal basis, young workers may not know their legal rights, or be lacking in self-confidence, communication or social skills to express H&S concerns (Loughlin and Frone 2004). The young workers in Zakocs *et al.*'s (1998) study reported that they felt intimidated about voicing their concerns to managers, partly because they believed their managers saw them as expendable. As well, these young workers perceived that their managers were not concerned about their safety and often failed to provide safety training and basic protective equipment (Zakocs *et al.* 1998). Breslin *et al.* (2007) also report reluctance to voice safety complaints or concerns particularly among young male workers in industries including construction. The young workers were reported to accept workplace injury "as part of the job", to which Breslin *et al.* (2007) suggest is related to the youths' subordinate status in the workplace and their perceived lack of control to improve or alter the conditions of their work.

Training within the construction industry

Whilst the provision of training by employers is an explicit requirement of the UK's H&S legislation and there is widespread acknowledgement by various authors of the benefits of safety training (Dufficy 2001, Loosemore *et al.* 2003). Loosemore *et al.* (2003) note that the construction industry does not have a good record of investing in training its employees, investing less in training its employees than many other industries. A study undertaken in the UK by the Training Agency (1989) also reveals that the construction industry provides less training to its employees than any other industry sector, including comparable industries in which casual employment is common, such as retail or catering.

Key features of the construction industry may have implications for the provision of occupational H&S training. For example, the fact that construction is a project-based industry is an important contextual issue. Bresnan *et al.* (2004) note that project-based organisations pose particular challenges for attempts to diffuse and embed new knowledge and learning within the firm due to their decentralised nature and time-constrained ways of working. As projects are often one-off, self-contained, temporary worksites consisting of a complex mix of different trades and activities, they do not fit into routine organisational processes (Bresnan *et al.* 2004). The regular secondment and movement of staff between projects is common, given the phasing of project activity across and within the design and construction stages and the transient and time-pressured nature of project activity (Bresnan *et al.* 2004). In such an environment, training activities are often assumed to be expensive in terms of both the cost and time (Loosemore *et al.* 2003). The situation is further exacerbated by the system of competitive tendering, as well as the practice of awarding contracts to the lowest bidder (Lingard and Rowlinson 1994). There is also a widely held view that the majority of formal training activities require key project-based staff to be removed temporarily from their operational responsibilities, causing additional pressure for already overstretched teams (Loosemore *et al.* 2003).

In addition, much of the industry's work is subcontracted out and workers are employed on short-term, fixed contracts and then released at the end of a project. Moreover, construction is sensitive to weather, resulting in seasonal fluctuations in employment. Such employment arrangements may erode the incentive for training investment. Loosemore *et al.* (2003) note that the small subcontractors which employ

the vast majority of the construction workforce, confuse training responsibilities and are so highly geared that long-term investments in training have been difficult. Even in major organisations, training and development activities are often squeezed in the face of programme pressures and small profit margins, and there is little sense of paternalism towards the subcontractors they employ (Loosemore *et al.* 2003).

Furthermore, the construction industry is a highly predatory and transitory industry with a strong culture of nomadism. Loosemore *et al.* (2003) state that it is highly likely, in the common absence of retention strategies that trained employees will take their skills elsewhere. Conversely, it is possible to attract trained employees from other companies through the use of remunerative incentives, negating the need for one's own training strategy (Loosemore *et al.* 2003).

All of these issues have implications for the provision of occupational H&S training. Nevertheless, training is still a fundamental requirement for improving occupational H&S performance. Moreover, many modern construction clients are increasingly demanding that construction firms demonstrate the competence of their project teams through their training and development activities. Thus, as Loosemore *et al.* (2003) argue, innovative training delivery methods must be considered, which provide employees with the opportunity to develop the learning skills and attitudes that will allow them to function in a more efficient and effective manner.

Learning styles of younger workers

Pritchard (2005) defined learning style as "An individual's preferred means of acquiring knowledge and skills", for example, using pictures instead of text or working in groups as opposed to working alone. Becta (2005) notes that the term "learning styles" is often used loosely and interchangeably with terms such as learning modalities, thinking styles and cognitive styles. In relation to learning modalities, the theory is that all learners have a preference for receiving and storing information through one or more sensory modalities: visual, auditory or kinaesthetic (tactile). Visual learners learn best from pictures or written text, auditory learners prefer the spoken word, whilst kinaesthetic learners think in terms of actions and bodily movement (Becta 2005).

The logic and appeal of learning styles is that training can be matched to the learning style preferences of particular learners, enabling them to learn better (Mowlam *et al.* 2010). As such, the role of trainers is to tailor their teaching style to suit the requirements of individual trainees (Wilkins 2011). However, as Becta (2005) note, learning styles "are at best one of a range of factors determining how learners react to learning opportunities, with factors such as environment, culture and teaching methods all having an influence. In addition, learning styles are not fixed traits that an individual will always display. Mowlam *et al.* (2010) argued that there is a danger of labelling learners as particular types of learners in all circumstances. Constantinidou and Baker (2002) found that pictorial presentation helped all learners taking an item recall test, with this being even more so for learners with a strong preference for verbal processing, rather than imagers as might be expected.

Mowlam *et al.* (2010) investigated the best ways of communicating H&S messages to young learners in vocational education and training. The young learners in that study found written information hard to engage with and they struggled with technical language. Instead, visually engaging material, practice and experience were considered more beneficial and easier learning routes than classroom teaching or written word (Mowlam *et al.* 2010). Wilkins (2011) notes the "literacy deficit" that

exists among construction workers and argues that the demographics and diversity of the construction industry, including age, experience, culture, educational attainment and levels of literacy, have to be considered when developing safety training methods. Thus, a varied approach to training, that takes into account the diversity of learning styles as well as the different methods in which varied information needs to be communicated, is likely to achieve the required performances.

Training methods

Many methods of training exist, or can be created, to communicate information and to involve participants in training programmes. The nature of such methods varies from ones that demand little participant involvement to ones where participants become involved and highly committed to the training process. Burke *et al.* (2006) and Goldenhar *et al.* (2001) categorise training methods as:

1. Passive, information based techniques e.g. lectures, videos, pamphlets, handbooks or other types of written materials.
2. Moderately engaging, which incorporate knowledge of results e.g. feedback interventions, in which performance information is provided, allowing learners to correct their mistakes. Other examples are programmed instruction and computer-based instruction.
3. Highly engaging/Interactive approaches, which focus on the development of knowledge in stages and emphasize principles of behavioural modelling, involving observation of practice and feedback designed to modify behaviour. Examples include hands-on demonstrations and simulation based methods. In the case of behavioural simulations and hands-on training, Burke *et al.* (2006) state that interactions between trainees and trainers will frequently go beyond 1-way feedback to engage trainees in dialogue concerning knowledge acquired or actions taken. Such dialogue is important because it is posited to enhance quality of reflection with respect to actions taken (Burke *et al.* 2006).

Ample evidence in the training literature suggests that active, highly engaging methods of training are superior to less active approaches (Burke *et al.* 2006, Mowlam *et al.* 2010). Burke *et al.* (2006) examined the effectiveness of different methods of worker H&S training aimed at improving safety knowledge and performance and reducing negative outcomes (accidents, illnesses and injuries), and found that as the method of health and safety training becomes more engaging, the effect of training is greater in terms of knowledge acquisition and reductions of negative health and safety outcomes. Their findings suggest that, to the extent possible, less engaging methods such as computer based and distance learning methods should, in some manner, include active participation on the part of learners, in the form of feedback and dialogue, to enhance their knowledge acquisition. In a similar study, Mowlam *et al.* (2010) also found a preference among young learners for modern interactive and innovative ways of learning, such as internet-based activities, CD-ROMS, videos and classroom activities. Where written information was used, it was more effective when text was limited and pictures were included.

Learning and practice

According to Brown and Duguid (1991), much conventional learning theory, including that in most training courses, tends to endorse the valuation of abstract knowledge over actual practice and as a result to separate learning from working, and more significantly, learners from workers. Learning in organisations is thought of as a

form of acquisition of knowledge, related to the notion of instruction and training (Gherardi and Nicolini 2002). In addition, training is thought of as the 'transmission of explicit, abstract knowledge from the head of someone who knows to the head of someone who does not in surroundings that specifically exclude the complexities of practice and the communities of practitioners' (Brown and Duguid 1991).

The concepts of knowledge or information transfer have however been under increasing attack, particularly from learning theorists (Bandura 1986, Lave and Wenger 1991, Brown and Duguid 1991; 2001, Gherardi and Nicolini 2002). Social learning theory, for example, proposes that learning can occur directly through interaction with the environment or indirectly through the observation of others who act as models, and the consequences which result from these actions (Bandura 1986). According to Brown and Duguid (2001), it is the shared know-how (or tacit understanding) that develops from shared experience within communities or networks of practice that enables the sharing and circulating of explicit knowledge. Lave and Wenger (1991) also reject transfer models, which isolate knowledge from practice, and develop a view of learning as social construction, putting knowledge back into the contexts in which it has meaning. From this perspective, learners are seen as social beings that construct their understanding and learn from social interaction within specific socio-cultural settings (Lave and Wenger 1991, Gherardi and Nicolini 2002). Learning within organisations is therefore conceived as a social process, the goal of which is to discover what to do, when to do it, how to do it according to routines and using specific artefacts, and then how to give a reasonable account of why it was done (Gherardi and Nicolini 2002).

From this practice-based standpoint, Gherardi and Nicolini (2002) set out to explore how safety knowledge is acquired and transmitted by and to novices on a building site, in order to highlight the social and cultural character of learning. In their research, they found that in Italy, most safety training is imparted based on knowledge acquisition and the notion of instruction and training. Workers are sat down in a class room or in a classroom-like setting and are spoken to by experts with the support of slides, videos and booklets. Workers are told what is dangerous and what the national regulations prescribe them to do and not to do. However, when they return to their workplaces, these workers were found to soon forget what they have learned (Gherardi and Nicolini 2002). In contrast, Gherardi and Nicolini (2002) emphasize the importance of learning in non-instructional settings. They consider safety as a social competence that cannot be learnt, but only practised, due to the tacit nature of personal safety knowledge. Their findings also suggest that learning a practice is an eminently situated activity based on the combined use of language, action and observation. The primary sources of learning are the persons close by, those who do the same or similar job in the same workplace.

These sociocultural views of learning and knowledge effectively highlight the shortcomings of much of the training interventions that are carried out in the industry to prevent accidents. Many of these interventions occur in surroundings that specifically exclude the complexities of practice and revolve around the idea of raising individual awareness by exposing workers to evidence of what is dangerous, by providing feedback on their actions and by imposing a regime of controls and inspections. However, these measures often fail, as evidenced by the prevalence of accidents, injuries and ill health. According to Gherardi and Nicolini (2002), safety does not improve for these interventions are incapable of affecting the extant work practices of the community. Therefore, as safety knowledge is to be found in the

process of interaction, in the effort of active observation and imitation of others, and in conversations, active participation by young learners is necessary for effective learning to take place. Thus, the manner in which H&S training is delivered may need to change, particularly when aimed at young workers, to adopt modern interactive approaches and move away from the traditional didactic methods of training.

CONCLUSIONS

The H&S of younger workers is critical to the construction industry's sustainability and future economic performance as well as of great importance for young people themselves, for their overall management of life, health and well-being. Yet the industry faces difficult challenges. For example, there remains a worrying and progressive trend for injury among vulnerable younger workers. In addition, the project based nature of the construction industry poses significant challenges to the provision of occupational H&S training.

Nevertheless, training is still a fundamental requirement for improving occupational H&S performance. Current training approaches, often conducted in instructional settings, while well intentioned, are limited in their ability to improve H&S for younger workers. These control-based approaches fail to consider the importance of the social context of learning. As H&S knowledge is to be found in the process of interaction with the environment, in the effort of active observation and imitation of others and in conversations, active participation by young learners is necessary for effective learning to take place. Learning effectively takes place among others and through others.

The literature review revealed a preference among young learners for interactive and innovative ways of learning, such as, interactive packages, internet-based activities, videos and case studies including site visits. Thus, the manner in which H&S training for younger workers is delivered may need to change, to adopt modern interactive approaches. Reviewing existing training methods in light of these stated preferences could be beneficial to the industry.

Following this literature review and in light of the review findings, further empirical research will be conducted, to examine the key issues identified. The empirical research will adopt wearable devices/simulations developed by Loughborough University (Cook *et al.* 2009 and 2012) to evaluate the effectiveness of interactive training approaches, aided by visually engaging, innovative tools. The devices called SKInS (Sensory and Kinaesthetic Interactive Simulations) simulate the key occupational health conditions affecting construction workers (dermatitis, hand-arm vibration syndrome, musculoskeletal disorders, noise-induced hearing loss and respiratory disorders) and their consequential impacts on both working and home life. The rationale for using these simulations to train younger workers is that, when worn, the SKInS enable younger workers to directly experience age-related occupational ill-health conditions and encourage behavioural change. Hence, the expectation will be that the SKInS will promote learning and raise awareness in order to drive change within the industry.

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THE PRINCIPAL CONTRACTOR'S ROLE UNDER CONSTRUCTION (DESIGN AND MANAGEMENT) REGULATIONS 2007: AREAS FOR FURTHER RESEARCH BASED ON A QUALITATIVE INQUIRY

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The dissimilarity between principal contractor and contractor organisations under CDM 2007 can often be over measured. In an effort to clearly distinguish the two, so as to understand the role of principal contractor as part of an on-going study, inevitable gaps emerge which invite further research into practice and procedure. Based on a desk research and three (3) focus group meetings with industry experts, it is established through a qualitative inquiry that the principal contractor contributes considerably to the successful implementation of CDM regulations during and after the construction phase. Crucial to this process are the legal and contractual obligations stipulating health and safety requirements before and during the construction phase – *regulation 23(1)(a)*. In order to successfully deliver the construction phase plan, critical to this process yet underestimated are key procedures such as appointment criteria, performance measurement and liability for instance which are hardly mentioned in the CDM 2007 or the practice guidance notes. Clearly, contractors are bound to coordinate numerous activities on construction sites let alone managing health, safety and welfare of employees in accordance with section two (2) of the Health and Safety at Work Act (HASAWA)1974 and part 4 of the CDM 2007 – *duties relating to health and safety on construction sites*. Providing explicit terms of engagement and carefully executed procedures such as appointments can enhance overall health and safety management through construction phase plans. The conclusions of the study therefore suggest further areas of research alluded to above consistent with the literature review and regulation 4(1)(b), 5(1)(2), 6 and 22 - 24.

Key words: CDM regulations, construction phase plan, health and safety management, principal contractor.

INTRODUCTION

Successfully delivered planned construction phase plans are bound to have significant benefits on overall health and safety management (Shiplee *et al.* 2011; Hare and Cameron 2012). Identified as a key duty undertaken by the principal contractor (see regulation 16(a), 23(1)(a), 23(2)) (HMG 2007), this role is crucial for implementation of CDM regulations. Given the subjectivity of the process for appointing principal contractor organisations under CDM regulations due to project type, size and complexity (Bennett 2006); inevitable gaps emerge such as appointment criteria,

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Mzyece D; Ndekugri I; Ankrah N and Hammond F.(2012) The principal contractor's role under construction (Design and Management) Regulations 2007: Areas for further research based on a qualitative inquiry *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 465-474.

terms of engagement and fee structure. For instance, demonstrated in earlier studies (e.g., Beal 2007; Dalby 2009; Pye tait consulting 2010), the role of principal contractor requires a clear distinction from that of the main contractor or contract administrator. This study therefore provides an insight into understanding the principal contractors' role, thereby identifying areas for further research in practice and procedure as part of an on-going study.

Overwhelming evidence in the recent past suggests uncertainties surrounding implementation of CDM regulations in practice (ICE, 2011; Löfstedt, 2011; Frontline Consultants, 2012) due to commercial pressures *inter alia*. Consistent with these findings, the principal contractor is identified as crucial not only in executing his roles but overall CDM regulations implementation. Clearly, the cruciality aligned with a well-executed construction phase plan cannot be overstated and therefore raises the question of understanding principal contractor obligations. In order to achieve this objective, a distinction is drawn between principal contractor roles from that of contractor under Construction (Design and Management) Regulations 2007 (CDM 2007).

Furthermore, motivation for this study stems from an on-going research which investigates the implementation of CDM regulations in practice due to uncertainties. For instance, out of 3237 sites inspected by the Health and Safety Executive (HSE), 1 in 5 failed safety checks (HSE 2012), demonstrating an inevitable link with CDM regulations particularly the construction phase plan prepared by the principal contractor. Consistent with this argument, Griffiths and Griffiths (2011) seems to suggest that the two roles are likely to operate independently although in practice this may not be feasible, given the nature of the duty to oversee the construction phase plan (i.e.) implied dependency rather than independency.

THE CONSTRUCTION (DESIGN AND MANAGEMENT) REGULATIONS 2007: THEIR APPLICATION IN PRACTICE

It is well documented that the CDM regulations 1994 failed to meet their intended purpose due to a whole host of reasons, most of which hinge on bureaucratic circumstances resulting in too much paper work and ambiguity of duties (Summerhayes, 2008; Donaghy, 2009; Griffiths and Griffiths, 2011). It is therefore unsurprising that this led to the CDM1994 regulations being revoked and introduction of the Construction (Design and Management) Regulations 2007 (Joyce 2007). The genesis behind these regulations stems from an EU directive 92/57ECC - *the management of health and safety requirements at temporary or mobile construction sites* (Baxendale and Jones, 2000; Griffith and Phillips, 2001; Joyce 2007), hence their introduction on 31st March 1995.

Since CDM clients have the overall responsibility for duty holder appointments (see regulation 4(a)), principal contractors are appointed after the CDM coordinator in accordance with regulation 14(2) while contractor appointments remain inexplicit (HMG 2007).

Although it is reasonable to suggest that CDM coordinator and principal contractor appointments are explicitly expressed as additional duties for the client (i.e.) - where a project lasts for more than 30 days or 500 person days of construction work (see

regulation 14(2) and 15(b)), glossing over other appointments leaves much to be desired.

Essentially, the principal contractors' initial duty will be to prepare the construction phase plan (Ashworth 2012), at which point, it is most certain that client organisations would have engaged other duty holders according to the practice guidance notes (L144) (HSE 2007) although this may not always be the case (i.e.) timing of appointments (CIOB, 2010). Prior to project commencement, project particulars are therefore notified to the Health and Safety Executive (HSE) through the F10 form providing details such as duty holder contact details (HMG 2007; HSE 2007).

APPOINTING THE PRINCIPAL CONTRACTOR

The Principal Contractor is only appointed if the project is notifiable to the HSE through the F10 form. Once appointed by the client in accordance with regulation 14(2), the principal contractors' main duty is to prepare the construction phase plan before the start of the construction phase (CIOB 2010). Once in place, it is a legal requirement and obligation for the client according to regulation 16(a) and 16(b) to ensure that the principal contractors' construction phase plan complies with regulation 23(1)(a) and 23(2). It has widely been acknowledged that the client has the legal obligation of appointing the principal contractor (e.g., Williams 2007; Perry 2010; ICE 2011; Frontline consultants 2012), although in practice, one off and occasional clients are likely to delegate this duty (Bamber 2011). The client is not required to appoint the main contractor as principal contractor according to Joyce (2007) since their role involves management duties rather than actual construction (*ibid*), although this will depends to a large extent on the project type (e.g., Shiplee *et al.* 2011).

ROLE OF THE PRINCIPAL CONTRACTOR

The Principal Contractor has the overall responsibility to coordinate health and safety in accordance with their construction phase plan by planning, managing and monitoring – *regulation 22(1)(a)* (HMG 2007). In order to take up this role the client must ensure competence of the duty holder according to regulation (4)(1)(a) and in the same vein a duty holder should not accept such an appointment – regulation 4(1)(b); without overlooking adequacy of resources. Table 2 defines regulation 22, 23 and 24 applicable to this role under CDM 2007. Clearly, out of the 27 regulations that apply to each role, the regulations that distinguish the role of contractor are 13, 15 and 19, while regulations 22 to 24 expressly apply to principal contractors (Summerhayes 2008). Arguably though, the principal contractor is likely to execute and comply with regulations distinctive to contractors. This is consistent with the HSE (2007) in which it states under paragraph 146 that: "Principal contractors must also comply with the duties placed on all contractors under the regulations". For instance regulation 22 (1)(c) suggests that the principal contractor ensures welfare facilities to comply with schedule two (2) of the CDM 2007; a clear replica of regulation 9(1)(b) and 13(7) applicable to the client and contractor organisations respectively.

Clearly from the literature review, inevitable areas which invite further research are established in order to convincingly identify lines of responsibility, liability, performance indicators and other procedures in practice. It therefore reasonable to suggest that providing site induction and training will apply to contractors in practice as detailed in regulation 22 which only apply to principal contractors.

Table 2: Duties of the Principal Contractor (HMG, 2007; Summerhayes, 2008)

Regulation	Description
	1. Plan, manage and monitor (i.e. co-operation and co-ordination, general principles of prevention);
	2. Liaise with CDM Coordinator (Regulation 20 (2)(d));
	3. Ensure welfare facilities comply;
	4. Draw up rules which are appropriate to the construction site activities;
	5. Give reasonable directions;
	6. Inform contractor about minimum amount of time allowed for planning and preparation before he begins construction work;
	7. Consult with contractor;
	8. Access to construction phase plan;
	9. Give further information;
	10. Identify information to health and safety file;
	11. Display F10;
	12. Prevent access by unauthorised persons;
	13. Provide site induction, information and training, any other further information and training.
22	14. Ensure compliance with welfare facilities – schedule 2
23	Prepare Construction phase plan
24	Cooperation and consultation

ROLE OF THE CONTRACTOR

In so far as their application is concerned, CDM regulations safe guard lives on construction sites as alluded to earlier. It is therefore reasonable and unsurprising to identify contractors to be in a riskier position than other duty holders as a result of direct contact with construction activities. For instance Griffiths and Griffiths (2011) argued that CDM regulations can succeed when perceived as a tool for protecting the construction industry workforce, particularly so for contractors.

Perceived as an employer according to section 2(1) and 3 of HASAWA 1974, the contractor therefore has a huge responsibility to safeguard the employees' work environment (construction site) and ensure that all risks are dealt with accordingly. It has been established on numerous occasions that contractors play a key part in dealing with health and safety issues on site (e.g., Ndekugri and Rycroft 2009) where for instance Joyce (2007) identifies the main contribution of contractors to be safety, planning, control and operational management while further acknowledging the constraints and actions to be taken on board from designers as well as the client or the clients' project team severally (Hare *et al.* 2006; Perry, 2009; CIOB 2010; Hare and Cameron 2012). Undoubtedly, such a scenario presents greater risk exposure to the contractor unlike other project team members, who to a great extent will operate from their offices and visit the site occasionally, inevitably leaving contractors exposed to safety matters in real time mode (Joyce 2007; SEC 2010; ICE 2011) in implied terms. Arguably, it is during the actual construction phase that planning construction procedures and activities in a safe manner remain paramount. For instance, Joyce

(2007:140) explicitly argues that accidents do not happen in the clients' boardroom or in the design office, but rather onus will be on the contractor after the planning and design is complete, at which point it becomes the principal contractors' responsibility for safe execution of construction works (*ibid*).

Depending on the magnitude and complexity of a project, the contractor is always likely to subcontract part or most of this work (Griffiths and Griffiths 2011); again presenting a different dynamic in the construction supply chain, particularly when dealing with health and safety matters (Manu *et al.* 2011).

Despite managing overall project management duties under CDM regulations 2007, where for instance regulation 13(2) states that (HMG 2007):

"Every contractor shall plan, manage and monitor construction work carried out by him or under his control in a way which ensures that, so far as is reasonably practicable, it is carried out without risks to health and safety," it is reasonable to suggest a critical alignment between the contractors' obligations and the construction phase plan prepared by the principal contractor.

Clearly the principal contractor will have a role to play in the overall control of construction work – *regulation 19(1)(b)*, therefore inviting further areas of research on procedural matters in practice such as performance monitoring, liability, basis of payment and the like. Table 1 describes regulations 13, 15 and 19 applicable to the role of contractor as detailed below. Inevitably though, these regulations will apply to principal contractors and the same can be said for table 2 vice-versa. Previously the contractor had the overall responsibility for managing all health and safety related matters (Baxendale and Jones, 2000); however under CDM 2007, all duty holders have a role to play; accountable for their actions and decisions. This can only be achieved through effective teamwork and planned coordinated activities where duties are explicitly detailed (Shiplee *et al.* 2011).

Table 1: Duties of the Contractor (HMG, 2007; Summerhayes, 2008)

Regulation	Description
13	Inform Client, Plan manage and monitor, information and training (suitable site induction, risks to health and safety, measures taken, any site rules, emergency procedures, identity of nominated person), Training as per the Management of Health and Safety at Work Regulations 1999.
15	Pre-construction information from the client/CDM Coordinator
19	1. Provided with: (i) names of CDM Coordinator and principal contractor; (ii) access to relevant parts of the construction phase plan; (iii) notice to HSE. 2. Provide principal contractor with information: (i) affecting health and safety; (ii) justifying review of construction phase plan; (iii) for inclusion in health and safety file. 3. Identify appointed contractors to principal contractor. 4. Comply with: (i) directions of principal contractor; (ii) site rules which are appropriate. 5. Report any accident and incidents to principal contractor. 6. Notify principal contractor of significant findings and alterations to construction phase plan.

SCOPE OF STUDY AND RESEARCH METHOD

Based on the literature review, grey areas in practice and procedural matters emerge. The role of principal contractor is identified as crucial for the management of health and safety on construction sites and the level of influence it has for successful implementation and delivery of CDM regulations. As revealed in the critical review of

literature, this duty holder is instrumental in not only preparing the construction phase plan but also the actual management and execution. It is in this context that understanding the role of principal contractor can have significant benefits thereby identifying areas for further research as part of an on-going study. Given the exploratory nature of this question, a qualitative inquiry is deemed fit as a research strategy or approach (Fellows and Liu, 2008; Creswell, 2009); for instance it is argued that research questions emanating from '*how'* are often best answered by a qualitative inquiry (Ankrah, 2007; Creswell, 2009; Maxwell, 2009) and therefore this option is chosen as viable.

Primary data was collected using focus group discussions with informed leading industry experts; for instance the facilitator in group 'C' has been identified by Chambers UK 2012 as a leading individual in construction, while group 'A' and 'B' facilitators had over 20 years of experience in the construction industry; particularly working with leading contracting organisations and clients. Qualitative data was recorded using a digital device, after which transcribing, memoing and coding were carried out as part of the analysis process (Bailey 2007); organised into themes summarised in table 1, without the predominant logic of empirical representation as is the form in a quantitative inquiry (Mason, 2002); but rather onus was on the ability to achieve reliability and triangulation with primary data obtained from the literature review.

Focus group meetings have been identified as a viable option for carrying out qualitative research, using purposefully selected participants with 'certain experience' (Bryman 2008; Creswell, 2009). Professional organisation affiliation was sought as a key criterion for the selection of focus group meetings attended. Both structured and semi structured interviews formed the larger part of the discussions with the majority of the participants getting fully involved. The advantage of the focus group as identified by Bryman (2008: 475) "offers the opportunity of allowing people to probe each other's reasons for holding a certain view."

The discussion with group 'A' predominantly surrounded management arrangements that are put in place to ensure H&S aspects on construction sites by players in the construction supply chain with a view to identify the role of principal contractor while group 'B' discussed the various roles in practice. Group 'C' meeting focused on contractual obligations with intent to establish standard practice and procedure.

FINDINGS AND DISCUSSION

The construction phase plan is identified as an important tool to safe guard lives on construction sites. For instance group 'A' identified 'choices' and 'decisions' made by duty holders as crucial in the successful implementation of the construction phase plan. Emphasis was placed on awareness of the fact that all duty holders had a role to play in successfully implementing the of construction phase plan although others suggested the need for clearer lines of communication in order to easily access information from various parties when preparing the construction phase plan. The client and the end users were identified as crucial in the process as one participant in group 'A' pointed out that:

"Always have the client and the end-user in mind…what are their needs…remember that the plan is for the present while the file is for the future."

It may seem inappropriate to think of the end user during the construction phase, but the whole point is have the whole building life span in mind as whatever happens

during construction is bound to affect its life cycle, be it during maintenance or demolition. The discussion summary for group 'A' as indicated in table 3 is consistent with the fundamental principles on which CDM regulations are based identified by Baxendale and Jones (2000) suggesting that all members who contribute to the health and safety of a project are to be accountable. This can be achieved to a large extent by making roles of various parties explicit with a view to design-in checks and balances as noted by one participant below:

"You need to have a mechanism internally to check that you are complying with the regulations and most importantly to check that the contractor is complying with the construction phase plan."

Table 3: Focus group discussion meetings

Group	Participants	Theme(s)	Discussion summary	No.	Type of meeting
A	Clients, Consultants (H&S, Architects, Engineers and Quantity Surveyors) and Contractor organisations.	Management (i.e. timing - *decision making*), prevention, competence, contractual obligations, risk.	Managing health and safety is everyone's responsibility in the supply chain. Appropriate appointments and competence checks are crucial for overall health and safety management on construction sites.	15	Semi structured
B	Clients, Principal Contractors and CDM coordinators	Prevention, competence requirements.	It is the duty holders' responsibility to ensure safety of buildings and other forms of infrastructure. Imbalance of liability can be viewed as a threat to overall health and safety management.	19	Structured
C	Consultants, Principal Contractors, specialist contractors and CDM coordinators	Contractual obligations, contract, practice, statute.	Terms and timing of appointment are crucial for the successful delivery of the construction phase plans.	17	Semi structured

While it was acknowledged by group 'B' and 'C' that the current regulations have been in force for just over five years, making the roles of various parties explicit removes the assumptions made in practice on who is to perform a particular task; for instance regulations 5(1)(a), 5(1)(b), 5(2), 6(a) and 6(b) – relating to regulation 20(2)(d), states that:

"to take reasonable steps to ensure cooperation between designers and principal contractor during the construction phase in relation to any design or change to a design," require cooperation and coordination by all parties concerned on a project on whom duties are placed by the regulations (HMG 2007), however in practice this may not be possible as indicated by practitioners in group 'C':

"90% of the time, we are appointed after the designer…it is not our responsibility to check whether they comply with the regulations or not as this would increase our

tasks…in practice this is not possible," while another participant argued in group 'B' that:

"There's need for a clear distinction of duties for instance the principal contractor is required under the CDM regulations to comply with welfare facilities but clearly that is the role of a contractors' organisation."

In line with the above statement, the suggestion made by the facilitator in group 'C' was that:

"The principal contractor should liaise with other duty holders if any changes are made…and it's important that everything is put in writing as an audit trail since you are not in contract with them."

For instance, there a concern was raised by one participant in group 'C' initially appointed as CDM coordinator and later asked to prepare the construction phase plan. Clearly, this demonstrates areas that invite further research into appointments and terms of engagement to cover additional services.

Depending on the type of project, the role of principal contractor can normally be taken up by the main contractor. Where a design and build project is commissioned, the contractor on paper takes up all the roles as was established by one participant working on specialist type of builds. Consequently, the type of client (i.e.) private or public will have an influence on who does what in practice. Where clients are occasional, bespoke type of contracts and procedures are drawn up such as the London 2012 (Shiplee *et al.* 2011) inviting inevitable areas for further research. Interestingly, others suggested that designers alone should not be liable for design decisions, but rather principal contractors should be accountable for how they manage and incorporate construction activities in the construction phase plan, while contractors are liable for constructability and workmanship if H&S standards are to be upheld.

AREAS FOR FURTHER RESEARCH AND CONCLUSION

From the foregoing findings and discussion, CDM regulations have provided proactive mechanisms which call for accountability by various parties with CDM contractual obligation. The principal contractor without a doubt is central to achieving a planned construction phase although the extent to which independence is achieved regarding choices and decisions made invites further debate. Clearly, timing of appointments and the subsequent execution of duties in practice in accordance with the regulations is far-fetched due to commercial pressures. In practice, an appointment to the role of principal contractor largely depends on the procurement routes, type of contract, complexity and scope of project. On large and complex projects for instance, (i.e.) bespoke one-off commercial projects, where autonomy is fully exercised rather than occasional projects where the main contractor assumes the role of principal contractor may provide explicit responsibilities. Eminent features for the implementation of the construction phase plan linked to the role of principal contractor emerge; therefore inviting further research into procurement procedures, liability, criteria for appointment and practical procedures for implementation. The extent to which these issues are clearly stipulated as part of the role of principal contractor distinctive from other duty holders such as the contractor leaves much to be desired.

CONTRIBUTION OF THE STUDY

Given the nature of the construction industry; fragmentation at many levels – (e.g. procurement procedures and the like); arguably this demands clarity in the expression of duties, bound to have significant benefits to the construction supply chain. It is therefore unsurprising that there has been a growing demand for accountability by 'players' in the supply chain and the same can be said for 'duty holders' under CDM 2007. Despite being in an eminent position to produce the construction phase plan and monitor its execution thereafter, principal contractors are likely to carry out additional services although this will hinge on *inter alia* industry commercial pressures. Notably, the study demonstrates and provides insight into 'grey areas' that invite further research when executing the role of principal contractor which sought clarity from a legal context in accordance with regulation 22 to 24.

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A FRAMEWORK FOR ENHANCING AND IMPROVING THE SAFETY CULTURE ON SAUDI CONSTRUCTION SITES

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Improving safety culture is necessary to reduce the number of injuries and fatalities on construction sites internationally. A comparative study of eight developed and Arab countries shows that Saudi Arabia is performing poorest in terms of the rates of major injuries and fatalities, and embedding a safety culture in practice remains a challenge. Three key elements of a safety culture model are identified from the literature: person (safety climate), environment/ situation (safety management system) and behaviour (safety behaviour). These have been constituted into safety culture models. There is also a fourth element relating to organisation. However, there is a lack of research which considers how these components can be integrated into a holistic safety culture model. A conceptual framework is proposed that adopts and integrates these elements for application to the Saudi construction industry. The framework is composed of the three elements derived from the existing frameworks in the literature, and the fourth element of organisational context. The framework will be developed and tested using Saudi construction projects and it is expected that the results of the study will be of benefit to contractors for measuring their own safety culture performance.

Keywords: safety culture, injuries and fatalities, comparative analysis, models, Saudi Arabia.

INTRODUCTION

Poor safety culture is one of the main attributes causing many injuries and fatalities in the construction industry all over the world (Choudhry *et al.* 2007). In Saudi Arabia, the General Organization for Social Insurance (GOSI, 2010; 2011) has revealed that the total number of serious injuries from 2004 to 2010 was 261076 (an annual average rate of 3413.9 per 100,000 employees), while the deaths totalled 2176 (an annual average rate of 28.3 per 100,000 employees). Most of these accidents were caused by the employee's safety culture due to the fact that majority of the employees (95%) in construction are from migrant workers. Therefore, applying any improvements to reduce or eliminate the accident record will not be effective until safety culture is considered as a principal matter (Blockley, 1995). Thus, the safety culture

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Alasamri H; Chrisp M.T. and Bowles G (2012) A framework for enhancing and improving the safety culture on Saudi construction sites *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 475-485.

measurement is good as a starting point for improvement and many studies have built models for this goal.

The "reciprocal safety culture model" is an example of one of these models (Bandura, 1986; Geller, 1997; Cooper, 2000; Choudry *et al.* 2007; Ismail *et al.* 2009) which focuses mainly on person (safety climate), environment/ situation (safety management system) and behaviour (safety behaviour). All these authors assert the importance of belief in the value of the organisation (top management) for support. However, there is a lack of research which considers how the organisation (top management) can be integrated into the reciprocal safety culture model. This paper is part of continuing PhD research aimed at improving the safety culture on Saudi construction sites with the following objectives:

1. Identify the current status of the safety performance in the Saudi construction industry.
2. Compare the safety problem in the Saudi construction industry to other countries.
3. Identify and incorporate the component(s) that need to be added to the Chaudhry's model to improve the safety culture in the Saudi construction industry.

BACKGROUND OF CONSTRUCTION SAFETY IN SAUDI ARABIA

Safety performance

Over the last two decades, Saudi Arabia has become one of the fastest-growing economies within the Arabian Middle East, especially in the construction sectors. Despite this fact, the safety level on construction sites lags behind this development and is considered relatively poor. To clarify this point, over the past 15 years many researches have been done and published on safety performance measurement based upon a random sampling and it is summarized in Table 1

As shown in Table 1, the earlier study done by Jannadi and Sudairi (1995) used only a traditional approach "lagging indicators" such as injury frequency rate and compensation costs. In fact, one of these tools has been used in research (injury rate) to find safety rate for company by calculating the number of all work injuries per million employee hours worked. It concluded that mean rate injury for large companies is better than others because the injury rate is relatively low. Nevertheless, Mohamed (2002) ; Choudhry *et al.*(2007) criticised this approach and considered it as a poor measurement tool to assess the safety performance of any company because its measure only historical events of the organizations based upon the availability and reliability of data regardless the current safety activities.
Alamoudi (1996) ;Jannadi and Assaf (1998); Alasmari (2010) tested the safety performance by using one of the modern approaches "leading indicators" such as safety climate measurement (Mohamed, 2002), safety culture (Cooper, 2000) and the hazard identification checklist or behaviour observation (Choudhry *et al.*2007).In particular , Alamoudi (1996) and Alasmari (2010) used safety climate as tool of the assessment by testing the individual perceptions of project managers or safety officers toward the safety. They concluded in one of the studies that the safety level was poor while the other ranged from poor to good.

Author & Year	Construction firms participated	company Size								
		Small			Medium			Large		
		Safety assessment methods			Safety assessment methods			Safety assessment methods		
		Mean Injury frequency rate	Mean Attitude score	Mean Checklist score	Mean Injury frequency rate	Mean Attitude score	Mean Checklist score	Mean Injury frequency rate	Mean Attitude score	Mean Checklist score
Jannadi & Al-Sudairi (1995)	16	43	---	---	19	---	---	11	---	---
Al-Utaibi (1996)	45	35.78	---	66.78% and rated "fair"	29.74	---	68.05% and rated "fair"	10.06	---	88.62% and rated "very good"
Al-Amoudi (1997)	122	---	16 % and rated poor	---	---	37% (poor)	---	---	45% (poor)	---
Jannadi and Assaf (1998)	14 sites	---	---	65.21 % and rated "fair"	---	---	---	---	84.55 % and rated "very good"	---
Baig (2001)	28	89.43		0.47 on a scale of 1 and rated (poor)	34.83		0.61 on a scale of 1 and rated "fair"	13.79		0.8 on a scale of 1 and rated "very good"
Alasmari (2010)	38	---	45.36 %, rated "poor"		---			---	75.23%, and rated "good"	

Table 1: Summary of earlier studies of safety performance in Saudi Arabia

Jannadi and Assaf (1998) used the hazard identification checklist as one of the tools of modern methods to measure the safety performance of the organisation .They concluded that safety level ranged from fair to very good. The good advantage of modern approaches is to display the current safety activities and to find out how successful the safety management system is for the organisation .A few researchers used the two approaches, modern and traditional, in combination (Baig ,2001;Al-utaibi,1996) which is indeed useful for helping the organisation to determine their safety performance in more accurate terms. Overall, these studies have indicated that the safety culture is a significant cause of the wide variations in health and safety performance levels in the construction industry.

COMPARATIVE STUDY

A comparative approach is considered the best option to emphasise and give clear images about the current state of any problem, which helps the practitioners to set plans to address these problems. The current comparative study concerns, the number of employees and the number and rate of injuries and deaths at sites depending on the statistics available in the following countries: Saudi Arabia, Jordan, Bahrain, Kuwait, the United Arab Emirates, the United States of America, the United Kingdom and Australia. These statistics are used to build a clearer picture of safety and to find where Saudi Arabia stands with respect to the other countries. Furthermore, a scale for the accident rates per 100,000 employees has been included and these rates have been calculated for some countries that do not include them in their documents by using the following formula: incidence rate = (number of injuries)/ (total number in employment) ×100,000. The incidence rate is a worldwide standard, which represents

the number of reported injuries on job sites during a 12-month period for the work of a group of 100,000 employees.

From Table 2, the findings of the comparison can be concluded as follows: (1) The methods of reporting vary from one country to another based on the culture of reporting, and for this reason the study will use the major injuries and deaths rate as a basic norm in this comparison; (2) Saudi Arabia has the highest rate of major injuries with 3117 out of every 100,000 workers injured in 2008; (3) the UK has the lowest rate of major injuries at 254.1 for every 100,000 workers in 2008; (4) Saudi Arabia has the highest rate of fatal injuries with 28 out of every 100,000 workers dying in 2008; (5) The UK has the lowest rate of fatal injuries with 3.4 out of every 100,000 workers dying in 2008; (6) Outcome final that Saudi Arabia was at the top of the list of selected countries in terms of the rate of fatal and non-fatal major injuries, and this indicates a very serious and worrying situation.

Country	Labour (Thousands)	No. injuries		No. deaths	Rate of major injuries / 100,000 employees/Year	Rate of fatal injuries /100,000 employees/Year	Date issued
United Kingdom	2404	Major	3286	53	254.1	3.4	2008
		Minor	6789		524.9		
Australia	926	Major	1621	55	175	5.9	2008
		Minor	13118		1416		
United Arab Emirates	1349	Serious	690*	20*	233.03*	6.7*	2008
United States Of America	13735	Major	164900	975	1200	9.7	2008
		Minor	316800		1500		
		Job transfer	207900		2300		
Kuwait	127	Serious	1257	13	1013	10.4	2008
*Jordan	374	Serious	2306	-	615.9	-	2008
*Bahrain	133	Serious	475	-	357.1	-	2008
Saudi Arabia	1248	Serious	38929	402	3117	28.19	2008
Max. Rate of Non-Fatal injuries (major)			3117 per 100,000 (Saudi Arabia)				
Max. Rate of Fatal injuries			28.19 per 100,000 (Saudi Arabia)				

Table 2: The comparative study for 2008

- *Source: BLS in the USA,2009; ONS in the UK, 2008;HSE, 2010; Safe Work Australia, 2011; GOSI, 2010; GOSI, 2011; NBS in UAE, 2010; Redfern, 2010; CSO in Kuwait, 2008; Al Sharaky, 2009; SSC in Jordan, 2008; SIO in Bahrain, 2008*
- ** Data released by Build Safe UEA which covered 388 projects with 296,093 people working on site.*
- **No data available for fatal injuries in Jordon and Bahrain.*

REVIEW AND DEVELOPMENT OF AN INITIAL FRAMEWORK FOR SAFETY CULTURE

Over the last two decades, safety culture has become a challenging and interesting topic around the world for many researchers and practitioners due to it being responsible for many accidents and disasters within organisations (Choudry *et al.* 2007). Most of these studies focus on building a model either for interpreting the concept of safety culture or an assessment for improvement. However, there is not yet any universal and acceptable model for safety culture (Cooper, 2000) .In this research,

the "reciprocal safety culture model" as example will be used as theoretical fundamental knowledge to prepare an initial draft of framework for safety culture in Saudi construction context. The following paragraph gives a brief context of some researches on such model.

In the earlier study, Bandura (1986) tried to interpret the concept of safety culture in terms of reciprocal determinism based on social cognitive theory, and derived three components: behaviour, person and environment. Geller (1997) adopted Bandura's work and made an excellent effort to identify the characteristics for each component and that leading to the development of a model called 'total safety culture'. Bandura's model was also adopted and developed by Cooper (2000) who asserted through his new model that safety culture is a product based on interactions between people, jobs and organisations. Ho and Zeta (2000) developed a model called the "safety culture table model" which involved person, environment, behaviour and organisation, and they pointed out that safety culture is similar to the table that is constructed on four legs. Molenaar *et al.* (2002) developed a snap-shot assessment model based on Bandura's conception with different names, people, process and value, using 31 characteristic hierarchies as positive culture indicators. Choudhry *et al.* (2007) adopted Cooper's model with some modification in order to make it suitable for use in the construction industry. Ismail *et al.* (2009) adopted Cooper's model to develop a framework for operationalization of construction safety culture in Malaysia which involved three phases: Psychological (value & beliefs), behavioural and situational (observable practices & provided environment) and safety officers &supervisors (communication, trust & commitment).

The reviews have disclosed that these models will not be effective for safety improvement until they get support from top management (the senior leadership) who has the power to maintain the positive culture within the organisation. For example, if the organisation has a good attitude from the top management toward health and safety then this is reflected in the safety performance result. However, a few research studies have been carried out to explore the top management perception and attitude about safety (Gadd. *et al.* 2002).

Based on this review, the initial framework in this research will be developed and formulated from the family roots of the past reciprocal determinism of safety culture models, a person (safety climate) comes under psychological factors, while behaviour and environment/ situation come under observational factors by adopting Choudhry's model due to the importance of these components as being mainly responsible for the majority of accidents (Suraji, 2001).

Nevertheless, this model does not adequately represent the Saudi context and has fundamental limitations through absence of organizational (top management). This will be considered and developed as separate components before implementing the model within the Saudi construction sites as illustrated in Figure 1. This is due to the fact that safety perceptions of those in upper level management of organization, for example president, chief, senior executives , etc., and their decisions that influence the firm level (Molenaar *et al.* 2002) is considered a significant element to keep the safety culture balanced without any collapse (Ho & Zeta ,2000).

Moreover, Ismail *et al.* (2009) asserted that the characteristics of the three original components will not be created until the senior management have a positive culture. In addition, according to Blair (2003), those in top management have a greater ability to create and extend the safety culture within the organisation. Moreover, Sawacha *et al.*

(1999) found the most critical factors that impact the construction sites was the top management's perception towards the safety. The following subsections illustrate the details of each component which has relations with organizational (top management):

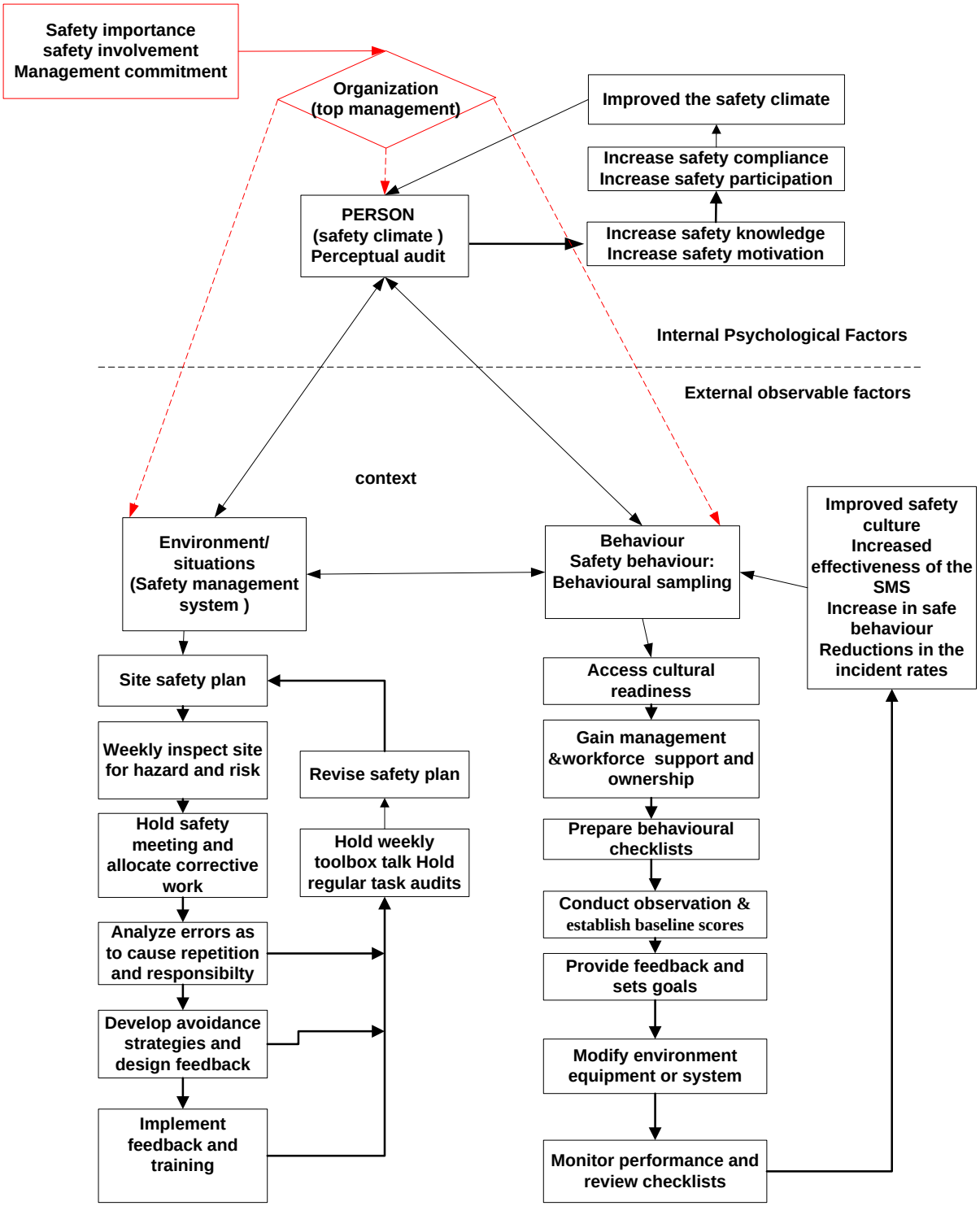

Figure 1: The Chaudhry's model with additional component in the red colour that need to be addressed

Person (safety climate)

The safety climate (value and belief) refers to safety perception of employees of the safety management system of the organization, and considered as product of safety culture (Mohamed, 2002). Because it is subcomponents of safety culture according to Cooper's (2000) definition that ' culture is the product of multiple goal- directed interactions between people (psychological),jobs(behavioural) and the organization (situational);while safety culture is that observable degree of effort by which all organizational members directs their attention and actions toward improving safety on a daily basis'. Nevertheless, there is wide confusion and overlap between the safety climate (perceptual approach from the bottom up) and safety culture the ability to manage the safety (organisational approach from the top down), and this may be one of the things that have contributed to slowing down the progress of improvement in safety performance (Mohamed, 2002).

The person as understood from Chaudhry's model refers to personal field which involves the middle management who are responsible at the project level for decision making (such as site engineers, project manager, etc) and also those in the front line who spend much time working on the site (such as workers, foremen, craftspeople etc.; Molenaar *et al.* 2002). Neal *et al.* (2000) indicated that one of the main influencing keys of the safety climate is the perceptions of senior management through considering the safety as important. Thus, when the organization have great understanding of the safety importance then it reflects their ability to improve safety climate by increasing employees' knowledge and the provision of motivation for compliance, and participation in safety activities (Neal *et al.* 2000).

Behaviour (safety behaviour)

It is useful as a starting point to mention the fundamental of behaviour, which refers to "How people think, behave, respond to a situation and how the environment influences people's behaviours"(Phillips, 2005). Therefore, when there is a shortcoming of understanding the value of safety and its priority within the workplace, then unsafe behaviour that leads to 80-90% of accidents will likely be the result, as past studies have indicated (Phillips, 2005; HSE, 2002). In addition, Slates (2008) indicated that the positive and negative attitudes towards safety of the top management have a great impact on people's behaviour. In contrast Wu *et al.* (2007) considered the relationship between the senior leadership and followers to be a process to achieve the organisational safety target. Therefore, the top management plays a major role in the promotion of safe behaviour for workers directly through their perception and behaviour (Muniz *et al.* 2007). However, previous studies suggest that behaviour should be changed to become a safe habit by using behaviour-based safety (BBS), a systematic approach to identify the critical behaviour through observation techniques which identifies base-period scores and aim to change these scores by arranging meetings and setting goals for improvement (Choudhry *et al.* 2007).

Situation/ environment (safety management system)

Situation/ environment refer to the quality of operations of the organisation's safety management system at the construction site (Choudhry *et al.* 2007). The main function of this system is to provide a process for planning, implementing, and monitoring and reviewing safety performance. Nevertheless, the safety management system will not be effective without support from the senior leadership who are considered as a vital element (Muniz *et al.* 2007). Also, Cooper (2000) stated that strong commitment and

involvement in safety within the organisation by senior management depends upon the extent of their perception of the value of safety.

THE MEASUREMENT TOOLS

The three main aspects of safety culture models (psychological, situational and behavioural) can be measured using different tools for quantitative and qualitative data collection to obtain a final score for each aspect (Cooper, 2000). In contrast, the new component that related to organization (Top management) that has not been considered in Chaudhry's model which is very important in construction sector will be developed using appropriate tools for measurement such as semi interview structure and questionnaire. The psychological aspect is popularly measured by quantitative approach using the safety climate questionnaire to assess employee's perception and attitude towards safety. The structuring of the questionnaire will be adopted from pervious questionnaires that have been developed by a number of researchers (e.g. Mohamed, 2002 etc). The situational aspect will appear in the firm's structure and will include such items as policies and safety management system, and can be measured by audits and regular inspections. The score will be calculated using the following equation (Cooper, 2000; Gadd. *et al.* 2002):

% Audits Score = (Positive Answer) / (Total Questions) × 100

The behavioural aspect can be seen in operational sites of construction by measuring the workforce behaviour periodically to determine whether they behave safely or unsafely to establish a baseline safety score. This can be repeated regularly to keep the review updated. These scores will help to give the employees a clear image of the status of safety behaviour at the site (Choudhry *et al.* 2007). Furthermore, the scores for this component are easily converted to percentages using the following equation (Glendon *et al.* 2001):

% Safety Behaviour = (Total Safe)/ (Total Safe + Total Unsafe) × 100.

Both behavioural and situational aspect of safety can be converted to five–point banding by dividing the percentage score by 100 and then multiplying the result by 0.5. This scale is of benefit as it can help identify which element(s) (legs) is/ are weaker and then attention can be paid in this area for corrective action (Cooper, 2000).

CONCLUSION

An extensive review of the scientific literature particularly the works of Cooper (2000), and Choudhry *et al.* (2007) has revealed that organization (top management) were not given enough attention or sometimes ignored especially when implementing safety culture procedures in construction sites. The Chaudhry's model that was adopted for this research has fundamental limitations when implementations within the Saudi construction context. These limitations will need to be developed and considered for the new conceptual framework due to their importance to the three original components. It will be developed and tested within context of the Saudi construction sites due to the fact that fatalities and injuries have continued to constitute a major problem. This is with a view to finding out their interactions in improving safety. It is expected that the results of the study will be of immense benefit to contractors for measuring their own safety culture performance and paying attention to weaker aspects.

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CULTURAL INTERPRETATION OF HEALTH AND SAFETY AND ITS APPROPRIATENESS IN THE UNITED ARAB EMIRATES

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In the UK we have a highly regulated construction industry to ensure health, safety and welfare of individuals in the workplace. Yet we still have an unacceptable number of fatalities and accidents. The expectation of professionals when they work abroad is that if the industry is not as regulated then it is not adequate. The research aim was to assess the health, safety and welfare in the construction industry within the United Arab Emirates and explore whether the current provision was adequate following on from the recent construction boom experienced in the region. An online questionnaire survey was carried out with construction professionals with experience of working in the UAE. The sample set produced 101 respondents, from 18 different countries, which provided a wide range of perceptions within the resulting data. The findings from the research provided evidence of a clear division emerging between European participants and respondents from other nations on how they perceived the observed standards within the UAE. The main conclusion drawn from the study is that cultural differences do affect how people perceive health, safety and welfare standards, as they judge what they see from what they are used to in their respective home countries.

Keywords: cultural perceptions, health and safety, United Arab Emirates.

INTRODUCTION

The United Arab Emirates (UAE) was formed 40 years ago after formally being known as the Trucial States. The region consists of seven emirates, which include the cities of Abu Dhabi, Dubai, Sharjah, Ras Al Khaimah, Fujeirah, Umm Al Quwain and Ajman. In 2010, the UAE's population was estimated at around 5 milllion, of which less than 20% were believed to be UAE nationals or Emiratis, while the majority of the population were expatriates (Migration Policy Unit, 2011). The UAE has recently spent billions of dollars on infrastructure and is the biggest projects market in the region, accounting for 37% of total project value within the construction, oil and gas, petrochemicals, power and water and waste sectors (Matly and Dillon, 2007).

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The Construction Industry is often considered a hazardous environment in which to be employed (Al Kaabi 2001). With these hazards come inherent dangers, which can often cause injury and sometimes death to workers. The UAE is one of the most rapidly growing and most developed countries in the Middle East and with this has come frequent accidents (Al Kaabi and Hadipriono 2003). Information regarding health and safety can often be difficult to find due to the sensitive nature and in the UAE it is even more difficult due to the lack of appropriate Regulation and reporting processes. Turley, D *et al.* (2011) identified that onsite safety has a poor reputation in the region, with accidents unreported and a wide-spread belief that regulation is non-existent. It is believed that many work related accidents and deaths in the UAE, particularly in construction go unreported (Hadid 2005). The aim of the research was to investigate the levels of health, safety and welfare provision within the UAE and how this could be improved to reduce accidents and fatalities.

The research commenced with an extensive search of relevant literature on health and safety within the Middle East which identified specific issues to the UAE briefly identified in the paper. Primary data was collected through an online questionnaire to ascertain whether health, safety and welfare standards are adequate for the construction industry in the UAE. The survey was launched to construction professionals with experience in the UAE's construction industry and managed to encapsulate respondents from a wide variety of countries and cultural backgrounds. The data was analysed and cross referenced to discover patterns and trends that emerged from various categories. One of the key findings from the survey was the geographical location of the respondents was a differentiating factor when analyzing the data this led to the conclusion that different cultural backgrounds do impact on how individuals perceive health and safety and welfare standards.

HEALTH AND SAFETY ISSUES IN UAE

The literature review identified the following main areas that impact on health and safety and welfare in the UAE:

Communication - Migrant Workers

Good communication is important in all aspects of the construction industry, but even more so when considering health and safety particularly as it can display so many risks to an operative's own health and safety. In UAE, with the majority of construction workers being migrant labour and unable to converse in what is generally the universal language of English, communication can be even more important. Also the migrant workers come from a wide variety of backgrounds with regard to their construction experience and education which can also cause a problem with a lack of understanding of the health and safety issues (Ghaemi 2006). Barss *et al.* (2005) identified that high levels of severe occupational injuries were apparent among migrant workers in the UAE.

Safety and the safe working conditions of these labourers is a growing concern, where they are either dying from heat exhaustion or from falling off the high rise buildings that they are constructing (Matly and Dillon, 2007).

Climate

The climate is very hot and humid in UAE and in the summer (June, July and August) temperatures exceed 50 degrees centigrade along with relative humidity of 100% (Shanks and Papworth 2001). Despite this workers are expected to perform their duties in exposed areas for long periods and consequently it is not unusual to see

workers collapsing onsite through heat exhaustion. Sankar (2005) identified that research figures showed that as many as 5,000 construction workers per month were brought to accident and emergency of Rashid Hospital in Dubai, during July and August of 2004, suffering from symptoms relating to heatstroke. Ramsey (1983) and Shanks and Papworth (2001) identified that the risk of accidents increase with extreme temperatures as mental confusion can develop and predispose workers to perform unsafe acts.

Management

According to Kartam (1997) accidents arise from different causes that can generally be classified as physical incidents posing hazardous situations, and behavioural incidents caused by unsafe acts. The construction process itself is also seen as being poorly planned in terms of both design and construction, with major inadequacies relating to the erection, maintenance, and demolition of buildings and structures (Cooke and Williams 1998). An underlying belief is that the majority of accidents are not caused by careless workers but by the failure in control, which ultimately is the responsibility of management (Baxendale and Jones 2000). Al Kaabi and Hadipriono (2003) also identified that companies in the region are deficient in providing workers benefits, site orientation, personal protective equipment, accident prevention, health and hygiene. These are all areas of good health and safety management that construction organisations should be providing.

New Initiatives

The most significant development was the launch of Abu Dhabi's environment, health and safety management system (EHSMS) which began to gain pace in 2011. This was to transform both working conditions and the country's reputation for delivering "world-class" construction (Turley *et al.* 2011). The regulations were developed to unify the standards implemented by the companies who come to operate in the UAE from around the world. Although the new Regulation is seen as a positive step, the industry concern is the aspect of compliance with the new systems and how they are to be enforced (Turley *et al.* 2011). Under UAE law, the Ministry of Labour Inspectors are to ensure that employers properly comply with health and safety regulations. Keane and McGeehan (2008) identified that the ministry employed only 140 inspectors to oversee the practices of over 240,000 companies making it very difficult to enforce the regulations across the whole of the UAE Industry.

The code of construction safety practice implemented across the UAE in 2011, is a single code which is quite descriptive, clear and explanatory and has some similarities with UK Health and Safety Executive guidelines. Previous to this code, each municipality had different regulations and practices, with different approaches being taken by different companies operating in the region based on their home working practices. Having one code will eradicate the current problem that exists in Dubai, where there are several regulatory authorities applying different rules within their respective operating zones (Schuster 2011).

RESEARCH APPROACH AND DATA COLLECTION

According to Fellows and Liu (2008), empirical work is concerned with knowledge gained from experimentation with much of that knowledge being gained through experience. It involves observation, evaluation, memory, and recall. All four activities include problems of selection and accuracy, so it is believed experience is unlikely to be totally reliable (Fellows and Liu, 2008). Personal experience allowed opinions to

form but this represents only one person's perception of how the industry operates in the region in terms of health and safety, so a wider audience was targeted. It was therefore important to find construction professionals with varied years of experience, and from differing construction disciplines, in order to obtain a wide variety of information and opinions. An attitudinal approach to the research was used, to 'subjectively' evaluate the 'opinion', 'view', or the 'perception' of each person, towards the particular topic (Naoum, 2007). An online questionnaire survey was chosen as the best method of data collection due to the location of the target population i.e. professionals predominantly working in UAE.

The questionnaire was designed to mix dichotomous and scaled questions to allow quantitative analysis. The scaled questions used a five point Likert Scale and allowed a qualitative response, a cognitive attitude statement, to be used as a quantitative variable for analysis (Oppenheim, 1992). The questionnaire had two sections; personal information and health, safety and welfare, and a total of thirty questions.

The questionnaire was piloted with industry professionals working in the UK who had previous experience of working in UAE. The questionnaire was published through Bristol online surveys. This allowed a structured questionnaire to be produced that could be easily navigated by its participants, in order to make the task simple. This led to greater participation from recipients. The method of data collection ensured each person was asked the same question in the same way, so that differences in answers could be held to be the real ones, unlike in an interview situation (May 2001). Ornstein (1998) suggested that despite this, even with the most carefully designed and tested questions, [it] is too imprecise to expect exactly uniform communications.

A form of snowball sampling was applied where a network of contacts were used as the initial sample and they were asked to distribute to their colleagues in the same organisation or professional field working within the UAE, hence expanding the sample creating the snowball effect. The original network considered of 60 personal contacts working in various construction organisations and professions in the UAE and 15 contractor and consultancy organisations in the region that were not part of the personal contacts. The advantage of this method was that it would increase the response rate that would be difficult to do due to geographical location of not being based in the UAE for data collection. A disadvantage of the snowball sampling technique however is the selection of the individuals at the first stage. If they have strong views on the particular subject they can influence the individuals in the second stage and the study can become biased (Kumar, 1999). The inclusion in the sample of the 15 contractor and consultancies with no personal contact was to reduce this possible bias. All of the individuals in the sample were contacted by email with a link to the online survey and the request to pass the survey on to fellow colleagues within their organisation and/or professional field.

A total of 101 responses were received allowing some statistical analysis through SPSS to be completed. The majority (55.4%) of respondents belonged to the 31-40 age group and although there were a varied number of professional roles the majority (43%) were in a Project, Construction Manager or Surveyor role.

RESEARCH FINDINGS

The literature review identified specific areas of health, safety and welfare concerns that are particular to the UAE that were further examined through the data analysis.

The variety of nationalities that participated in the survey, 18 different nationalities from across the world, reinforced the literature on the high number of migrant workers in UAE and provided valuable perspectives from differing cultural backgrounds. Outside of the UK and Ireland (62%), 17% were from the Indian Continent (India, Bangladesh, Sri Lanka), 7% from the Philippines, 4% from Eastern Europe (Bosnia, Macedonia, Serbia), 4% Middle East (Eygpt, Syria, Palestine, UAE) and 3% Africa (South Africa, Zimbabwe). The high number of responses from UK and Ireland was expected due to the sample collection method.

Perceptions on Health Safety and Welfare in UAE

88% of the total sample strongly agreed or agreed to the question, do you think cultural differences and attitudes towards health, safety and welfare contribute to the standards observed in the UAE. Table 1 shows a breakdown of these results by geographical location of the respondents.

Collectively respondents originating from the UK and Ireland were generally agreeable with the question and a combined 90.3% of this group felt the statement was valid. The majority of respondents representing other nations also felt that the statement was valid with 69.2% of this group classification being agreeable. The chi-square test produced a value less than the benchmark of 0.05 (0.00026) which suggests that there was a significant difference between the expected and observed result. It was expected that the other nation's category would believe that cultural differences did not influence health and safety standards, however the majority of this category felt this factor contributed.

Response Options	UK and Ireland	Other Nations	Total	%
Strongly Agree	28	5	33	32.67
Agree	28	22	50	49.50
Neutral	2	6	8	7.92
Disagree	3	6	9	8.91
Strongly Disagree	1	0	1	0.99
Total	62	39	101	

Table 1: Cultural differences and attitudes: Distribution of responses from differing geographical locations.

The question how do you compare health, safety and welfare standards in the UAE compared to your home country was asked to assess the respondent's perception on the standard of health, safety and welfare within the UAE. Respondents originating from Europe (95.3%) believed that health and safety standards are higher in the construction industry within their home countries. 77.7% of the respondents from the other nations outside Europe thought that the UAE provided better standards for health and safety than in their home countries. The chi-square test produced a value of 8.164 more than the benchmark of 0.05 which statistically proved that there was not a significant difference between the expected and observed result.

Most Significant Contributor to Accidents

Respondents were asked to identify which they thought contributed to the most accidents between lack of experience and training and unsafe design practice that were identified by Ghaemi (2006) and Mohamed (2001) respectively. Overwhelmingly

(92%) of respondents agreed with Ghaemi (2006) that lack of experience and training was the most significant contributor to accidents.

The respondents were asked to rate in order of significance the following 3 options which influence the causes of construction related accidents.

- Poor Management Control
- Careless Worker
- Poor planning of the design and construction stages

The results indicated that poor management control was the most significant and poor planning of the stages was the least significant of the options. This contradicted the views of Baxendale and Jones (2000) that accidents were not significantly caused by careless workers, and that poor planning of the construction and design stages was the key contributor to accidents in construction.

To the question, there is a perception in the UAE that many work related accidents and deaths in construction go unreported, 55% answered yes they thought this statement was valid. This concurred with the views of Kean and McGeehan, 2008 and Hadid, 2005 that a lot of accidents go unreported. 18% decided they would rather not comment, which leads to the conclusion that despite the statement being controversial it contains a strong element of substance.

Table 2: Order of Importance of the contributing factors that affect sound health and safety culture within construction organisations

	Factor
Rank 1=	Senior Management Influence
	Workforce Attitudes
Rank 3=	Regular Training
	Site Management Team Cohesion
Rank 5	Awareness of Legislation

Table 2 identifies the results of the rating of the factors in contributing to a sound health and safety culture. All category options to this question were viewed as having significant importance, as all have a part to play in providing a sound health and safety culture within construction organisations. However, Senior Management Influence and Site Management Team Cohesion could be viewed as the most important as they influence the other three options. In other words if senior management and site management provide the correct standards and procedures for their respective construction workforce the other factors will then be provided for. The respondents did identify this with Senior Management Influence being ranked joint first.

To test the effectiveness of the UAE's Code of Construction Safety Practice, the questionnaire asked ' it is believed that the regulations relating to construction health and safety are broadly based on the UK practices, do you feel they have the same desired affect when implemented in the UAE'. As the sample was expected to have a high percentage of respondents from UK and Ireland with a knowledge of HSE guidelines, the result would indicate whether the regulations are being implemented by the UAE Construction Industry. 55% of respondent’s expressed that the regulations in the UAE did not have the same desired effect as in the UK. 21% were unsure and

this result is due to 38% of the respondents being from outside the UK and Ireland and with no experience of UK practices.

The effectiveness of the Code is also linked to enforcement. The Ministry of Labour have powers to ensure that employers properly comply with health, safety and welfare regulations and the questionnaire asked 'do you feel there are adequate resources to carry out this role'. 72% believed that adequate resources are not available and this concurred with Turley *et al.* (2011) as a major concern.

CONCLUSIONS

This research was undertaken with the aim of discovering whether provision for health, safety and welfare is adequate within the UAE's construction industry. By identifying the main issues, these could then be linked to possible factors that affect sound health and safety culture within the construction industry. The literature review and the survey results identify the following key areas that need to be improved within the UAE Construction Industry to improve its health, safety and welfare record:

- Management on Site to include area's of control, communication and training
- Improved working conditions during peak summer months
- Better enforcement of regulations - increased municipality resource to inspect construction sites and welfare accommodation

The UAE Construction Industry involves mainly migrant workers at all levels and this adds to the requirement to ensure that there are clear consistent communication methods that are appropriate to the circumstances. This could improve the health and safety training that is required for the majority of the migrant workers that are uneducated and inexperienced. Through better training of these workers on the health and safety issues on site, this will reduce accidents. This training could also improve the health, safety and welfare culture of the management in the construction organisations as different standards are expected based on the home country experience. This training and consistent communication will also improve control.

The main finding that was not identified within the literature review was that cultural background has a bearing on how people perceive the standards within the UAE's construction industry. The results of the survey provided a divide between Europe and the developing nations with regard to how they viewed the UAE's standards. Participants emanating from western countries perceived the standards as lower than their respective countries, whereas other nations felt the UAE provided superior standards to those experienced on home soil. This therefore makes it difficult for the UAE to improve its health, safety and welfare record without regulation that sets a common standard for all construction organisations to meet and that is enforced.

The next stage of the research will be to investigate further the cultural aspect through an analysis of literature specifically looking into cultural aspects within construction and in the UAE followed by a series of interviews in the UAE with construction professionals and workers. It will also assess the Environment, Health and Safety Management System (EHMS) and their enforcement to assess if a common approach has improved health and safety within Abu Dhabi and UAE.

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HUMAN BEHAVIOUR AND CULTURE

CONSTRUCTING A SENSE OF TIME IN PROJECTS: IMPLICATIONS OF A BERGSONIAN VIEW OF TIME

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Construction management researchers have long been concerned with explaining time performance in projects. Many have simply relied on the quantitative notion of 'clock' time to explain how the actions of participants, as rational purposive beings, contribute to the time performance of projects. In this article, the central argument that the emphasis of managerial methods of time management in construction has failed to account for the full spectrum of time is put forward. By researching project time performance as an objectified goal, construction management researchers have not fully imagined the qualitative possibilities of individual time scales (or temporal perspectives) in organisations. Drawing on the work of French philosopher Henri Bergson (1859-1941) and empirical examples from an ongoing ethnographic study of infrastructure development projects in an international airport (MyAirport), it is argued that time cannot be simply represented as a homogeneous numerical order. Rather, researchers must open up potential questions about the multiplicity (i.e. heterogeneity and continuity) of the qualitative experiences of time in (organisational) life, which has hitherto been taken for granted in the field of construction management. Implications of the more plural perspectives of time are also discussed, in relation to space (context), strategy (future-orientation), and sense-making (connecting temporal perspectives).

Keywords: Henri Bergson, sensemaking, temporality, time.

INTRODUCTION

The advancement of knowledge on how projects can be completed on time has long preoccupied the minds of scholars in the field of construction management research (see e.g. Nkado, 1995; Chan and Kumaraswamy, 2002; Xiao and Proverbs, 2002, and; Hoffman *et al.* 2007). The need to finish building projects on time is certainly understandable, especially in contexts where there is a finite deadline on which the start date of the use of the built facility is critical (e.g. the stadium of a major sporting event like the Olympics). In dealing with time, therefore, research efforts have centred on three main themes, including the identification of ways to shorten time durations (e.g. Chan and Kumaraswamy, 2002) and optimise the time spent (e.g. Zhang and Li, 2010), as well as the identification of factors causing time overruns in projects (e.g.

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Chan P.W. (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.

Toor and Ogunlana, 2008). However, in spite of the wealth of research on the use of time in construction, delays in construction projects continue to be a persistent problem.

It is argued that this 'problem' of delays is likely to prevail, in theoretical and practical discourses in the construction industry, because of the over-simplified, commoditised view of 'time' adopted in the field of construction management. Time is almost always treated as a linear and quantitative measure in the construction management literature, mobilised in managerial concerns of rational planning and purposive actions for a supposedly better future. It is this narrow perspective of time, which results in the relative neglect of the qualitative experiences associated with moving through (and in) time that add to a more holistic comprehension to how individuals working in the industry construct a sense of time. It is only through this rounded understanding that one could potentially find the clues to unlock the puzzle of the performance of time in projects.

In this article, the theory of time by French philosopher Henri Bergson is drawn upon to explain the heterogeneous and multiplex views of time in society and social change. We juxtapose Bergson's view of time with the use of 'time' in construction management and wider fields of organisational and management studies to demonstrate the limits of current understanding of time in construction management. Empirical examples from an ongoing ethnographic research on infrastructure development in an airport context (hereinafter known as MyAirport) will then be used to explore the possibilities and implications of applying Bergson's philosophy to better capture the realities of time in construction. Thus, the fundamental contribution of this article is to open up broader perspectives of time to see how qualitative experiences of time can help enrich current notions of time performance in construction management research.

THE USE OF 'TIME' IN CONSTRUCTION AND ITS LIMITS

Time is often perceived as a critical performance criterion that is usually connected with cost (e.g. Atkinson, 1999, and; Lambropoulos, 2007). Thus, as the old adage 'Time is Money' goes, there is a wealth of studies on time performance in the industry that either seek to improve the industry's productivity (see Drewin, 1982) or reduce the occurrence of delays in projects (see Flyvbjerg *et al.* 2003). Underpinning many of these studies is the rationalist assumption that time can be objectively managed in the running of projects, and all that really mattered is the ability for research and practice to develop better planning techniques. For instance, in Drewin's (1982) well-known work-time model of construction productivity, he categorised working time into various components that help managers identify productive and unproductive time. The idea is that explaining time in such concrete components, managerial actions can then be appropriated to eliminate activities that are unproductive in order to maximise productive time.

However, such an approach that conceptualises time as a binary between productive and unproductive time is problematic for a number of reasons. Firstly, there is still a lack of empirical evidence to show that reduction of unproductive time would necessarily lead to increments in productive time (see e.g. Thomas *et al.* 1990). There are also asymmetries between different actors in organisations (e.g. workers and managers) in the way they qualitatively perceive what productive time is (see e.g. Dai *et al.* 2007). Thus, this limits the possibilities of objectively creating categories of time that is based on the dichotomy of productive and unproductive work.

Secondly, the underlying assumption behind counting time in such a quantitative manner is that time can then be subjected to the planning prerogative of individuals (mainly managers) as rational purposive actors. Indeed, the vast volume of work found in distilling the factors causing delays in construction can simply be taken as prescriptive advice for future managers who intend to avoid such pitfalls. Yet, there is strong evidence to indicate that arming oneself with the knowledge of such factors that cause time overruns on projects does not automatically guarantee its avoidance (see Flyvbjerg *et al.* 2003). Perhaps this is because of the relative inability of our cognitive power to predict too far into the long-term future (Lejeune and Wearden, 2009). Thus, calls to refine planning at the earlier, front-end stages of the project life cycle (e.g. Williams and Samset, 2010) might simply prove to be futile, since studies have shown that project actors struggle even to make sense of what they are required to do in the present, let alone predicting the timely outcomes of the future (see e.g. Knight *et al.* 2002, and; Tzortzopoulos *et al.* 2006).

Further to the difficulties entailed in the objective classification of (productive) time and the shortcomings of rational planning approaches, the third problem in the use of 'time' in construction is its atemporal treatment. Time is largely treated by construction management researchers as numerical reduction, counted chronologically as 'clock time', and mobilised like any natural and physical resource at the disposal of managers. It has been argued that such a position on 'time' is too narrow. Rämö (2002), for example, argued that chronological notions of time (chronos) should be complemented by cosmological notions of timing (kairos) so that project participants are not only productive ("do things right"), but are also effective ("do the right thing"). Moffatt and Kohler (2008), when arguing for a socio-ecological perspective of the built environment, also stressed that built environment professionals need to develop a more sophisticated sense of time that not only evaluates its numerical characteristics, but also consider the plurality of the time periods that individuals go through. After all, as they noted, "some species respond quickly to change and shocks, others more slowly (Moffatt and Kohler, 2008: 260)", thereby requiring differential, qualitative time scales (or temporal perspectives) that go beyond quantitative means of 'clock time'. It is at this point that an introduction of Henri Bergson's enduring ideas about time is appropriate.

HENRI BERGSON'S IDEAS ABOUT TIME, AND THE RELEVANCE TO ORGANISATION AND MANAGEMENT

Henri Bergson is a Professor of Philosophy at the Collège de France, whose writings tend to extend explanations about reality from a physical science worldview to consider the realities of life (Carr, 1911). According to Carr (1911), Bergson's most influential pieces of work lay in the trilogy comprising Time and Free Will (1888), Matter and Memory (1896), and the more well-known Creative Evolution (1907). For the purpose of summarising Bergson's ideas about time within the confines of this article, two key themes will be elaborated in this section, namely consciousness and change.

As noted by Carr (1911), Bergson's writings served to provide countervailing yet complementary arguments to the growing dominance of the Scientific Method, which placed primacy on cognitive logic and material realities of the physical world. Bergson argued that the worldview of physical science that privileges cognitive perspectives ignores the critical importance of intuition. Rather than emphasising cognition as the basis of knowledge about the world, Bergson suggests delving deeper

into the consciousness of human life. Related to this notion of consciousness, Bergson rejects the causality of time. By using the clock pendulum as an example, Bergson asked whether time is simply represented by linear and successive oscillations of the pendulum, or whether time consists of a much more emotive element such that listening to the swings of the pendulum makes one sleepy enough to dose off. He then raises the dilemma as to whether it is the final swing of the pendulum that resulted in (or caused) the sleepiness or whether the sleepiness was actually induced from the recollection of its first and intermediate oscillations. Through this example, Bergson rendered cognitive explanations of time causality as a problematic concept since things are never that immutable; consciousness, as in life, is constantly changing, on the move and evolving.

Thus, Bergson's philosophy is really about change and movement. For Bergson, understanding social change requires a deeper appreciation of pure duration. It is important that one distinguishes between time (clock-time) and pure duration, for the former relies on one's cognitive abilities to count homogeneous states in linear succession (e.g. 60 seconds in a minute, 60 minutes in an hour, etc.) whereas the latter is based wholly on heterogeneous, qualitative experiences of individuals shaped by an ever increasing sense of history and continuity. Bergson also argued that time in its quantified form does not change; instead, it is the qualitative forms of time embodied in pure duration that changes. Perhaps his most illustrative example is expressed in the description of the cinematograph (a film camera) where each frame, like each second in a minute, is lined up successively in an immobile physical state, but quickly transforms into a moving scene when the unmovable images are projected on to the screen such that the individuals in the audience can imagine their movable possibilities (Carr, 1911).

The symbolic example of the cinematograph also denotes how individuals recollect about the growing past. As the film reel moves forward and changes into the future, the past (frames already shown) becomes ever more extensive. Like the metaphor of the swinging pendulum, it is the potentiality of the past that adds to an individual's intuitive knowledge that unleashes the possibility of its creative evolution. Put another way, history matters and so are its many ways of qualitative interpretation embedded within human consciousness, which cannot simply be explained through intellectually-codified conceptualisations of causality. An individual's time horizon is, therefore, at least three-dimensional in that emotional capacity, imagination and intellectual capacity combine to shape one's ideas of the sense of time, including the past, present and future orientations (Boniecki, 1980). As Lee and Sawyer (2010:299) eloquently explained:

"[T]ime is more complex than a linear measure would suggest. Time has properties [...] concerned with norms, rules and conventions. To represent both, we use 'temporality'. [...]Temporality helps us to explain to others, and for others to make sense, that one minute of time in a tender embrace with a loved one is experienced as 'shorter' than one minute of time with you stuck in an elevator."

Temporality is also why we are simply more accurate at planning for the near-term than the long-term (Lejeune and Wearden, 2009). Furthermore, this probably explains why lean management tools such as the Last Planner System works in an operational, day-to-day context (see e.g. Kim and Ballard, 2010) not because of the efficacy of the tool, but because human consciousness responds more realistically to the now than the

future. Therefore, Bergson's ideas about time are about placing more focus on the living, as life evolves and moves into the future.

This multiplex notion of time in general, and Bergson's philosophy of change in particular, have captured the attention of scholars in organisational and management studies (see e.g. Gherardi and Strati, 1988; Das, 1993; Whipp, 1994; Chia, 2002; Hatch, 2002, and; Linstead, 2002). This growing literature has, at its core, the central belief that the constitution of organisation is not through the "calculative and formalistic (Linstead, 2002)." Rather, organisation invokes a sense of becoming (Tsoukas and Chia, 2002) where organisational change requires its actors to move around and metamorphose within time and space (Hatch, 2002) and at different paces and rhythms (Sabelis, 2001), as opposed to simply tracing changes of physical states over time. Organisations cannot thus be treated as stable and coherent through the range of intellectual properties codified in the commodities of managerial tools (Chia, 2002). Instead, organisation (or rather organising) is forever moving, and contingent upon intuitive knowledge that can never be logo-centrically codified (Styhre, 2004). It is this corpus of intellectual debate that inspires the basis of this article, which in turn aspires to open up the heterogeneous notions of time, and seek the relevance of its ensuing movement in constructing a sense of time and temporalities in construction. To do this, the next section will present a number of empirical examples from an ongoing ethnographic study at MyAirport.

TIME PERSPECTIVES AT MYAIRPORT

Airports are highly complex spaces, made up of interactive assemblages of people, materials and information (Knox *et al.* 2008). The following excerpt from Doherty's (2008: xii) reflection on the construction of Heathrow Terminal 5 epitomises the scale of an airport's complexity.

" BAA [British Airports Authority] had created an environment that actually allowed them to focus on being the best they could as project managers, design leaders, engineers or supervisors, rather than spending time second guessing the commercial impact on their company of every challenge. This book is dedicated to the people who were involved in T5, some who gave a few weeks, but many who gave five, ten and in some cases over twenty years to see T5 opened successfully."

This quote by Doherty (2008) demonstrates the organisational pluralism at airports, not only in terms of the various professionals and working classes involved, but also in the varying time scales of social relationships forged in the project of constructing Heathrow Terminal 5. So, the involvement of people in different time frames - a few weeks, five, ten and over twenty years - is noteworthy, since the qualitative experiences and organisational sensemaking are likely to differ depending on the quantitative amount of time spent in the project. Indeed, sensemaking appears to be the only certainty, as Doherty's (2008: 328) conclusions remarkably highlight:

"Time will tell if the operating profits, retail spend and workforce efficiencies are actually delivered. But what stands the test of time will be the passenger experience."

Thus, only time will tell suggests a tentative, uncertain future where managerial concerns are secondary to the (qualitative) experience of passengers. It is this experience of time perspectives at airports that is the central focus of this section.

Empirical examples of the different ways actors at MyAirport conceptualise time will be presented here. The data is drawn from a wider study into how internal stakeholders at MyAirport make decisions about infrastructure development. The data

was collected through over 800 hours of participant observations, documentary analysis and numerous formal interviews and informal conversations with actors from the Environmental, Terminal Operations, Finance, and Finance departments at MyAirport. The purpose of these examples is not to present conclusive findings of the wider study, but to highlight the multiple time perspectives at MyAirport. The observations to date have provisionally identified temporal perspectives across three themes, namely space, strategy, and sensemaking, which will be discussed in turn.

Time and Space (Context)

Time matters a lot to airports. Indeed, as a traveller passing through the space of airports, one is likely to encounter departure time, arrival time, and transit time. Clearly, these different sources of time at an airport would have different interpretive consequences depending on the traveller's destination (e.g. is one going away on holiday, or returning back to work?). The different experiences of time are also observed in the hierarchical space at MyAirport. Consider, for example, the two extracts from interviews with the Head of External Engineering and the Programme Manager of Capital Expenditure (CAPEX) respectively on the issue of maintenance.

"[...] as far as the air maintenance team, we have the same number of the resources on at the same time of the shift, irrespective of the time of year, or time of the day. So I have four guys – a maximum of four guys – who were in work on a wet November morning as I did on a July afternoon. Well, there is a lot more work for the airfield maintenance team to do in July. It is weather related and season-dependent. So, you know in the summer, we have a lot of grass cutting to do... erm renewal marking erm... a huge amount to do during the summer, but we don't have the resource to do it [...] we found in the previous winter was that after a certain number of days, the guys were just not wanting to come in because they were just knackered (tired), and couldn't get enough bodies to do the snow clearance." (Head of External Engineering)

"We going to be having 25 year capital budget, because… a lot of these things are predicable. Because, there are… we have a large site here with a lot of assets on it. Basically, over time it will degrade, and we need to replace them. And… we have a life cycle; we should be able to forecast when you actually spend the money to replace each of them, right? Say if the high voltage network last 15 years, you can forecast that 15 years… really! Erm, a lot of these is just about maintaining our current infrastructure we got here." (Programme Manager of CAPEX)

Therefore, time for the Head of External Engineering is intimately associated with seasonality and weather, and natural objects of grass and snow. The frustrations expressed by the Head of External Engineering of having to cope with limited human resources are clearly not featured in the viewpoint of the Programme Manager of CAPEX. The Programme Manager's concern is mainly technically driven by the managerial object of delivering a "25-year capital budget" which necessitates long-term, rational planning (and predictability) of weather. Arguably, this tension between the rational and uncertain will result in conflictual positions of time in MyAirport.

Time and Strategy (Future-Orientation)

The management of time perspectives also tends to be future-oriented. In this extract from the announcement of restructuring decisions by the Chief Executive of MyAirport, the use of 'time' in explaining his strategic intent is noteworthy:

"Well, the new operating model is now complete. We spent the last two or three months looking at processes and organisation structures, and the model is now built around an asset division, a commercial division, and an operations division. They are all now in place. So, as far as I am concerned, the organisational restructuring is now done. I think when you make any changes, in terms of the process, but more important, in terms of the organisation, it takes some time. And actually to get people used to it. So clearly there is a degree of anxiety within the system. Probably in the last two or three months, it's important that we actually get people involved in the final design, which we have done." (Transcript from a video briefing by the incumbent Chief Executive on the conclusion of organisational restructuring, June 2011)

It is worth noting that the incumbent Chief Executive has been in post for a year before the release of this video briefing. This is set in the context of a decline in the aviation sector as a result of the global economic downturn, increasing security concerns and growing recognition of carbon constraints. Thus, there is clearly a lot of angst among employees of MyAirport. This briefing is simultaneously affective and authoritative. So, the Chief Executive acknowledges the anxieties that the employees are encountering, but yet instructs them to "get used to it". There is recognition of the plurality of views that exists in MyAirport, but there is also assertiveness in proclaiming how "the organisational restructuring is now done." There is also a sense of legitimising this decision by stating the 'fact' that people were "involved in the final design", despite the design taking place over a short period of "two or three months."

So, again, it can be seen from this extract that time is not simply rational. The quantity of time is often combined with recognition of the way time is qualitatively experienced across the diversity of stakeholders within the organisation of MyAirport as it is (re-)organising. There is also an attempt to recollect the past in making sense of the future as the context is located in the present.

Time and Sense-making (Connecting Temporal Perspectives)

The observations also reveal how actors at MyAirport often make sense of time in the present. The following quote by the Head of External Engineering refers to the way he perceives the financial approval process that departments have to go through when suggesting improvements on MyAirport's infrastructure.

"We all got schemes in. We all had a couple of seconds as you know." (Head of External Engineering)

It is noticeable that he talks of having just "a couple of seconds" to make his pitch to colleagues from the Finance department. In reality, of course, these meetings can last a few hours with lengthy presentations made in due process. Yet, the qualitative feeling that one can never have sufficient time to get the business case across is just an example of the temporality faced by organisational actors. Nevertheless, it is this temporality, as Lee and Sawyer (2010) suggests, that helps shape the internal norms and identities of the respective departments at MyAirport.

In another example, the rhythm of time is disrupted by the eruption of the Icelandic volcano, Eyjafjallajökull, in 2010. Here, the management team of MyAirport was in the process of making a managerial decision on bonus payments on the basis of financial performance. Yet, the following quote from a management briefing shows that the managerial decision is as much an emotive decision as it is an economic one. So, the careful consideration of re-categorising the financial loss resulting from Eyjafjallajökull and the announcement of intended payment of incentives by "the end

of June" before the holiday season begins is yet another example of how the qualitative experiences of time and the timeliness of managerial decisions/announcements count as much, if not more than, the quantitative treatment of time, especially in terms of reconciling tensions between divergent views.

"The remuneration committee, which is a sub division of the board, will look at the numbers. We will look at what we deliver as a business, and then make a decision about what the incentive payment will be. The key issue they will be deciding is whether to treat the Ash Cloud, which closed the airspace around the airport in April... whether to treat that as an exceptional, or whether to include it in the performance of the business. The end of June is when they will make the decision and then the payment will be made in the July pay packet so people are ready to go on holiday. The good news is the incentive scheme will continue for another year for all colleagues." (Transcript from Airport Team Briefing, June 2010)

CONCLUDING NOTE ON IMPLICATIONS FOR SERVING TIME IN CONSTRUCTION MANAGEMENT RESEARCH

The starting point of this article emanated from the dissatisfaction with the dominant use of 'time' in construction management research. That is, time is often framed as a quantitative lever to determine the performative outcomes of construction projects. Yet, there are indeterminate aspects of time that are often overlooked in the assuming of a rational, managerial position. This article has thus contributed by opening up the possibilities of analysing time perspectives in the review of wider organisational and management studies and empirical examples of the ways in which time is referred to at MyAirport. The analysis revealed several points of alignment with Henri Bergson's theory of time and philosophy of change. Fundamentally, quotes from participants at MyAirport have illustrated a more textured view of time that transcends numerical 'clock-time' to include qualitative, often emotional responses to temporalities at the workplace. Time is thus heterogeneous, which can potentially create conflictual tensions between various actors at MyAirport. These aspects are often ignored in construction management research.

So, what are the implications of this broader time perspective for construction management research? Three preliminary challenges are concluded here. Firstly, there is a need to recognise the limitations of rational planning approaches and the management of time in the delivery of projects. Pursuing more research on examining 'clock-time' in construction management may prove fruitless in solving the problems of 'time' in construction. Rational methods need to be supplemented by an appreciation of how individuals scale their time in organisations and how this subsequently shapes the rhythm and pace of organisational practices. Thus, the use of qualitative methods generally, and ethnography more specifically, could be helpful.

Secondly, tensions in the way time and temporalities are conceptualised and mobilised in organisations should not be treated as a scholarly problem to be designed away. Rather, the existence of such tensions, as depicted in the examples from MyAirport above, could invite productive questions as to what these concepts mean for practitioners in terms of sensemaking and identity construction (see Brown and Phua, 2011). Identifying the multiple ways in which time and temporalities unfold in organisations could enable deeper discussions about possible futures of organising and becoming, bearing in mind reconstructions of the past in the moving, constructing present. This in turn could creatively unlock potential ideas about improving time performance in construction.

Finally, the understanding of the plurality of time requires researchers to become embedded in the context and consciousness of the living in organisations. In so doing, researchers will then be able to explore how the past and the future connect with the ever-changing present, and discover how the actors we follow subjectively experience and construct their time in organisations (see Alexander, 2008). It is hoped that these challenges provide useful leads for finding better ways to serve time in construction management research and practice.

ACKNOWLEDGEMENTS

The author would like to thank the Engineering and Physical Sciences Research Council (EPSRC) in the UK for funding the wider project (ref: EP/H004505/1) upon which this article is based. Gratitude is also expressed to Vivian Liang who collected the data that resulted in the examples of MyAirport presented here. Any errors or omissions remain the responsibility of the author.

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IDEA CONTRIBUTION IN CONSTRUCTION: IN SEARCH FOR EVIDENCE OF THE INTERFACE BETWEEN IDEA GENERATION AND ITS IMPLEMENTATION

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To innovate, retain competitiveness, succeed and flourish, construction firms need a constant stream of innovative ideas and suggestions from highly motivated and committed employees. This drive for employee engagement in the innovation process becomes even more apparent in the construction sector with problems of multi-tiered subcontracting and the widespread reliance on self employment. This study investigates idea contribution as a crucial interface between idea generation (i.e. creativity) and its implementation (i.e. innovation). Based on the critical review of construction and mainstream literature on innovation, creativity and employee engagement this study proposes a conceptual framework for employees' perceptions of ideas contribution involved in the processes of converting ideas into new products, processes or services. The framework is derived under the assumption that decisions on whether or not to contribute new ideas for organisational improvement is influenced by personal characteristics (knowledge, perceived radicality of ideas, favouring of ideas, openness to experience, self-confidence and curiosity), group and organisational factors (rewards, managerial support, collaborative team culture, position in the company and in the team) that might well be unique to each organisational unit. The philosophical epistemology adopted in this study is realism that shares positions of positivism and interpretivism where the conceptual framework is based on explanations, understanding, argumentation and is tested using a mixed methods research design (experimental tasks, questionnaires and observations). The preliminary results confirmed the influence of assumed factors on idea contribution where personal characteristics were valued higher than group and organisational factors. Discussion of recommendations for the future research is provided.

Keywords: construction sector, idea contribution, idea generation, idea implementation, realism.

INTRODUCTION

The construction industry has been subjected to criticism of the way it approaches innovation and inability to meet clients' expectations of quality and price (Kissi *et al.* 2012). The need to innovate has been recognised by researchers as well as the UK

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Sergeeva N. and Radosavljevic M. (2012) IDEA contribution in construction: In search for evidence of the interface between idea generation and its implementation *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 509-519.

government. For example, recent report by Wolstenholme (2009) has advocated innovative ideas that occur in construction projects through personal incentives and initiatives. Construction is often considered to be behind other sectors in terms of ability to innovate that much of the academic research often argues (Winch 1998, Gann 2000). One of the challenges construction firms face is motivation of individual employees to contribute innovative ideas (Loosemore *et al.* 2003). Although creativity and innovation have been extensively studied over the last fifty years (Hennessey and Amabile 2010), little is understood about ideas contribution as an interface between the two. Some recent studies in mainstream literature on creativity and innovation (Unsworth 2001, Van de Ven *et al.* 2008) as well as construction literature into innovation (Aouad *et al.* 2010, Ozorhon *et al.* 2010) have recognised that before ideas are implemented they need to be first generated, but even more importantly shared with people responsible for their development. In order to investigate idea contribution the influence of contextual as well as personal factors should be taken into consideration. Csikszentmihalyi (1992) and Furnham *et al.* (2009) found a positive correlation between creativity and personal factors like knowledge, intrinsic motivation, curiosity, intelligence, self-confidence and personality types. In addition, Amabile (1996) and Shalley *et al.* (2004) found a positive correlation between creativity and organisational factors like supportive work environment, autonomy and challenging tasks. Innovation scholars have also found positive correlation between all of these factors and innovativeness, adding flexibility, empowerment and leadership styles (Kanter 1983, Quinn 1985). The factors that influence idea contribution process in the context of construction are yet to be explored. In response to this call, using a mixed method research design including experimental tasks, questionnaires and observations, this study seeks to provide insights into factors that influence employee idea contribution. This information allows exploring the nature of idea contribution process, clarifying factors that are perceived to be important by construction employees within their organisations.

The research starts with reviewing literature on innovation, creativity and employee engagement. From this the conceptual framework for employees' perceptions of idea contribution is derived. The adopted philosophical epistemology and methodology of current study are discussed, followed by the discussion of preliminary results and conclusion.

IDEAS AND INNOVATIONS IN CONSTRUCTION

Sources of ideas for innovation

The need to better understand ideas and innovations within the characteristics of construction context has been elucidated by Bresnen and Marshall (2001). It is argued that construction predominantly implements ideas that originate from elsewhere. Utterback (1971), for example, found that 75 percent of ideas used in development of product innovations come from outside the organisation, suppliers, other organisations or customers. Suppliers can be a source of innovation as firms can take advantage through their innovative inputs or an interactive development where they work closely to develop products. Innovations could also come from other organisations through collaboration, development of projects and learning from each other’s experience. Similarly, Gann (2000) showed that ideas can originate from R&D activities of suppliers and manufacturers of materials which are then translated into new products. In the study of Von Hippel (1981), on the other hand, it is shown that ideas for most new product innovations come from customers. It could be in a from of forwarding

information about competitors and their new innovations or through their expertise about the final product.

While it is certain that innovations could occur in response to external needs in the construction sector, Harty (2008) and Li and Love (1998) further argues that problem-solving can also lead to innovative solutions, and is primarily based upon employees involved in the process. Companies heavily rely on internal sources - problem solving and developing new innovative ideas by employees within their organisations as also illustrated by Salter and Gann (2003). There is often resistance to idea creation and willingness to innovate from employees at different levels of organisations. Generally, the industry is inclined towards external stimulus, with little attention being paid to internal sources of innovations and the role of employees in the process.

Innovation process: From idea generation to its implementation

According to Rogers (1983) and Van de Ven *et al.* (2008) the innovation process can be considered as three overlapping phases:

1. Ideas generation, i.e. production of a design concept or technical proposal, recognition of needs or problems;
2. Ideas development, i.e. origination of a technical solution or an invention, production and testing into a concrete product, process or service;
3. Ideas implementation, i.e. introduction of the solution into the market, transforming of the tested idea into adoption of users.

Before ideas are implemented they need to be first generated and contributed by employees and then converted into new products, processes or services. Within the construction management arena recent report by Ozorhon *et al.* (2010) provides an interesting insight into the innovative process from the contractor perspective showing their innovativeness to improve existing products, processes and services. Particularly, more than half of the respondents associated their innovativeness with effectiveness of leadership, work environment and collaborations with partners. They found that while they can be regarded as successful at idea generation process, they believe that they are less successful at diffusing generated ideas and converting them into products, processes and services (Ozorhon *et al.* 2010). These lessons are further strengthened by Aouad *et al.* (2010), stating that beneficence of innovation can be achieved through new ideas and conversion them into practical solutions. As they argue, idea generation process is easier than their conversion into practice because the latter requires employee engagement, commitment and advanced skills. These studies as well as mainstream theories of innovation and employee engagement recognise that ideas need to be converted into new products, processes or services and accept the important role of motivated and committed employees. However, further empirical investigations into idea conversion process from the individual employee perspective within the construction context are required (Greasley *et al.* 2004, Hartmann 2006).

Creativity in construction

People represent the most valuable asset especially for labour-intensive industries like construction (Loosemore *et al.* 2003). At the same time people represent the most difficult resource to manage. They have their own individual needs, and their ability to generate and put forward ideas may vary significantly. The construction industry is represented by diverse groups of individuals (e.g. clients, designers, constructors and suppliers), working alone or in teams on projects. Creativity as a behavioural outcome is seen in the work of architects, but is also necessary in a different form, in other

occupations in construction. Engineers also need to be creative in the solutions to architect's visions, quantity surveyors in their cost advice and procurement systems and project managers in their organisational skills (Walker 2011). The industry's project-based nature represents many disparate organisations which manage project objectives and individual organisational objectives. However, these objectives may not be in line with people's personal objectives.

In the construction management literature the desire for creativity has been occasionally noted (Barrett *et al.* 2008, Salter and Gann 2003). The crucial role of motivated individual team members who share experiences and exploit creativity have also been emphasised (Egbu 2004, Eaton *et al.* 2006). A recent study by Love *et al.* (2011) recognises that for fostering innovation, a job requires creativity and alternative thinking to develop new ideas and solve work-related problems as well as personal initiative (i.e. employees' willingness to take responsibility and challenge). However, there is still no empirical evidence on how employees perceive idea development and contribution and the authors call for more research on how individual employees perceive these processes within their organisations.

Employee engagement in construction

Poor performance and slow innovations in the construction sector could be partly explained by the way the industry manages and respects employees who work within it. As a result, a working group was set up by the government in response to the need for improving respect for people. Consequently, the report (RfP 2000) developed some practical ways to achieve industry wide improvement in terms of employment practices based on profits, ability to achieve effective team working, innovation and productivity. The report highlighted the need to explore how employee engagement enhancing strategies could be applied within construction if the performance of the sector is to be improved. From the first sight, the discussion appears to assume that employee engagement strategies should be appropriate for the construction industry. The socio-technical system of the industry arguably provides a suitable environment for employee engagement in the innovation process to benefit form the advantages it offers (Costa *et al.* 2006). Construction companies thus could be better managed by the appropriate use of employee engagement. Although scholars have examined it from the viewpoint of employees, the concept remains a poorly defined construct. The study of Wilson (1989) is perhaps one of the most explicit in recognising, among recommendations for safety improvement within the construction industry, its dependence on the employees' willingness to engage with the issues of accidents prevention techniques and training. Perception, as Wilkins (2011) further explains, may significantly influence individual's willingness to be engaged regardless of whether one is investigating the activity of safety training or idea contribution process.

Personal, group and organisational factors that influence creativity and innovation in construction

Construction innovation is influenced by a number of internal and external contextual factors (Barrett *et al.* 2008, Hartmann 2006). Among external factors are the market, technological, economical, political factors, regulations, clients and manufacturing (Blayse and Manly 2004). Among internal factors that influence innovation are organisational climate, culture, strategy and personal characteristics (Hartmann 2006), championing behaviour from managerial perspective (Dulami *et al.* 2005, Kissi *et al.* 2012) which are considered in detail below.

Supportive climate and culture
Supportive climate has been found to foster innovation championing behaviour of project managers (Dulami *et al.* 2005). Supportive organisational climate may include culture, a clear strategic vision of the company, reward for creativity that values ideas and innovations (Park *et al.* 2004). The chance of an idea to transform project requirements into viable solutions was found to be dependent on the external environment (Blayse and Manley 2004, Park *et al.* 2004). Scholars argue that organisational climate for innovation is based on an individual's perceptions of an organisation's expectations and the potential outcome of innovative behaviour.

Organisational culture represents the system of values and beliefs which influence individual employee behaviour and actions. Cultural attributes that are likely to be inductive to innovation include encouragement of employees to create ideas and innovate without a fear of penalty if they are unsuccessful. It also refers to shared perceptions that employees are striving to achieve a better understanding of each other's goals and openness to new ideas as described by Blayse and Manley (2004). However, these studies are focused on the impact of factors on innovation from senior managers' perspective and less on middle, low level management and employees holding other positions (Kissi *et al.* 2012). Furthermore, these studies are primarily focused on the nature and the impact of innovative behaviour and limited attention is given to individual intentions to innovate. It is, therefore, still somewhat unclear how employees perceive contextual and personality-induced factors and what the interdependences between them are. Kissi *et al.* (2012) recognise that innovative behaviour is significantly influenced by organisational climate, resources and autonomy, but acknowledged that:

'Research into personal and contextual characteristics that moderates the effect of the middle managers' innovation supporting behaviours, could provide more insight into factors that enhance the middle managers' innovation supporting behaviours.' (Kissi *et al.* 2012: 25).

Personal characteristics
Sexton and Barrett (2003) explored the organisational factors of innovation by conducting case studies and developed a model which consists of business strategy, organisation of work, technology and people variables. Engaged employees involved in the technology transfer process need knowledge, skills and motivation. Common attributes of individual innovativeness and creativity include background experience, personal traits like openness to experience, high level of energy, self-confidence and strong belief, and cognitive abilities like intelligence and knowledge (Walker 2011). Creation of supportive work environment, on the other hand, is necessary to develop the capabilities (Sexton and Barrett 2003). Managers cannot force implementation of innovation, but can encourage employees to be engaged in the innovative process. Clearly further empirical research is required to investigate other personal characteristics in relation to employees' innovativeness within the construction sector.

CONCEPTUAL FRAMEWORK FOR EMPLOYEE IDEA CONTRIBUTION IN CONSTRUCTION

Personal, group and organisational factors that influence employee idea contribution

Overall, employee decision on whether or not to contribute innovative ideas to employer and work colleagues is assumed to be dependent upon perception of

personality characteristics, group and organisational factors. Figure 1 illustrates a proposed conceptual framework for idea contribution as a dynamic interface between idea generation and its implementation.

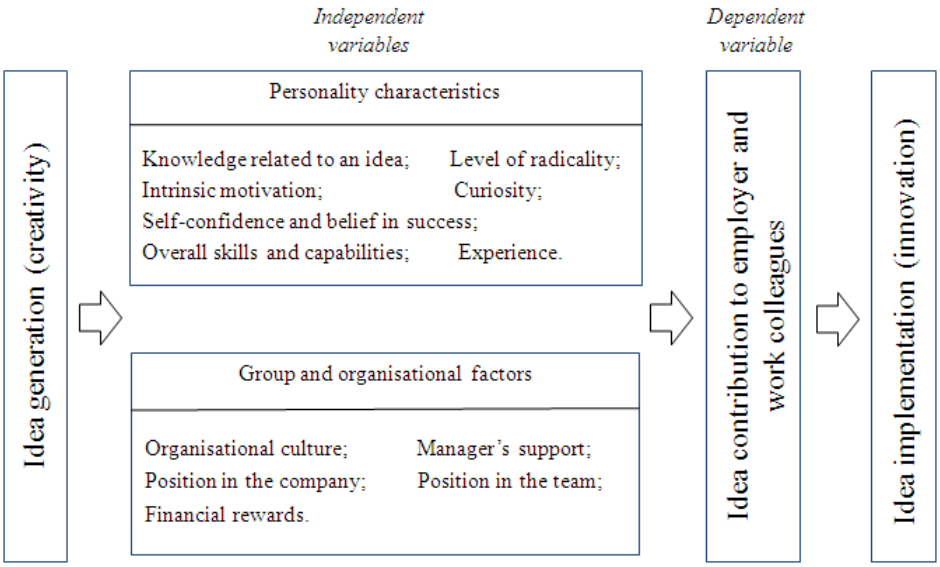

Figure 1: Employee idea contribution as a dynamic interface between idea generation and its implementation including the influence of personal, group and organisational factors

RESEARCH METHODOLOGY

The purpose of this study is to examine how employees' perceptions of personal, group and organisational factors influence their decisions on whether or not to contribute ideas to employers and work colleagues within their organisations. In order to address the above aim and place idea contribution on the map of innovation-related constructs, the specific objectives from the main path of this study are:

1. Develop a conceptual framework for idea contribution drawing from the literature review on innovation, creativity and employee engagement in the mainstream and the construction management literature;
2. Investigate how personal, group and organisational factors influence idea contribution as perceived by construction and non-construction professionals;
3. Formalise and operationalise a mixed-method approach comprising analytical investigation of a series of experimental tasks, questionnaires and observations.

The overall philosophical epistemology adopted in this study is realism since the interpretation of individual idea contribution phenomena is crucial, and the differences between external and constructed reality have to be identified and understood to explain its relationship with personal factors. One of the most distinctive features of realism is its analysis of causation: explaining why idea contribution exists involves discovering the nature of the phenomenon and investigation of whether employee idea contribution depends on personal, group and organisational factors. Realism shares positivism and interpretivist positions, implying a connection between positive (explanatory/descriptive) and interpretive (concept-dependent/have to be understood) approaches by critiquing and endorsing a relatively wide range of research methods, but suggesting that the particular choices depend on the nature of the subject (Sayer 2000). Realism is applied in current study where conceptual framework is based on explanations, understanding and argumentation and tested empirically by mixed

methods research design including experimental task, series of questionnaires and observations.

As a result of the sampling frame used in this study, 38 employees were drawn from construction industry and 38 employees from a wide variety of industries. On average, the employees were 31.25 years old and had an organisational tenure of 5 years in the UK. Of the construction employees there were office building professionals (32%), housing building professionals (12%) and industrial building professionals (6%). Of the all employees there were senior managers (32%), junior managers (27%) and entry-level employees (41%).

PRELIMINARY RESULTS AND DISCUSSION

The employees were asked to generate change-oriented and improvement ideas about famous building Taipei 101. After the task the employees were asked whether or not they are willing to contribute generated ideas to employer and work colleagues. When the employees were willing to share their ideas, they were finally asked to evaluate to what extent their intentions to contribute ideas depend on personal, group and organisational factors. Table 1 presents mean and standard errors for evaluation of personal, group and organisational factors as drivers for employee idea contribution by a total of 76 employees. On average, personal factors are evaluated as more important than group and organisational ones. In particular, knowledge, intrinsic motivation, skills and capabilities have been valued as more important for idea contribution than level of radicality of an idea, position in the company and financial rewards. This means that employee intention to contribute generated ideas depends to a greater extent on intrinsic, personal characteristics and to a lesser extent on contextual organisational settings. The employee cognitive and psychological characteristics play critical role in the idea contribution process. Organisations can not force employees to share their innovative ideas, but can encourage them to engage in the innovation process by providing a supportive work atmosphere.

Table 1: Mean (M) and standard errors (SE) for personal, group and organisational factors as drivers for idea contribution (based on 1-5 Likert scale: from 1 - least important to 5 - most important

	M	SE
1 Knowledge	4.18	.10
2 Intrinsic motivation	4.17	.09
3 Skills and capabilities	4.07	.10
4 Curiosity	4.04	.10
5 Self-confidence	4.00	.10
6 Organisational culture	3.84	.11
7 Experience	3.83	.10
8 Manager support	3.57	.13
9 Position in the team	3.38	.12
10 Level of radicality	3.32	.10
11 Position in the company	3.20	.12
12 Financial rewards	3.01	.15

Some managerial implications

Businesses who wish to adopt innovations should be focused on encouragement of employees to come up and make creative contributions. Since the intrinsic factors are valued higher than group and organisational ones for idea contribution, organisations may pay greater attention to employees' personalities. Table 2 presents some managerial implications derived from the preliminary results.

Table 2: Some managerial implications

Drivers for idea contribution	Managerial actions
Better knowledge and understanding	Possibility for employees to obtain information and learning inside of organisation by special trainings and outside the firm.
Greater intrinsic motivation, enhanced skills, increased confidence	Managers should not reject ideas based on personal judgements or immediately without consideration. They should accept useful and appropriate ideas and reward contributors. Managers should remember that negative experience in the past can lead to lower self-confidence in the future; whereas positive experience can lead to increased confidence in the future.
Organisational culture and managerial support	Organisations should create a supportive climate and culture, a clear strategic vision of the company, reward contributors for valuable innovative ideas.

CONCLUSIONS

In this paper the mainstream and the construction management literature regarding employee engagement in the innovation process has been reviewed in order to develop a conceptual framework for idea contribution as a mediator between creativity and innovation. Adopting critical realism philosophical position, the study investigates determinants of employee intentions to contribute ideas using mixed-methods research design involving quasi-experiments, questionnaires and observations. The preliminary

results show that, on average, personal characteristics (intrinsic motivation, knowledge and curiosity) are more important than group and organisational factors (position in the company and financial rewards) for idea contribution as perceived by construction and non-construction employees. Construction companies should pay special attention to idea contribution as a critical link between idea generation and its implementation. Greater attention should be paid to the employees, their role and intrinsic characteristics. Better understanding of determinants of employee intentions to contribute innovative ideas is crucial for organisational effective development. Further research may investigate the impact of other personal and contextual factors (e.g. trust, team configurations, empowerment, etc.) on idea contribution using other research methods (e.g. interviews, multiple case studies, longitudinal research, etc.).

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CORRUPTION IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY: A MIXED METHODS STUDY

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The construction industry is susceptible to corruption and the effects are substantial. The experiences and perceptions of corruption in the South African construction industry are investigated through an opinion survey of clients and construction professionals. A mixed methods approach is used to analyse the response data. Corruption is perceived to be widespread. Conflicts of interest, tender rigging (collusion), "fronting" and "kickbacks" are the forms of corruption most encountered. Government officials (as clients), contractors, and sub-contractors are perceived to be the parties most involved in corrupt activities. Forms of corruption most associated with government officials include the awarding of contracts for political gain, nepotism and conflicts of interest, and interference in the tender award process. Corruption is most prevalent during the bid evaluation and tendering phases of projects. Facilitating factors include a lack of transparency in the awarding of contracts and the operating environment of the industry. Barriers to reporting include a lack of confidence in the criminal justice system, a belief that no action will be taken, and a perception that 'whistle-blowers' are not adequately protected. Addressing the issues of corruption will require the inclusion of ethics topics in tertiary education and training curricula, special continuing development seminars provided by professional associations and industry bodies, tightening of building procurement procedures, and more forensic detection systems.

Keywords: corruption, mixed methods research, clients, construction professionals, South Africa.

INTRODUCTION

The Competition Commission of South Africa is currently probing alleged bid-rigging and anti-competitive conduct associated with projects associated with the construction of football stadia, and road and rail infrastructure for the 2010 FIFA Soccer World Cup. The Commission is investigating 65 alleged bid-rigging cases in the construction sector involving 70 projects valued at R29bn (Engineering News, 2011). Framed by

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Bowen P.; Edwards P. and Cattell K. (2012) Corruption in the South African construction industry: A mixed methods study *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 521-531.

this perspective, the research reported in this paper examines the personal experiences and views of construction clients and construction professionals with regard to corruption in the South African construction industry. Issues examined include the nature and extent of corruption, participants in corruption, project phases susceptible to corruption, factors facilitating corruption, and barriers to reporting corruption. Using a web-based, online survey questionnaire, data were collected from building clients, and registered construction project managers, architects, civil engineers, quantity surveyors, and construction managers. The paper commences with a background review of corruption in general, and in the construction industry in particular, followed by a description of the survey design and administration. The findings of the opinion survey response data are then presented and discussed.

BACKGROUND TO THE STUDY

Corruption, in the form of dishonest or illegal behavior, is seen as a growing challenge for businesses and society (Transparency International, 2009). Citing World Bank estimates, Ostermann and Staudinger (2008) indicate that corruption represents 5% of the world economy; translating into an estimated US$1.5 trillion per year. Fantaye (2004) notes that developing countries are particularly susceptible to corruption, and that it impacts negatively on the attainment of sustainable development (Pillay, 2004).

Grobler and Joubert (2004) and Hartley (2009) identify the main forms of corruption as: patronage, nepotism, bribery, ghosting, kickbacks, front companies, embezzlement, bid rigging and collusion, and conflict of interest. The latter, it may be argued, is more a matter of unethical conduct than corruption, but it is appropriate to view it as occurring at the lower end of a long corruption continuum. The construction industry has been identified as the most corrupt sector in the world (de Jong *et al.* 2009). Transparency International (2005) describes construction as an industry possessing characteristics that render it particularly susceptible to corruption. May *et al.* (2001) examined the nature of bid-cutting in construction tendering in Queensland from economic, legal, ethical and management perspectives, finding that, after their tender has been successful, main contractors coerce sub-contractors into reducing the sub-contract prices used to support the original bid. Although the main contractors considered the practice to be ethical, this is not a view shared by the sub-contractors.

Internationally, several research studies have explored corruption. Vee and Skitmore (2003), in a survey of the Australian construction industry, found that respondents had experienced or witnessed some degree of unethical or corrupt practice in the form of negligence, conflict of interest, collusive tendering, fraud, and bribery.

In the USA, FMI/CMAA (2004) found that 84% of the responding building owners, architects, building services firms, construction managers, contractors and sub-contractors had been exposed to construction industry-related acts or transactions that they would consider unethical. Bid shopping, change order games, payment games, unreliable contractors and claims games were identified as prominent issues. Competitive pressures in a low-profit margin industry and other industry factors were cited as complicating factors.

The Chartered Institute of Building (CIOB, 2006) reported on corruption in the UK construction industry. A small majority of respondents in this study saw corruption in the industry to be fairly common. A lack of a clear definition of ‘corruption’ was apparent, and ambiguity arose as to what constitutes corruption. ‘Shades of grey’ were found to exist. Zou (2006) identified the forms of government

official/client/consultant-centred and contractor-centred corruption present in the Chinese construction industry. The former category included administrative interference, the illegal award of contracts or sub-contracts, the disclosure of confidential information to certain tenderers, and the extortion of kickbacks by clients and government officials from contractors. Contractor-centred corruption was found to comprise the offering of bribes (money or benefits in-kind) to clients or tender committee members in an endeavor to secure a tender, collusive tendering and bid rigging, invoice fraud, the use of sub-standard materials and workmanship, and collusion between contractors and supervisory authorities.

Sichombo *et al.* (2009) describe the need for (proactive) and benefits of technical auditing in the Zambian construction industry, and advocate the appointment of technical auditors at the planning stage of construction projects given their finding that the pre-contract stage is the more susceptible to corruption. Benefits of technical auditing are claimed to be increased client confidence, enhanced accountability, and reduced project costs and disputes. Shakantu and Chiocha (2009) investigated corruption in the Malawian construction industry. Forms of corruption were found to include bribery, fraud, collusion, price fixing, kickbacks, and negligence. They conclude that the nature of the industry renders it susceptible to corruption, and that local conditions and procurement systems shape the form and extent of corruption.

The research findings that follow help to establish baseline data for South Africa that were previously not available and which can be used in future to draw comparisons over time.

RESEARCH METHOD

Opinion survey was used for data collection, and the research adopted a mixed methods analytical approach. Mixed methods include '*the collection and analysis of both qualitative and quantitative data in a single study in which the data are collected concurrently or sequentially* [and which] *involve the integration of data at one or more stages in the process of research*' (Creswell *et al.* 2003: 212). Bak (2011) cites three advantages of mixed method research, namely: convergence and integration of findings; shrinkage of other possible explanations for conclusions; and clarifying different aspects of the phenomenon under investigation. In the study described here, the data were collected concurrently using a web-based online questionnaire survey.

QUESTIONNAIRE DESIGN

Drawing on the work of Zarkada-Fraser and Skitmore (2000), Vee and Skitmore (2003), Shakantu (2006), CIOB (2006, 2009), and Shakantu and Chiocha (2009) to develop an item catalogue, a sectioned opinion survey questionnaire instrument was designed, utilizing a mixture of closed, dichotomous, declarative, multiple-choice, and open-ended questions. The strength of respondents' opinions was elicited by using 5-point Likert scales of agreement or importance. The survey questionnaire sought demographic, cultural and professional background information from respondents; explored the extent of personal exposure to corruption and the prevalence of corrupt activities; investigated the relative levels of participation in corruption by clients, consultants, regulators (building inspectors), contractors (including sub-contractors), and suppliers. It explored perceptions of the causes of, and barriers to, corrupt practices. The reporting of corruption was also investigated. Participants were asked to base their responses on personal experiences rather than third-party hearsay evidence.

METHOD OF DATA COLLECTION

The web-based, online questionnaire survey was administered to building clients, professional consultants, and registered construction managers in South Africa.

The registration and professional activities of construction professionals in South Africa are regulated by statutory councils. Target populations for the survey therefore included members of the South African Property Owners' Association (SAPOA) (representing building clients); and construction project managers (Pr.CPM); architects (Pr.Arch); civil engineers (Pr.Eng); quantity surveyors (Pr.QS); and construction managers (Pr.CM), all registered with their relevant statutory councils. A pilot (web-based) study was conducted using a national firm of quantity surveyors to test the adequacy of the survey instrument and the feasibility of its administration. The full survey was conducted between January and March 2011. Clients and registered construction professionals were emailed by their respective associations and statutory bodies, given a URL where the questionnaire could be accessed online, and asked to participate.

Disregarding notified email rejection messages ('bounces'), indicative response rates are: clients (1.3%: n=50; N=3929); construction project managers (2.5%: n=44; N=1782); architects (3.4%: n=78; N=2324); civil engineers (6.6%: n=132; N=2000); quantity surveyors (9.4%: n=139; N=1477); and construction managers (7.2%: n=50; N=696). The overall response is: n=493. These response rates are not unusual for web-based surveys of this nature (see Fricker, 2008) and are considered sufficient for the intended level of generalisation of the findings. The response rates for SAPOA members, CPMs and CMs are likely to be higher than stated as many of them are also practicing architects, engineers and quantity surveyors.

DATA ANALYSIS

The *numerical* data associated with responses to Likert-scale questions have been analysed using the Statistical Package for the Social Sciences (SPSS V18.0 for Mac) software application. Pearson's chi-square test at the 5% level of significance is used to compare category groups. The *qualitative* (textual) data, largely arising from responses to open-ended questions, were subjected to thematic analysis using *NVivo (Version 9) software*. The latter analysis confirmed four main themes of corruption as: involvement, forms of corruption, facilitating factors, and combating corruption. Professional sub-group sources of the italicised *verbatim* statements of survey respondents are parenthesised in the analyses presented here.

Survey respondent profile

The majority of the survey respondents are South African, male (88%), 'White' (82%), and aged 40 years or older (74%). Gender (p=0.003) and ethnicity (p=0.014) are all significantly related to professional grouping of respondents. Proportionately less female construction managers and engineers responded compared to the other groups, with respondents in the architectural profession reflecting the highest proportion of females (18%). The construction manager group reflects the highest proportion of 'Whites' (92%), whilst the client grouping is the more ethnically diverse (29% 'White'). As far as can be determined (given that the age, gender, ethnicity and experience profiles for each profession are not comprehensively accessible) the survey respondent profile broadly corresponds to the available demographics of the target populations.

The nature of the survey topic necessitates the question: are the participants' responses genuinely and honestly made? A definitive answer is impossible, but the data analysis revealed no evident negative indications among the nearly 500 responses. Additionally, respondents are professionals registered with their respective professional disciplines, and therefore have at least a basic understanding of ethical conduct. Survey participants were encouraged, but not instructed, to offer additional comment to the catalogued question items, so these opinions are freely volunteered. The web-based survey administration meant that participants were self-selecting and this appeared to offer sufficient confidentiality to induce candour among respondents. It is therefore fair to say that there is no evidence to suggest that any responses are other than genuinely honest factual recollections of experiences or expressions of opinion on the part of the survey respondents. However, the analysis identifies instances where the researchers believe exaggeration may have occurred.

Nature and extent of corruption and participants in corrupt activities

Respondents were asked to indicate their assessment (based upon direct knowledge/experience) of whether or not corruption is widespread in the construction industry in South Africa. Differences between groups are not significant. Overall, 71% of *all* respondents report that they consider corruption to be *widespread*. Verbatim responses included statements such as:

[ENG38] *Should you not engage in the bribery, you will either not get the job or you will bump into various obstacles that will prevent you from doing your work as required.*

[PM3] *It is easier to follow the pack, than stand against corruption.*

[CON16] *Corruption in the construction industry is rife, perpetuated mainly by government officials for personal or political gain.*

Respondents' were questioned on their *personal experiences* ('Yes/No') of the various forms of corruption. Multiple responses were permitted. Conflict of interest is reportedly the form of corruption most experienced by all respondents (69%), and for each separate group except construction managers, for whom tender rigging and collusion is most frequently experienced. While conflict of interest might not be considered as corruption *per se*, it could be regarded as a first step on an inevitably slippery slope. Embezzlement and fraud (both criminal activities) are the forms of corruption least frequently experienced by all respondents and by each group. Examples of verbatim statements include:

[ENG50] *When I tender as consulting engineer I'm 99.9% of the times phoned* [by public officials] *for kickbacks, bribes, etc., sometimes during tender stage, most of the time before they want to award the tender.*

[QS42] *Sex for contracts demanded by* [public official] *male client representatives.*

While the "99.9%" frequency may be regarded as an exaggeration, the important interpretation here is that, for this respondent, the corrupt solicitations occur more often than not. They are not perceived to be rare and the invitations are overt.

Respondents' assessments regarding the *prevalence* of the various forms of corruption, and the *degree of the involvement* in corruption of various industry stakeholders, were explored. Respondents generally view tender rigging and collusion (65%) as the most prevalent form of corruption, followed by fronting (64%), kickbacks (64%), and

conflicts of interest (63%). Differences between respondent groups regarding prevalence are not significant. A response statement here:

[ENG23] *It is during the tender and evaluation phase where generally corrupt* [public] *officials within the client bodies are able to manipulate tenders and tender results to suit their own purposes. This is where tenders are deemed non-responsive* [ineligible] *based on insignificant reasons in order to elevate favoured tenderers.*

There is unanimity across all respondent groups that government officials (as clients) are the most frequently involved in corruption compared to the other respondent groups. Overall, contractors are seen as the next most corrupt grouping, followed by sub-contractors and building inspectors. Engineers, architects and quantity surveyors are reportedly the least corrupt groups of professionals. Some verbatim statements include:

[DEV14] *Local Authorities have fine-tuned their corrupt practices. They promise all tenderers they are going to influence the award of tenders and then extort kickbacks from the successful bidder. There is no apparent paper trail.*

[PM3] *It is standard industry practice that you are obliged to pay* [public officials] *for work, pay for processing of payments, pay for meetings, and this payment process starts at the top of most* [organization] *structures and the value* [amount] *decreases as the position of the individual changes.*

[QS33] [Public officials] *Overpaying favoured contractors irrespective of the QS's payment certificate.*

[ENG41] *I was told by a contractor how they manipulated tender prices as far back as 1983/84.*

[PM3] *Kick backs to M&E consultants is becoming an increasing problem.*

Respondents' experiences were sought regarding the forms of corruption most associated with the various industry participants. Multiple responses were permitted. There is unanimity across respondent groups that government officials (as clients) are most associated with kickbacks, tender rigging and collusion, and conflicts of interest; although the ranking of these activities varies between respondent groups. Architects, engineers and quantity surveyors are most associated with conflict of interest, kickbacks and fronting; whilst contractors are associated with tender rigging, bribery, and fronting.

Project phases most susceptible to corruption

Across all respondent sub-groups, the *tendering* and *bid evaluation* stages emerged as the most prominent project phases for corrupt activities. The contract close-out ('final account') stage is not seen as particularly susceptible to corrupt practices, although significantly more contractors (41%) see this as a phase in which corruption is widespread. Pertinent verbatim responses include:

[ENG45] [Unspecified parties] *During the contract implementation and closeout money changes hands.*

[QS1] *Bid evaluation and final account provide opportunities* [for fraud] *to professionals and contractors agents alike.*

Facilitators to corruption, and barriers to reporting corruption

Factors perceived to facilitate corruption
Respondent sub-groups generally hold similar views concerning factors that facilitate corruption, particularly a lack of transparency in the awarding of contracts, and the private opening of tenders; the latter reportedly being used to facilitate tampering with the bid results during the tender evaluation period. At least 77% of all respondents are in agreement about these two concerns. Other factors revealed in verbatim statements include:

[ENG56] *Project planning on government projects is very, very poor. Close Out Reports on government projects are almost non-existent.*

[QS43] *Poor skills lead to poor financial management and lack of auditing procedures which provide ample opportunity for criminal acts such as bribery, theft, and fraud.*

[QS30] *The apparent lack of political will to tackle corruption in the broader RSA context makes it hard to impose discipline in the construction sector.*

Reporting of corruption
Survey respondents suggest that, if corruption is detected, it is reported to a superior or the detector's organization (74%), or to the client and the professional consultants (70%). Differences of opinion are significant between respondent sub-groups in the case of reporting to supervisors (p=0.019); with proportionately more contractors and comparatively fewer quantity surveyors and architects adopting this procedure. However, 61% of all respondents report that corruption is sometimes never reported. Recourse to professional councils or regulatory bodies is not generally widespread, being reported by only 45% of all respondents. Reporting to the police is infrequent. Reporting difficulties include:

[ENG45] *It is difficult to report corruption. Very often the party you have to report to is involved. Most people who try to report corruption are marginalised in some manner, or give up. Leaking details to the press is currently the most effective, although they only take up cases selectively. Involving politicians or elected officials is a joke, they do nothing that does not have something in it for them, even the opposition.*

[ENG44] *When reported to ECSA* [Engineering Council of South Africa] *they do not follow up or when they eventually do, after years of persistent follow-up, it is glossed over. They promise it will be investigated - and then give no further response until prompted some time later. And this is supposed to be the regulatory body. It is a case of "Who guards the guardians?"*

Barriers to the reporting of corruption

Survey respondents report that corruption, once uncovered, is not reported due to: a lack of confidence in the anti-corruption agency and the judicial system (82%); a belief that no action will be forthcoming (83%); a concern that the South African Protected Disclosures Act (Act 26 of 2000) does not adequately protect 'whistle blowers' (67%); and loyalty (albeit misplaced) to friends or an organization (72%). Differences of opinion between respondent groups are not significant, except in the case of 'loyalty', where proportionately fewer project managers were found to hold this view. Other reasons cited by participants as reporting barriers include a fear of retaliation and physical harm to one's self or family, fear of an occupational penalty (e.g. dismissal) by the employer, fear of being stigmatized as a 'whistle blower', and being unaware of the reporting channels to be followed. A majority of *all* respondents share these views,

except in the case of ignorance of reporting channels (47%). Verbatim statements include:

[ENG56] [Corruption is] *Mostly never reported due to distrust in system and due to believe that Government by and large is corrupt at the top echelons - decision makers are the most corrupt regardless of speeches and verbal commitments to get rid of corruption. It is all talk to appease masses*.

[ARCH23] *As long as competitive tendering remains uncontrolled, i.e. known perpetrators are not reported/brought to book, these actions will continue, and will continue to drive conforming business owners out of the industry*.

[ARCH16] *Most of us do not have the time or the resources to give evidence in court or at a hearing*.

DISCUSSION

The survey findings present a somewhat depressing picture of corruption in the South African construction industry, but a valuable baseline has been established, against which future anti-corruption measures can be benchmarked. Such counter-measures must be regarded as essential given the universal perceptions of survey respondents that corruption is presently widespread.The findings generally support those of earlier researchers and suggest that the extent and form of corruption in the construction industry in South Africa is little different to that in other countries. Some addressable priorities can be identified in terms of combating current levels and forms of corruption.

Conflicts of interest must be seen as an urgent target for attention. As noted earlier, such conflicts may be regarded as a relatively mild form of corruption and inevitable in a fragmented industry comprising a great number of players where decision-making is diversified but ultimate power relatively focused, thus creating the conditions precedent (i.e. opportunities) for interests to conflict. The pervasive danger of conflicts of interest is that they sow the seeds for more serious corruption activity and serve to anaesthetise the consciences of those who engage in it. Avoiding conflicts of interest is best addressed by the professional associations in the construction industry and by the education and training institutions that serve it. Professional ethics should be strengthened in course *curricula* and reinforced through career development seminars. Public sector officials must be presented with clear procedural guidelines that highlight ethical requirements. The absence of ‘paper trails’ (Respondent DEV14) would, in most contemporary business organisations, be synonymous with the difficulty of tracking and auditing email, text and telephone communications. Modern technology allows this to be done, but it is always likely to lag behind the concealment ingenuity of the perpetrators of corruption. Despite this, random IT audits should not be ignored in the fight against corruption, particularly in public administration.

Other forms of corruption stem largely from opportunities arising in the building procurement process, and more particularly during the tendering and bid evaluation stages. Greater procedural transparency and tighter control measures would help to combat corruption here – removing or minimising opportunities for corruption would automatically reduce the incidence. More forensic approaches to detection should be developed and adopted, particularly in the tender evaluation process, where more sophisticated statistical analysis techniques could be used. This approach would not only facilitate corruption discovery but also act as a deterrent, especially if accompanied by more severe penalties for corrupt behaviours. Besides monetary fines,

penalties (depending upon the transgression) could include suspension or cancellation of professional registration; dismissal from public service with removal or curtailment of benefits; or restriction on capacity to tender for future projects. Importantly, anti-corruption measures should be effective and be seen to be effective ('to have teeth and to bite').

Addressing all the issues of corruption and the barriers to reporting will require a longer-term approach, since it will inevitably involve cultural and attitudinal shifts. These are difficult to achieve: process changes can be rapidly implemented, but mind-sets are more intractable. However, South Africa has unique experience in this over the past two decades, showing that it is not impossible, given patience and perseverance. The paramount aim is to restore integrity to, and trust in, an industry that is increasingly called upon to be at the forefront of national development.

CONCLUSIONS

Concern for the extent and nature of corrupt activities in the construction industry in South Africa is evidenced by the survey findings. Corruption appears to be widely prevalent, most notably in the form of conflicts of interest, but substantially also in terms of tender rigging and collusive pricing. Government officials (generally acting in a *quasi-client* role) are thought to be the people most frequently involved, but no participant group in the construction procurement process is seen as entirely innocent.Counter-measures to corruption require determined activity at all levels: from inclusion in professional education and training *curricula*; career development opportunities through professional and industry associations; improvements in procurement processes and detection procedures; increased severity and targeting of infringement penalties; to seeking shifts in attitudes and cultures.

While the research here has focused upon the construction industry, solutions for combating corruption are unlikely to be industry specific. Nor will they be unidirectional. 'Top-down' approaches should address ethical standards and conduct in public administration and procurement processes across all industries. Anti-corruption commissions/organizations should be adequately resourced and armed. Legislation should be both punitive and deterrent. A 'sideways' approach would involve educators and the professions expanding their responsibilities in terms of inculcating ethical conduct. The 'bottom-up' direction would see enhancement of 'whistle-blower' opportunities and protection. None of these approaches are sufficient in themselves to deal with corruption, and leadership will have to come from government, industries and the professions acting in concert. Failure to act would mean that the construction industry corruption baseline established in this research will reveal inevitable decline in the future.

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THE CASE FOR SLACK TO PROMOTE INNOVATIVE BEHAVIOUR IN CONSTRUCTION FIRMS

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The ability and willingness of individuals is a prerequisite to innovation. These traits are not unique to innovation in construction, but are universal amongst all innovative firms. Innovative behaviours depend on organisational resources and their deployment via managerial action. Organisational slack is forwarded as an enabler of innovation, as it makes a pool of unallocated resources available to connect ability to innovate and willingness to innovate. The authors posit that researchers and practitioners alike have failed to appreciate this enabler of innovative behaviour causing the principles of slack to be improperly overlooked. The case for slack resource allocation as a precursor to innovation is developed and the need to survey the attitudes towards slack organisational management held by construction organisations established. Institutionalism is identified as an analytical framework capable of explaining the interactions within the firm that differentiate between innovative and non-innovative construction organisations. A theoretical model of the role played by slack resource availability in stimulating innovative behaviours is developed for validation by a subsequent fieldwork programme.

Keywords: behaviour, innovation, organisational slack, organisational culture, resource management.

INTRODUCTION

The construction sector contributes significantly to the gross domestic product of most developed nations. The sector is characterised as being poor at innovating in comparison to other industries such as manufacturing and utilities providers (Thorpe *et al.* 2009). Despite innovation being central to organisational strategy and essential for organisational survival (Delbecq and Mills 1985; Hartmann 2006), the construction sector is further characterised by substantive barriers to the development of innovation. These barriers comprise individuals' attitudes and characteristics of the construction process, such as adversarial relationships and the cost of developing new technologies respectively (Blayse and Manley 2004).

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Horsthuis C.; Thomson D. and Fernie S. (2012) The case for slack to promote innovative behaviour in construction firms *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 533-542.

As a precursor to empirical study of the above, this paper develops and proposes a theoretical explanation of the organisational determinants of innovation, allowing the discrepancy between innovating and non-innovating construction firms to be explained. The behaviours of innovative construction firms are argued to be caused by the presence of universal elements of innovative firms per se that are not unique to the construction sector. It is reasoned that organisational slack allows firms to establish the universal elements of innovation. Alongside culture, a key universal element is the provision of the resources consumed by the innovative behaviour of individuals.

For the purpose of this study, a construction firm is an organisation with a distinct culture, with access to resources, and which generates profit by supplying a product or service to the construction sector. In the following discussion, construction firms include contractors, architects, manufacturers, suppliers, surveyors, engineers and consultants. Thorpe *et al.* (2009) characterise the global construction industry as being less able to improve its productivity than other industries such as the textile, steel and automotive sectors. They suggest that this is caused by a lower rate of innovation. The construction sector is also claimed to exhibit structural barriers to innovation, including: fragmentation; high technical risk; high cost; government regulation; adversarial relationships; strong client/end user influence and uncontrollable project contexts (Hardie and Newell 2011; Thorpe *et al.* 2009).

While the above influences on innovation in construction have been confirmed by Blayse and Manley (2004) and Hardie and Newell (2011), it is suggested that they exist independently of an organisation's or manager's sphere of influence. Consequentially, organisations have a limited control over their external environment. The ability of an individual firm to innovative is therefore dependent on its own capacity, rather than traits of its context. This is supported by the ongoing innovation of construction firms, despite the presence of sectorial barriers to innovation. Research into construction SMEs - historically stereotyped as unable to innovate - has revealed their ability produce multiple technical innovations (Thorpe *et al.* 2009; Barrett and Sexton 2006; Hardie and Newell 2011); an ability more traditionally associated with the larger construction firms (Davey *et al.* 2004) that do have the ability to influence their sectorial context.

The difference between innovative and non-innovative construction firms must therefore be caused by something other than their operating context: it must be a consequential of organisational characteristics. These will only be identified and understood if innovation is viewed from the perspective of the firm. This will shift the focus of investigation from interpreting the features of innovations or the context in which firms exist to studying the elements within firms that allow them to innovate. Adopting the perspective of the firm is anticipated to reveal innovative behaviours (referred to as willingness to innovate) within innovating construction firms that are absent in non-innovating firms. These behaviours are hypothesised to be supported by access to sufficient and appropriate resources (referred to as ability to innovate). Organisational slack is forwarded as a theoretical perspective on resource allocation within the firm that can explain the organisational traits that enable and reinforce innovative behaviours.

The following discussion uses the theory of organisational slack to explain anticipated differences between innovative and non-innovative construction organisations. Subsequent empirical fieldwork will test this application of slack theory by observing

the internal environment of innovative construction organisations from the perspective of actors within innovative and non-innovative constructions organisations.

A FIRM PERSPECTIVE OF INNOVATION

Confusion often arises when discussing "innovation" as it can be interpreted as a verb or a noun. In this discussion it is considered a noun, adopting Rogers' (1995) definition of an innovation as “an idea, application or a subject which is considered new by a person” (see Ekvall and Ryhammar 1998: 1393). Hartmann (2006: 156) states that "the implementation of new products, services and processes has become a critical challenge for construction firms." Although construction organisations are argued to operate amid 'unique' conditions, the wider management literature does not make innovation contingent upon any organisational traits that are unique to construction firms (c.f. Medina *et al.* 2005). Thompson (1967) argues that a field matures by developing patterned variation after the discovery of universal elements. The following discussion combines theories of innovation from management and construction literature to develop a holistic understanding of the universal elements of innovation within organisations per se.

Innovations are predominantly differentiated in research following two classifications. The first considers the nature of innovations themselves to distinguish their relation to existing products or processes. With this view, Radical and Incremental innovations comprise large and small advancements respectively (Damanpour and Wischnevsky 2006).

The second classification distinguishes innovations by their Administrative or Technical purpose. Administrative innovations occur within the administrative components of an organisation. They affect the organisation's social system by altering the relationships, rules and structures that frame organisation members' communication and interaction. Technical innovations, on the other hand, influence the organisation's technical systems by altering the equipment and methods that support product or service provision (Subramanian and Nilakanta 1996).

These classifications have not aided research into the act of innovation to any great extent, with empirical work yet to provide the evidence validating organisational innovation theories that are based upon the differences between innovation types (Damanpour and Wischnevsky 2006). For example, the Radical and Incremental classification only permits the post-rationalisation of innovations after their impact on technological advances has become known. The universal elements of innovative organisations that lead to innovative behaviours must therefore be identified by primary research rather than being extracted from prior classifications. They can be found by comparing innovative and non-innovative organisations.

Establishing the Universal Elements of Innovative Firms

Hartmann (2006) suggests that the presence, or otherwise, of an 'ability' (the resources available to facilitate innovation) to innovative and a 'willingness' (patterns of resource allocation decision making) to innovative are key differences between innovative and non-innovative firms. Innovation can consume vast amounts of money and time (see Gambatese and Hallowell 2011), requiring the 'ability' to consume appropriate resources. To ensure that activities related to innovation do not compete with routine organisation activities for those resources, the ability to consume a variety of resource types is essential (Delbecq and Mills 1985). These resources can be intangible (such as Hartmann's (2006) observation of intellectual effort) or tangible

(such as finance). Innovation also requires 'willingness' in the form of appropriate culture and behaviour: a key component of which is the willingness to apply resources to activities related to innovation.

Delbecq and Mills (1985), Egbu *et al.* (1998) and Hartmann (2006) each find distinct behaviours and attitudes in innovative organisations that are missing in non-innovative organisations. Hartman (2006: 162) summarises them as follows:

1. Innovation is encouraged.
2. The status quo is challenged.
3. Focus on long term issues.
4. Risks are accepted as inevitable and tolerated.
5. Failure is accepted and represents learning.
6. Members have autonomy to act, and are encouraged to be creative.
7. Information is shared between all levels and units.
8. People are seen as valuable capital.

Without these cultural traits, non-innovative organisations become entrenched in their norms and risk avoidance behaviours (Delbecq and Mills 1985; Egbu *et al.* 1998). Hartmann (2006) suggests these non-innovative behaviours can be overcome by managerial action including: autonomy; pay raises; fringe benefits; workshops; training and job enrichment or enlargement. Hence, the nurturing of an innovative culture within an organisation itself requires further resource consumption.

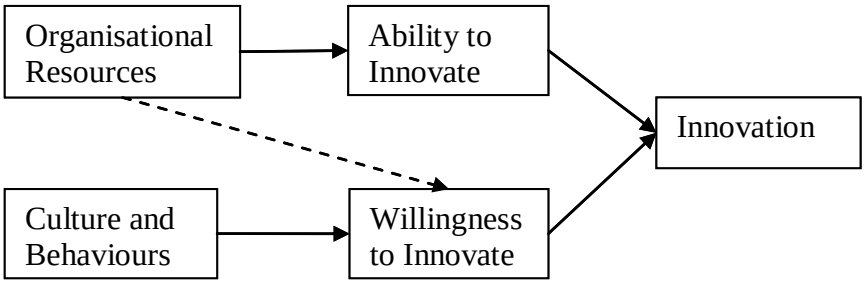

Figure 7 - The importance of organisational resources to the development of innovations

The concept that willingness to innovate is underpinned by ability to innovate (Figure 1) is evident in Hartmann's innovative behaviours. For the risk and possibility of failure to be acceptable, organisations require sufficient resources to tolerate the possible loss, most likely in terms of additional finances. The concept of excess, available resources can be further expanded to include autonomy and information sharing, both of which required time resources to be exploited.

It may be the case that the pivotal importance of access to resources is not recognised by practitioners. When surveying influences on innovation, Hardie and Newell (2011) found that construction SMEs consider resources a less important enabler of innovation than other external issues such as government regulation, industrial and client relationships. The practitioners were less aware of the importance of their own ability (i.e. access to resources) and willingness (i.e. desire to consume available resources) to innovate. This is a critical misunderstanding. With resources enabling innovation and enabling the promotion and reward of innovative behaviours within an organisation, it is clear that their effective deployment and influence over innovation is misunderstood.

SLACK IN CONSTRUCTION ORGANISATIONS

Organisational slack is forwarded as a theory capable of linking the ability and willingness to innovate with innovation. Slack theory addresses the allocation of resources within an organisation and can direct the nurturing of an innovation-conducive culture by establishing enabling and motivating factors that allow the cost and risk of innovation to be tolerated.

Having argued that construction organisations are not unique from the perspective of innovation, the same is held for organisational slack as all firms, irrespective of sector, have resources available to them and have the ability to generate and deploy additional resources. There is, however, a disparity between the development of slack as a theory in relation to innovation generally and its adoption in the field of construction research. There is a paucity of literature explicitly discussing the concept in a construction context. Nam and Tatum (1997) and Barrett and Sexton (2006) both refer to 'slack' but do so without exploring the implications of slack resources for construction organisation management. To inform that management, the relationship between slack and innovation must be understood in greater detail.

Defining 'slack'

Cyert and March (1963) first defined 'slack' to characterise payments to the members of a coalition in excess of the resources required by that organisation to operate. These payments included dividends, excess income and prestige. Over the past 50 years the concept of slack has expanded beyond the payment of actors. Initially exclusively related to financial resources (Bourgeois 1981; Bourgeois and Singh, 1983), theories of slack have since expanded to include more diverse resources such as raw materials, labour and production capacity (Sharfman *et al.* 1988). More recent treatments also consider intangible resources (such as knowledge) to be components of slack (Renzi and Simone 2011). As later developments have depreciated a purely financial interpretation of slack resources, Nohria and Gulati's (1997) definition is adopted, viz.:

"The pool of resources in an organisation that is in excess of the minimum necessary to produce a given level of organisational output" (1997: 604)

Not all resources are the same: the consumption of different types of resource cause different effects within an organisation. Researchers have attempted to categorise slack resources according to: the ease by which slack can to revert to cash (Bourgeois and Singh 1983); their level of absorption into the organisational system (Singh 1983); the level of discretion with which they are allocated (Sharfman *et al.* 1988); and their 'stickiness' (Mishina *et al.* 2004). Discretion refers to the ability of a resource to be converted into another use, should the need arise. Cash is seen as highly discretionary because it can be readily converted for use in a variety of situations (Sharfman *et al.* 1998). The stickiness of a resource is a more complex issue, relating to both the divisibility and fungibility. Divisibility refers to the ability to vary the amount of resource allocated in response to demand. Fungibility is the ability of a resource to be used in a variety of situations: a specialist engineer, with fixed long employment hours would be an example of a 'sticky resource' (Mishina *et al.* 2004).

THE ROLE OF SLACK IN RELATION TO INNOVATION

Due to the diversity of innovation, a variety of excess resources might be required including but not limited to financial, human and time resources. Although Gambatese and Hallowell (2010) have established that the Technical innovations of construction firms consume significant time and financial resources, the need to also consume human (and other intangible) resources is yet to be widely recognised. Administrative innovations are also likely to place similar demands on both tangible and intangible resources.

Application of slack

Slack can promote innovative behaviours by providing the ability of individuals to innovate within an organisation. The resources that it makes available within an organisation can be used for several functions. Those commonly discussed in slack literature are presented below:

Risk taking
Slack organisations are able to experiment with strategies or technologies and can accommodate the risk associated with such activities. Additional slack resources allow risk, and possible failure, to be tolerated (Bourgeois 1981). Without such a cushion, investment in any unsuccessful project could be extremely damaging.

Inducement
Slack provides organisations with the ability to nurture an organisational culture in which behaviours are condoned (Bourgeois 1981) by, for example, challenging current ideas and encouraging innovation. Organisational decision makers can use slack financial resources to reward and reinforce desired practices or behaviours through incentive payments. Many of the managerial actions in Hartmann (2006) are closely associated with inducement: pay rises, fringe benefits, pleasant working conditions, workshops, excursions and open work spaces are all examples of inducement through managerial action.

Technical buffer
A vital function of slack is its ability to act as a technical buffer. Technical buffering was first considered to be applied in order to protect an organisation from fluctuations in demand for its goods and/or services and supply in the resources consumed in their production (Bourgeois 1981). When available within an organisation and not required by this application, the technical buffer grants individuals free time to engage in experimentation (Nohira and Gulati 1997).

Sharfman *et al.* (1988) extended this conceptualisation of slack by differentiating slack from other buffers, as they believed that technical buffers operate differently. They argued that, although both buffers and slack can alleviate external fluctuations, slack also lessens internal fluctuations by mitigating the conflict that would otherwise arise when tension between existing processes and those required by a changed external environment becomes untenable. Furthermore, buffers are employed in situations of high resource dependency (where resources are available from one or few sources), whereas slack is more appropriate to the resolution of conflicting demands.

Bourgeois (1981) argues that, when slack is applied within an organisation, it allows individuals time to engage in innovative activities that might otherwise be impractical. If an individual were required to allocate all of their time to organisational responsibilities, for example, they would not be able to engage in activities associated with innovation. By granting workers an element of spare capacity, slack facilitates

the autonomy that can lead to innovation. This requirement for independence is recognised by 3M, where individuals are permitted to allocate 15% of their time to the pursuit of innovative concepts (Brand 1998). When coupled with appropriate behaviours established by inducements and risk tolerance, autonomy becomes a driving force behind the ability to innovate.

Conflict resolution
Slack minimises the conflict in conditions where incompatible operational goals are forced to compete for finite organisational resources (Nohria and Gulati 1997). Additional resources provide competing goals sufficient resources to generate a solution. Competition and resulting conflict can reduce the information sharing and co-operation within the organisation that is vital to innovation.

Summary
It seen from the above that slack enables a variety of functions within an organisation that, in turn, enable or motivate individuals' ability and willingness to innovate. Communication and knowledge transfer has been linked to conflict resolution, risk acceptance. Tolerance is provided through a cushion of excess resources. Autonomy is provided through technical buffering from both internal and external fluctuation. Finally, innovative behaviours are seen to be motivated through inducement.

To instil organisational slack as a precursor to the universal elements of innovation, the ability and willingness to innovate, it is essential to understand how firms operate and understand the interactions that occur within them by selecting a suitable theory of the firm.

For slack to be effective in stimulating innovation, it must be infused into an organisation in a manner compatible with an understanding of how that firm operates. This requires the diffusion of slack principles and resources to reflect an appropriate theory of the firm.

THEORY OF THE FIRM

The complexity and diversity of firms permits their analysis in a variety of ways (Penrose 1995). To approach innovation from an organisational perspective, it is necessary to adopt an appropriate theory of the firm. In this context, an appropriate theory must accommodate a variety of factors associated with innovation and organisational slack.

The selection of an explanatory theory of the firm requires the field of study to be re-established. Although the preceding discussion considers the influence of resource availability within the firm on the behaviours of individuals in terms of slack, this is not the intended field of study. The intention of this paper is to argue that innovative construction organisations are not dissimilar to other innovative organisations, and that there are universal elements or similarities between them. Therefore both a resource and behavioural theory of the firm (Pitelis 2007) cannot be used to establish a basis for the study.

Institutionalism is forwarded as a theory of the firm which offers an analytical lens capable of explaining the phenomenon of isomorphism (i.e. similarity) of firms. This would allow the salient, differentiating features of innovative construction organisations to be established by comparing their willingness to innovate and the presence of organisational slack with those of non-innovating construction organisations.

According to institutional theorists, behaviours are the product of "ideas, values and beliefs that originate in the institutional context" (Greenwood and Hinings 1996). This position compliments Hartmann's (2006) model of innovation, in which innovative behaviours are perpetuated by the values of the organisation. As isomorphism is the process by which organisations copy each other through mimetic process (Greenwood and Hinings 1996), it is argued that firms develop and embed slack within their organisational culture in order to nurture the innovative behaviours that drive innovation.

Selznick (1996) contends that the culture of an organisation is mediated social construction and therefore depends on actors' perception and evaluation. Immergut (1998) extends this view by considering the role of institutionalism in permitting critique of the behaviour of individuals within the firm. Behaviouralists argue that an individual's 'true' preferences cannot be ascertained but must be revealed by observing their behaviour. By contrast, institutionalists recognise the potential for discrepancy between an individual's expressed preferences and their 'real' preferences (Immergut 1998) when the individual must reconcile the immediacy and political constraints of their situation with the full potential of the slack resources available to them. This discrepancy is important as it can explain why organisations claim to optimise resource consumption (as their expressed preferences) and therefore exclude preference from resource consumption, yet remain able to innovate as slack resources remain present due to their real preferences. It is therefore proposed that innovative construction firms will contain slack as a manifestation of a stated preference to be 'innovative.' Moreover, their operating culture will embody values that enable slack resources to have consequence by validating and endorsing individuals' decisions to consume such resources to support innovative behaviours. Hence, innovative construction organisations will also exhibit the innovative behaviours discussed by Egbu *et al.* (1998) to a greater extent than non-innovative organisations.

CONCLUSION

This paper characterised the universal elements that underpin a theory of innovation from an organisational perspective. The ability and willingness of organisations to innovate are seen to provide these universal elements, with the availability of organisational resources facilitating their translation into innovative behaviours.

Organisational slack has been forwarded as the theory that could explain this application of 'excess' resources by innovative construction firms to generate innovative behaviours.

From a theoretical perspective institutionalism has explained the presence of slack and innovative behaviours as universal element of innovative firms, this confirming the presented hypothesis. The perception of slack and associated innovative behaviours will be observed by subsequent fieldwork to validate this preliminary synthesis.

In the course of developing the above theoretical framework, several research questions have emerged as the subject of subsequent study. These are:

1. Do those organisations characterised as being innovative by their constituent members exhibit the universal elements associated with slack?
2. What informs organisational members' understanding of their ability to innovate?
3. What informs organisational members' understanding of their willingness to innovate?

4. How do organisational members identify situations in which the consumption of slack resources is appropriate?

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CULTURE SHOCK OF ALLIANCE PROJECTS

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The Alliance procurement approach is used to stimulate collaborative working between project participants. When human resources are drawn from traditional project environments, the extent to which this is realized depends, in large part, on the ability of project participants to manage the shock of transition to a radically different organizational culture. Exploring the nature of this transition and individuals' experiences and coping mechanisms for dealing with it, we propose a theoretical model of culture shock, which helps to explain the transition process into alliance projects. We conclude that projects that recognise the culture shock that individuals experience are better equipped to manage 'non-alliance' behaviours and steer the right behaviours from these individuals to fit within the new culture.

Keywords: alliances, culture, culture shock, procurement, relational contracting.

INTRODUCTION

The Australian construction industry has been extensively criticised in recent years for its poor performance and productivity (RCBCI 2003; Davis and Love, 2011). Part of the solution to this problem has been the development of new collaborative procurement approaches such as alliancing, which are said to challenge the construction industry's historically ingrained adversarial practices (Jefferies *et al.* 2006). Although alliancing is in its embryonic stages of development internationally (Hauck *et al.* 2004), its use in the Australian construction sector has been extensive, particularly in complex building and infrastructure projects where complexities make traditional procurement options problematic to implement (Walker and Hampson 2008; Davis and Love, 2011). In simple terms, an alliance project is meant to be differentiated from traditional contracting by two core principles: sharing risk and reward and; behavioural alignment to project objectives. The sharing of risk and reward is achieved through a project alliance agreement, which incorporates a gainshare and painshare model (Yeung *et al.* 2007). Behavioural alignment is achieved through relational-based integration that encourages trust, cooperation, long term commitment and a sustainable relationship throughout the project lifecycle (Yeung *et al.* 2007). Given that these principles are fundamentally different to those which drive traditional procurement approaches, the success of an alliance project depends on the ability of participants to steer-away from the traditional adversarial approach and work collaboratively (Davies and Love 2011). While there has been research in the areas of alliance contractual arrangements, knowledge management, organisational culture, and alliance capabilities, the issue of cultural transition from a traditional to a relational-based project culture has not been explored (Walker and Hampson 2001; Duysters and Heimeriks 2005; Jefferies *et al.* 2006). Recent focus in

Reed, H and Loosemore M. (2012) Culture shock of alliance projects *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 543-552.

construction research has steered towards issues that impact culture to improve performance (Gajendran *et al.* 2012).

A better understanding of the behavioural changes that need to occur for successful transition between these cultures is important in explaining the continued variability in project alliance performance being experienced in many projects (Duysters and Heimeriks 2005). In this context, the aim of this paper is to critically review the literature and explore the concept of culture shock as a theoretical construct. Our objective is to develop a theoretical model which can be used to understand this process in more detail and guide further research in the area.

The difference between traditional procurement and alliance procurement culture

Organisational culture has been a topic of interest in the organisational studies literature over the last thirty years and has a plethora of definitions. For the purpose of this paper we define organisational culture as the social glue that holds the organizational members together and expresses the values, social ideas, basic assumptions and beliefs that members share within a work environment (Peters and Waterman 1982; Martin 1992; Denison 1996; Helms and Stern 2001).

Traditional Project Culture

There are three basic models of traditional contracting in construction, namely 'construct only, design and construct and project management'. These forms of contract either utilise external consultants to design the scope of works with the contractor engaged to build under a separate agreement; issue the responsibility of design and construction to the contractor with their own chosen architect/designers; or utilise trade contractors to complete the work under the management of a principal contractor. Typically, traditional contracts are 'won' through competitive bidding processes based on fixed pricing or schedule of rates arrangements (DTF, 2010). The well documented risks that project participants face with this contracting style include poor design, poor construction, scope changes due to changing conditions, design errors and poor communication (DTF, 2010). To deal with these potential problems, contracts are written to allocate risk, leading to a lack of cooperation, distrust and adversarial behaviours between project participants who see their futures as independent of, and even in conflict with, those of other project participants (Rowlinson and Cheung 2006; Walker and Rowlinson 2007; Hauck *et al.* 2004; DTF 2010). As Ankar *et al.* (2009) point out, this culture of antagonism and confrontation has become known as the way 'things are done' in the construction industry.

Alliance Project Culture

As Gajendran *et al.* (2012) point out, attention to cultural issues in construction has gained momentum in recent years in an attempt to improve the performance of the industry. Yet as they also point out, a clear understanding of how culture influences performance has not yet emerged and nor has a commonly accepted notion of what it means. In this context, it is not surprising that alliance project culture is not well defined in construction research. However, in trying to understand this we do know that two key elements define alliance projects and in essence provide the cultural framework that establishes alliance relationships. These include the hard (contractual) element and soft (relationship) element. The distinct difference between alliance and traditional projects is the 'working environment' that is created through the contractual arrangements of the Project Alliance Agreement (PAA). Alliance partners

are generally selected before a project price is considered and agreed with resources that are pooled with relevant expertise and are considered to best maximise the potential from the shared risk and reward (Walker *et al.* 2002; Hauck *et al.* 2004).

Collaboration between partners is a driver of success (Rowlinson and Cheung 2006), and this is developed in an alliance through the careful selection of project participants. Adapting behaviours to the overall project objectives through sharing of ideas and information in order to expose hidden risks and new opportunities to improve performance is vital (Rowlinson *et al.* 2006). Risks and rewards are agreed through an open book financial approach where corporate costs are placed at risk to ensure project costs are met, and a bonus mechanism is agreed and shared by all alliance partners to drive and encourage innovation, excellence and optimal project solutions (Walker *et al.* 2002; Hauck *et al.* 2004). The idea is that this also eliminates hidden risks and drives the project team to have a sense of ownership and to focus on outcomes rather than blame. Trust is reinforced in the PAA through a 'No Dispute' clause in the agreement, where participants waive the rights of action against each other (Cheung and Rowlinson 2005). Therefore, trust is crucial within alliance teams (Davis and Walker 2009) and at the most basic level, alliancing is dependent on individual's adapting their behaviour to the new type of project culture, which requires and values collaboration rather than conflict.

To drive this behavioural change, performance measures in alliances are typically aligned to desired behaviours (DTF 2010) and are driven through Key Performance Indicators (KPI) which are an important element of setting up the project objectives and which are not normally seen on traditional contract projects (Cheung and Rowlinson 2005). These KPIs are non cost indicators and generally focus on three target tiers in areas including: Safety; Community; Environment; Quality Assurance; Innovation and Human Resource Management. Tier 1 relates to expected levels of performance, for example; rate of frequency of lost time injury; Tier 2 relate to stretch targets which aim for better than expected performance, for example; reducing the project program through innovative approach to resourcing; and Tier 3 relates to breakthrough targets which require a paradigm shift and / or new ways of operating.

A collaborative organisational culture is argued to be one of the 'non-price' elements that is fundamental to a successful alliance. The culture is set through the initial framework that is agreed between project participants and underpins the joint decision-making process and commitment to the no-blame, no fault ethos. This framework is designed to drive optimal performance through alignment of commercial interests to develop powerful relationships (DTF 2010). An outline of the differences in culture between traditional and alliance projects is compared in Figure 1 using Schein's 1992 Model of Organisational Culture.

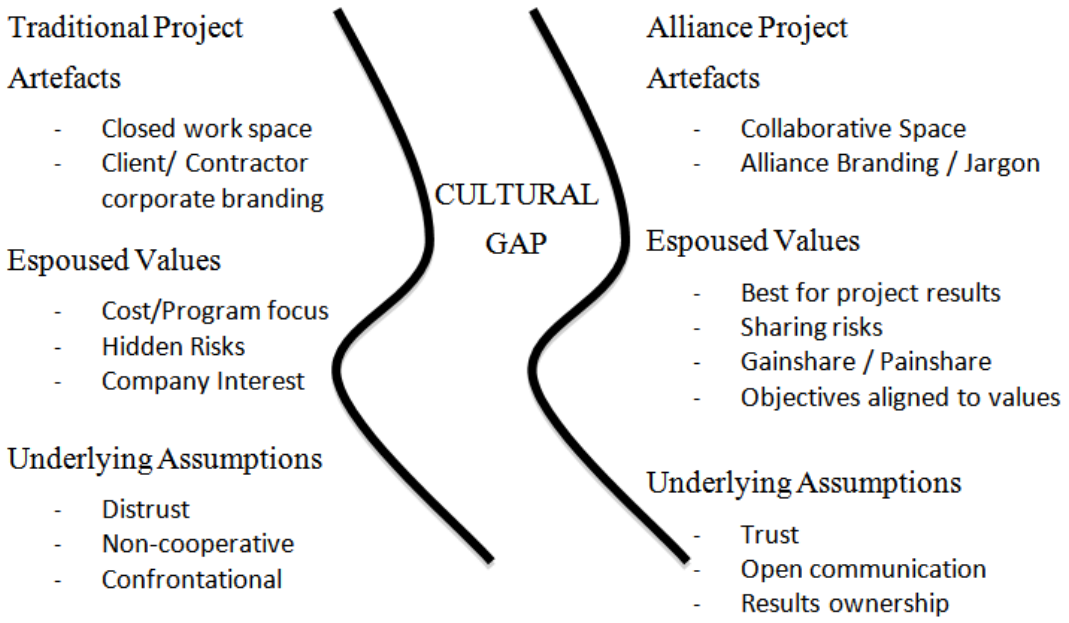

Figure 1: Cultural Difference between traditional and alliance projects

CULTURE SHOCK

While the idea of a collaborative project culture is good in theory, the reality of alliance projects can be very different. Project participants bring with them habits and behaviours formed in old traditional cultures, which may lead to culture shock and consequentially problems in adapting to a collaborative approach to communications and the management of inter-firm relationships and conflict. Marx (1999) suggests that the culture shock experience is not limited to geographical relocation and while the concept of culture shock has been explored in the areas of international education, international aid, international and business culture, migration and tourism, there has been no research in the construction industry to explore the experiences of individuals in transitioning from traditional project to alliance project environments.

Culture shock is a term that is used to describe the disorientation and confusion experienced in moving from familiar to unfamiliar environments. Specifically culture shock has been defined as ‘a state of distress one experiences when experiencing an unfamiliar environment’ (Furnham and Bochner 1986; Hofstede 1999); ‘the experience of foreignness’ (Marx 1999) and ‘being out of place in a certain place and time’ (Irwin 2007). The broader view of culture shock extends to the process of adaptation, which refers to the ‘changes that occur as a result of culture shock’ and the acculturation, which is the extent to which an individual adapts to the foreign culture over time (Ward 1996; Manz 2003). The experiences described above are perceived by individuals as a threat to their well-being in a new environment, and are normally associated with negative feelings. Individual identity becomes unfamiliar, leading to feelings of helplessness, desire for dependence, anger and fear (Furnham and Bochner 1986) or any sort of distress, mentally or physically experienced in a foreign location (Irwin 2007). Indicators of culture shock include not feeling a part of the new culture, confusion in role and role expectations, and not being able to cope with the new environment (Oberg 1960; Furnham and Bochner1986). Marx (1999) later suggested that working within a new culture can produce a variety of reactions such as confusion, anxiety, frustration, isolation and depression as well as exhilaration. However, research also indicates that individuals who experience culture shock

experience it as a routine part of the adaptation process from one environment to another. Culture shock occurrences are normal in foreign cultural environments and dealing with culture shock effectively requires recognition of their existence, implementing behaviours to overcome the shock and utilizing adaptation strategies to deal with the exposure to culture shock (Winkleman 1994; Furnham1993; Manz 2003; Zhou *et al.* 2008).

While numerous researchers have identified the negative effects of culture shock, few have explored its positive aspects. To this end, Adler (1975) and David (1971) believe that culture shock could be viewed as a transitional experience which results in adopting new values, attitudes and behaviours (Furnham 1993), and can be achieved through having a flexible approach to the situation (Manz 2003). A review of the culture shock literature indicates that there are generally four phases involved in the culture shock process (Oberg 1960; Adler 1975; Berry 1980; Mohamed 1997) with research since Oberg determining that culture shock is an expected routine process of adaptation to cultural differences (Furnham 1993). As a result of this, most of the literature over the last decade or so heavily focuses on the adaptation or acculturation to the new environment through strategies such as increased knowledge, acquisition of new skills, and emphasis of the positive aspects of cultural adjustment. (Furnham 1993; Ting-Toomey 1999; Manz 2003).

It is possible that people within organisations face culture shock as a result of the different business cultures (Hofstede 1999) as working in these environments challenges individual identity. It is widely accepted that people move through the phases of culture shock at different rates depending on a range of factors, such as the cultural distance between the familiar and unfamiliar environment and their cognitive capacity to adjust (Marx 1999; Manz 2003). While Oberg (1960) argued that progression through the phases of culture shock is a sequential process, Marx (1999) argues that people progress in a dynamic and repetitive cycle of positive and negative phases until the breakthrough of culture shock. Marx (1999) also produced a culture shock triangle to show how managers that travel internationally deal with culture shock. The model exhibits three dimensions: emotions to deal with mood swings; thinking to understand a foreign environment; social skills and identity development to create a social and professional network and; develop effective skills to manage these networks.

Marx's Culture Shock Triangle evolved from questions to determine the levels of culture shock international managers face with the objective of providing a framework to assist individuals in gaining a better understanding of different cultures. The model determines three adaptation levels to dealing with culture shock: coping with the stress of the transition; changing the perception and interpretation of events and behaviour leading to a way of thinking that is culturally effective; and developing better social skills (Marx 1999). These three components may be applied to individuals that are transitioning from traditional to alliance projects. The emotional aspect can be used to identify whether individuals are experiencing any negative emotions towards the alliance during the initial stages of the transition process, and put in place coping mechanisms to deal with the transition. The thinking component can be applied to establish the gap in cultural learning; that is, what further information and support an individual requires to ease the level of foreignness that an individual is experiencing in the new culture. The social skills and identity component can be utilised to determine what networks and relationships the individuals needs to forge to assist not only in day to day job functions, but in terms of socialising within the alliance culture.

The earlier models of culture shock focused on mental health issues as a result of migration and focused on individuals as victims of culture shock, whereas these later models are based on psychological and educational theories that regard the individuals that are facing culture shock as an active participant in the process (Zhou *et al.* 2008). Although a simple process that can be indirectly applied, the model is limited in that it lacks the behavioural adaptation required to transition within new cultural environments.

Ward *et al.*'s (2003) ABC Model provides a differential view to Marx's in that it depicts culture shock through management of how people think, behave and perceive when exposed to different cultural influences of a second culture, or in the case of alliance projects, a radically different culture to one of traditional projects. The model focuses on two domains of adaptation that are relevant for acculturating individuals into new cultures: the psychological domain refers to psychological wellbeing and satisfaction, and the socio-cultural domain which refers to the ability to operate effectively in new cultural environments. This model suggests three components of the culture shock process – affective, behavioural and cognitive. The affective component is associated with stress and coping mechanisms, and resembles Oberg's initial representation of culture shock as a period of disorientation and confusion. It deals with negative emotions instigated through unfamiliar environments, such as traditional projects vs. alliance projects and highlights responses such as anxiety, perplexity, and a desire to be elsewhere. It is managed through emphasis on social support and emotional resilience.

In an alliance setting determining the right candidate for the role and providing site mentoring maximises the individuals' ability to adapt (Ward *et al.* 2003). The behavioural component is associated with cultural learning, suggesting that individuals that are culturally skilled are more likely to achieve their goals, forge beneficial relations, and eliminate the negative effect associated with cultural contact and influences. Extending social skills and knowledge within an alliance project may reduce misunderstandings and allow individuals to understand and model the expected behaviours. The cognitive component considers how individuals define their own identity both inwardly and outwardly, so that they can cope with their definition of social reality. Ward *et al.* (2003) suggest four alternative approaches: remaining mono-cultural in their traditions, succumbing to the new culture, synthesising both elements of cultures and becoming bicultural or oscillating between cultures and not identifying with either.

When exploring the ABC Model, Ward *et al.* 2003 discuss the affective and behavioural components as tangible elements of how people deal with culture shock. For example, the affective component focuses on an individual's stress levels and coping mechanisms. Similarly the behavioural component focuses on skills and knowledge that can be attained by individuals. The cognitive component however is not immediately visible in individuals as it focuses around their thought processes of self identity (Ward *et al.* 2003) and as such, manifests itself within both the affective and behavioural components as outcomes, and ultimately drives the stress, coping and cultural learning theories. Although a complex process met with difficulty in separation of the individual components (Zhou *et al.* 2008), this theory is concerned with adaptation and adjustment and can be applied to alliances to determine the coping process involved with cultural change.

Culture Shock in Alliance Projects

Drawing on the behavioural and affective components of the ABC Model and Marx's Culture Shock Triangle thinking component, we propose a theoretical model of culture shock in alliance projects (Figure 2). This model distinguishes between the cultures and practices of traditional and alliance projects and acknowledges that the individuals transitioning between the two environments will undergo two cyclical processes simultaneously. The two processes are: culture shock experienced in the new environment, and coping within a new live project environment. In essence, individuals not only have to carry out their day to day roles whilst experiencing culture shock, they have to also adjust to it whilst experiencing it at the same time. Whilst experiencing this process, individuals may be feeling negatively about the project, have sense of loss from their comfort zone of the traditional project environment and are stressed by the unknowns and changes within this environment. Simultaneously, for individuals to feel a sense of contentment and well being within their roles, the individuals are required to develop new skills to deal with a radically different culture and adjust to the new environment swiftly. Attributes within the culture shock and coping management processes may include coping with communicating openly, collaborating with alliance partners, subcontractors and colleagues and sharing all information with all stakeholders which are typical and expected behaviours within alliance projects. Typically, individuals in this situation will not have been socialised to the values and behaviours pertaining to the alliance environment. It is therefore important for management within the alliance project to provide interventions to assist with management of stress and adjustment.

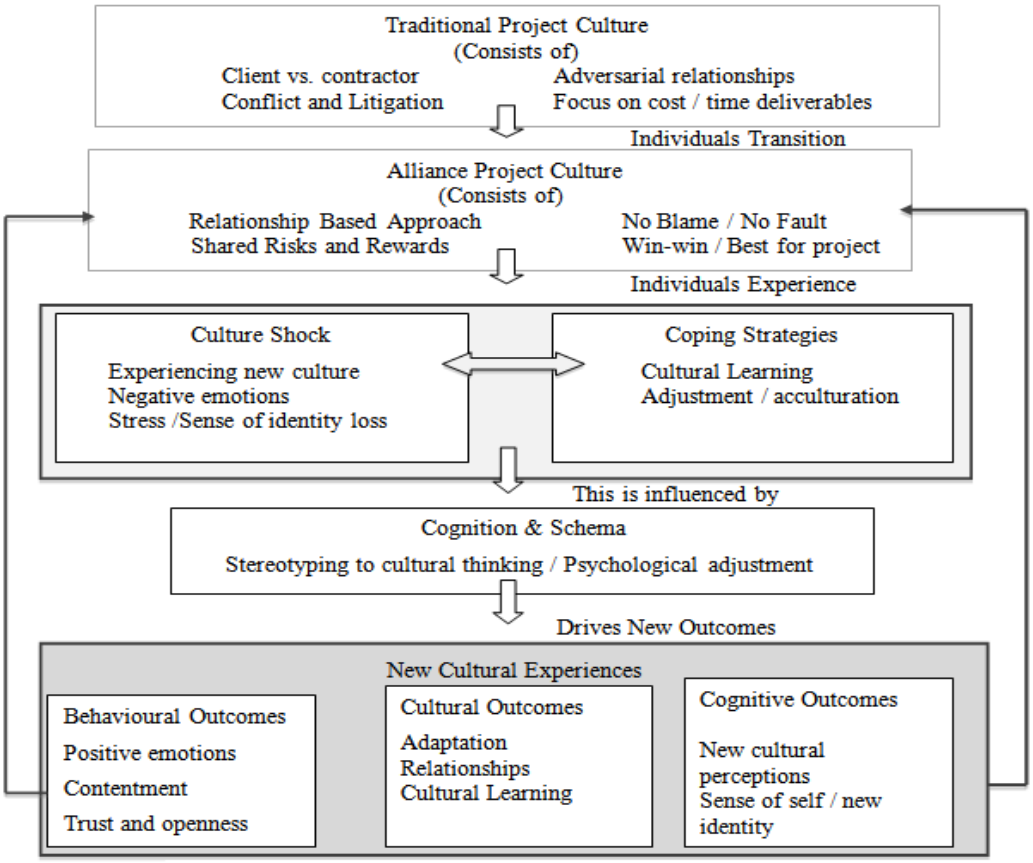

Figure 2: Culture Shock Model of Alliance Projects

The next stage of the model suggests that the culture shock and coping mechanisms stages are influenced by individuals' schemas and cognitions. This stage of the model bases itself on Marx's 'thinking' component where thought processes ultimately drive new behaviours, cognitions and cultural learning's that are then filtered back into the alliance culture. A schema is a knowledge structure that exists in an individual's memory that is developed to encode and represent new incoming information, which enables individuals to orientate themselves within their new surroundings (Harris 1994). The model insinuates that individuals will ultimately be influenced by their new and old experiences and individuals will develop project specific schemas that provide internalised and non-internalised beliefs and values and ultimately an insight and commitment to the alliance culture (Harris 1994). These specific schemas may evolve through the individuals' experience of culture shock or, may be engineered through the interventions that are applied by management.

Further, the model shows that this will result in new cultural experiences with positive behavioural, cultural and cognitive outcomes. Individuals will experience these new outcomes that are reinforced through positive thoughts and feelings towards the project. This can also be achieved through acquisition of new or enhanced skills, a relationship building approach to managing contractors and client, and a new sense of identity. The affective, behavioural and cognitive components are what form the basis of the alliance culture, which is shared at a project level through individuals' sense making of their new environment (Harris 1994).

CONCLUSION

The aims of this paper were to explore the culture shock concept related to individuals that transition from traditional to alliance projects through understanding of the behavioural changes that need to be adopted. This paper explored the differences in cultural environments between traditional and alliance projects utilising Schein's organisational culture model to describe the differences. It is evident that working within alliance projects requires a relational based approach where individual behaviours relate to open communication, collaboration and a strong focus on achieving best for project outcomes rather than individual gain. This radically different approach can result in culture shock for individuals transitioning to this environment. We explored the concept of culture shock and introduced Marx's Culture Shock Triangle and the ABC Model as exploratory models to determine the components of culture shock that may affect these individuals. Using the basis of these models, we have developed our own model to explore the culture shock process for individuals during their transition phase, hypothesising the behavioural, cultural and cognitive outcomes to be tested in alliance project environments for future research. We conclude that projects which recognise the culture shock that individuals experience are better equipped to manage 'non-alliance' behaviours and steer the right behaviours from these individuals to fit within the new culture.

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A CASE STUDY OF THE IMPACT OF CULTURAL DIFFERENCES DURING A CONSTRUCTION PROJECT IN GHANA

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The lack of native engineers in developing countries means that often foreign engineers have a role to play in implementing the water and sanitation systems for rural communities as needed to meet the Millennium Development Goals targets for access to clean water and sanitation facilities. However, cultural differences between foreign engineers and local communities can lead to ineffective project management where these differences are not identified and managed successfully. A case study of a water and sanitation project undertaken in the Eastern Region of Ghana, with a British engineer and project manager, is used as the basis for exploration of some of the issues that arise when engineers work cross-culturally on this type of project. Hofstede's cultural dimensions are used as a conceptual paradigm through which to understand the behaviours and actions observed during the case study. The aim is to identify possible explanations for why cultural tensions arose during the project as a step towards understanding how these tensions might be reduced or eliminated in future projects in similar cultural contexts. It is found that cultural differences between engineer and community at the case study project led to issues with communication and implications for the effectiveness of different management structures. Findings may have broad relevance and help other engineers avoid some of the pitfalls of working in a cross-cultural context.

Keywords: culture, developing countries, Ghana, Hofstede.

INTRODUCTION

On average there are only five engineers and scientists for every ten thousand people in developing countries; in some African countries there is less than one. This compares to between twenty and fifty engineers and scientists per ten thousand people in developed countries (UNESCO, 2010). If water and sanitation facility access is to reach everyone in Sub-Saharan Africa it is estimated that two and a half million new engineers would be required in the region (ibid). The lack of local engineers means that support from foreign engineers is needed to improve access to this vital infrastructure.

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Furber, A; Smith, S.D and Crapper, M (2012) A case study of the impact of cultural differences during a construction project in Ghana *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 553-562.

Engineers from developed countries need to be able to cross cultural boundaries effectively in order to work successfully in developing countries. Other authors have demonstrated that working successfully in a cross-cultural context is not a trivial undertaking. Hall and Jagger (1998) interviewed British construction professionals working internationally and found awareness of cultural differences to be quite high. 60% said that working internationally was more problematic than undertaking domestic work with most citing culture as the root cause of many of the issues.

Enshassi and Burgess (1991) found that construction managers working in cross-cultural contexts needed to have a strong awareness of cultural differences and be able to adapt their managerial style in order to work effectively when managing a multi-cultural work force. Rabbat and Harris (1982) studied international construction firms operating in the Middle East and raised the issue of the need for managers to adapt to the local culture in order to reduce conflict and lessen the implications of conflict on project outcomes. English (2001) documented the way that different cultural perspectives can lead to difficulties with effective communication whilst studying cross-cultural communication of construction workers in South Africa.

Even within regions cultural differences can cause issues for project management. Low and Shi (2001) looked at Singaporean firms working in China and found that, "Mismanaging cultural differences can render otherwise successful managers and organizations ineffective and frustrated when working across cultures".

The aim of this research is to contribute to understanding of the ways in which cultural differences impact on the work of engineers in cross-cultural contexts as a step towards understanding how projects – specifically small-scale rural projects – may be better managed to lessen the impact of cultural issues on project implementation. In order to do this a case study of a small water and sanitation project in the village of Emem in Ghana, in which one of the authors acted as engineer and project manager, is used as the basis of discussion. Hofstede's (2010) cultural dimensions are used as a framework to offer insight into the issues that arose due to cultural differences during the case study.

A brief overview of the conceptual paradigms which can be used to aid exploration of culture is first presented, and then the case study project at Emem, Ghana is introduced. Following this, the project management issues experienced during the case study are examined through the lens of Hofstede's dimensions of culture. The consequence of the main finding, that cultural differences impacted on the work of the engineer by creating issues related to communication, participation and management structure, will be discussed specifically for the project under study, and also in a broader and more generic context.

METHODOLOGICAL APPROACH

Fieldwork was undertaken over an initial period of seven months in 2010 and a later period of two months in 2011. During this time author Furber lived and worked in the Eastern Region of Ghana and was involved in rural water and sanitation projects, one of which forms the case study for this paper. During the 2010 phase of fieldwork, after several project management issues were encountered, it became clear that culture would form an important factor for consideration.

The concept of culture is notoriously difficult to define (see Kroeber and Kluckhohn, 1952 for an extensive list of definitions). For this research a definition and conceptual paradigm of culture has been selected for the practical purpose of providing a

framework to inform understanding of the issues that were encountered during fieldwork. Ogbor (1990) classed approaches to studying the implications of culture into three categories, approaches concerned with looking at the patterns of meaning (Geertz, 1973), cultural paradigms (Schein, 1985), and cultural dimensions (Hofstede, 1980, 1991, 2010).

The most influential model of culture is probably Hofstede's six dimension model. Hofstede defines culture as, "the collective programming of the mind that distinguishes the members of one human group from those of another. Culture in this sense is a system of collectively held values" (Hodstede, 1981). Hofstede's model has been selected for the pragmatic reason that it offers theoretical insights into the difficulties experienced during the fieldwork. Other frameworks could have equally been applied; this is discussed further in the 'Alternative Analysis' section below.

Hofstede statistically analysed over 100,000 questionnaires which measured the values of employees at IBM in over 50 countries. In the original version of his model four independent dimensions were identified that could be used to characterise cultures on a national scale (Hofstede, 1980). The fifth and sixth dimensions were added later in 1991 and 2010 respectively (Hofstede, 1991 and 2010). Hofstede himself notes that the cultural dimensions do not exist per se; they are in fact useful constructs. “A construct is a product of our imagination, supposed to help our understanding. Constructs do not “exist” in an absolute sense: We define them into existence” (Hofstede, 1980: Ch.1, p14). Hofstede has been criticised for making generalisations about cultures but his work is unarguably useful for predicting how a group of people from a given culture may react in a given scenario.

Hofstede's original four dimensions will be considered here:

- Power Distance Index - "the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is unequally distributed" (Hofstede, 2010 p61);
- Individualism versus Collectivism - "individualism pertains to societies in which the ties between individuals are loose: everyone is expected to look after him- or herself and his or her immediate family. Collectivism as its opposite pertains to societies in which people from birth onward are integrated into strong, cohesive in-groups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty" (ibid p92);
- Masculinity versus Femininity - "a society is called masculine when emotional gender roles are clearly distinct: men are supposed to be assertive, tough, and focused on material success, whereas women are supposed to be more modest, tender, and concerned with the quality of life. A society is called feminine when emotional gender roles overlap: both men and women are supposed to be modest, tender, and concerned with the quality of life" (ibid p140); and
- Uncertainty Avoidance Index - "the extent to which members of a culture feel threatened by ambiguous or unknown situations" (ibid p191).

Table 1: Hofstede's Cultural Dimension Scores for West Africa and Great Britain

		West Africa	Great Britain
Power Distance Index	PDI	77	35
Individualism v Collectivism	IND	20	89
Masculinity versus Femininity	MAS	46	66
Uncertainty Avoidance Index	UAI	54	35

As can be seen by Table 1, Ghana (as part of West Africa which includes Ghana, Nigeria and Sierra Leone in Hofstede's rating) has a culture which has much greater power distance that Great Britain, is much more collectively orientated, more feminine and more uncertainty adverse.

Many authors have found Hofstede's cultural dimensions to be a useful tool to explore the implications of culture (within construction management see for example, Low and Shi, 2001). Hofstede's dimensions have been used here to see if any further insights or explanations can be found regarding events that happened during the fieldwork. A case study of one particular project, at a village called Emem, has been selected for further inquiry.

The next section describes the case study project; following this a few examples of the cultural issues that were encountered during the project at Emem are given. Consideration is then given to the insights that can be gleaned by deliberating these issues framed by Hofstede's theory of culture. Discussion then turns to the broader implications of these insights for engineers.

Case study: Emem, Ghana

Emem is a small rural community of approximately two hundred people situated in the Eastern Region of Ghana beside Lake Volta. The community is of predominantly Ewe lineage, run by a chief with the help of seven elder men. The majority of the men in the village work as farmers and fishermen, whilst the women are farmers and traders. Prior to the water and sanitation project the community collected water for all purposes, including drinking, from the Lake. There were a couple of simple pit latrines in the village but these were privately owned by families and the majority of the people living in the village had no access to a toilet.

The project was intended to be a water and sanitation project, to help the community gain access to clean drinking water and hygienic sanitation facilities. At this time a water system has been constructed but work on the toilets was delayed due to construction management issues, which are discussed below. The construction was undertaken by members of the community, with the help of a few paid labourers where skilled labour was required. Author Furber was the engineer and project manager, working under the auspices of 'Original Volunteers Ghana' for the duration of the project. During 2011 she spent two months living at the village, having built a close relationship with the community.

Data collection

Of the two hundred people living in the village of Emem (including children) around thirty five adults were regularly involved in the construction project, either by participating in construction work or by contributing opinions to the design of the systems. Those who contributed ideas but did not participate in construction tended to be the more elderly members of the village who were no longer able to work.

Throughout the project author Furber kept a reflexive diary of the events as they were occurring, including notes on events including all members of the community but particularly focusing on those members who were regularly involved in the project. The issues described in the following section are based on data from this source.

ISSUES EXPERIENCED DURING THE PROJECT AT EMEM

A number of misunderstandings between engineer and community occurred during the project at Emem, which caused great frustration and confusion. Pseudonyms are used in the examples below, which describe some of the issues encountered.

Example 1: "Whatever you think"
The engineer approached the project with the opinion that she was working on behalf of the community who ought to lead the development process in their own community. The community, according to the engineer's preconceptions, should bring their opinions about a wide range of topics including the water and sanitation system design, the project process and any other aspects about which the community had a view. There was a noticeable reticence, however, on the part of most of the community to voice their opinions. Throughout the project, "Whatever you think" was a response heard time and time again to the engineer's questions. The chief and elders on the other hand had no such inhibitions and were very happy to voice their opinions. The engineer could not understand why the ordinary members of the community did not want to be more involved in the project.

Example 2: "My mother has already spoken"
During the project it was observed that when individuals did give opinions they did not want to disagree with the opinions that others had given. During an informal conversation with two women about what meetings needed to be scheduled the elder woman, Amma, was predominantly speaking and presenting what the author presumed to be her own opinion that it would be better to have a few family meetings rather than one big village meeting. The engineer then asked the younger women, Yaa, for her opinions, assuming that Yaa would have her own, possibly different, opinion. Yaa looked confused and said, "My mother has already spoken". It appeared strange from the engineer's perspective that Yaa would not give her opinion, even though it may be beneficial to the project.

Example 3: For the greater good
In another case the engineer was specifically looking for a personal opinion from a woman called Adzoa, who had trouble walking. She was the only lady in the village who had this particular issue and her input into the design of the water and sanitation systems to make it easier for her to collect water or use the latrines was sought. Adzoa’s opinion, however, was not forthcoming as she did not feel that her own wellbeing was important when the majority of the group did not have her problem. In a group meeting with several women to discuss how the water collection point should be designed, another woman suggested making the approach as flat as possible to help Adzoa collect her water a little bit more easily. When the rest of the community cared about the Adzoa's wellbeing, it seemed odd that she would not contribute her opinion regarding how to design the systems to allow her ease of access.

Example 4: When the Chief's away…
Initially during the project at Emem it seemed easy to organise the work schedule and progress was good. Many of the members of the community were helping on the project, even on days that were not designated communal labour days. However,

towards the end of the project the chief lost interest in the project temporarily. His mother had died and his attention was turned towards planning her funeral and he had acquired a girlfriend in a neighbouring village and seemed more interested in visiting her than attending to his village duties. Of course there was a period of time following the funeral where work had to stop to allow the village to mourn the loss of a well respected elder, but when members of the village started to return to work it was considered an appropriate time to continue work on the project.

At this point the engineer had a limited time period remaining on the project and pressure was mounting to complete the project. There were clearly defined jobs that needed to be done and the engineer set about negotiating with individuals about who would do what to get the project completed. But at this late stage in the project the community appeared complacent to organise themselves to work. The engineer could not understand the lethargy apparent in the community; it seemed as though everyone had given up on the project and work was rapidly falling behind schedule.

DISCUSSION

To the foreign engineer these issues seemed perplexing. Why was the community so reticent to give their opinions? Why can two individuals not have their own different perspectives or speak up for their own needs? Why would the whole community put down their tools as soon as the chief turns his back on the project? The following paragraphs explore whether the use of Hofstede's cultural dimensions can elucidate any understanding of these events.

Explanations Based on Hofstede's Cultural Dimensions

Power Distance Index

The community belong to a culture which scores high on Hofstede's power distance index. According to Hofstede, subordinates in cultures with high power distance scores are accustomed to being told what to do and are less familiar with the more democratic ways of working that are commonplace in cultures with smaller power distances (Hofstede, 2010 pp73-74). Conversely the engineer belongs to a culture with a low power distance index and is used to flatter structures of power where subordinates and authority work together on more equal terms and subordinates expect to be consulted. Perhaps this explains the reticence of the community to give their opinions about particular topics and leads them to respond, "Whatever you think", as described in example 1. It is not a sign of disinterest in the project but rather the community do not feel it is their role to provide opinions.

Individualism versus Collectivism

The community also belong to a culture which is much more collectively orientated that the engineer's individualist culture. Collectivist cultures tend to present the opinions of their group rather than their own personal opinion, with the word 'I' used much less than in individualist cultures (ibid pp112-117). It is likely that Amma in example 2 was presenting the opinion of the group to the engineer. Therefore, when the Yaa was asked for her opinion this appeared a strange request from her cultural perspective. Amma had given the group opinion and therefore there was no need for her to reiterate it, her mother had already spoken.

It is possible that similar reasons led to Adzoa in example 3 being reticent to share opinions about her own well being. As the majority of the group did not have her problem she perhaps did not feel that it was for the benefit of the group to design the systems with her individual problems in mind. The group however, were happy to

look out for the all their members and so brought up the issue of ease of access on behalf of Adzoa.

Power Distance Index and Uncertainty Avoidance Index
Hofstede identifies four classifications in the way that different cultures structure their organisations. These classifications are based on the cultural dimensions of power distance index and uncertainty avoidance index (ibid p303). The community, coming from a culture with a high power distance index and a low uncertainty avoidance index would tend to organise themselves naturally into a structure that operates a bit like an 'extended family'. In the community at Emem the 'grandfather' of the family is the chief, he is the central authority and his role is to listen to the rest of the family but the responsibility falls to him to decide on the best course of action to take.

The engineer, by contrast, comes from a culture with low power distance and low uncertainty avoidance which tends towards structures that work like a village market. In the village market model members of the organisation are required to negotiate with others in the organisation to come to an agreed course of action. In example 4 the engineer assumed that it would be possible to negotiate with members of the community in order to complete the project without the presence of the chief and was therefore confused by the inaction of members of the community, thinking their lack of action represented disinterest in the project.

The use of Hofstede's framework provides an alternative explanation for the community's inaction, however. As the community operate like an 'extended family', a family in which the engineer does not belong, the engineer has no authority to ask people in the village to do any work. Work can not be negotiated like in the 'village market'.

Implications for Engineers

Considering the above examples of the cultural misunderstandings that occurred at Emem through the lens of Hofstede's cultural dimensions suggests implications for engineers working on community based projects in developing countries. This section looks at the implications that were apparent at Emem; the following section looks at the extent to which findings may be relevant for other projects in other locations.

Communication and participation
Research corroborates the findings of English (2002) as it was found that cultural differences impacted upon the ability of the engineer to communicate effectively with the community. The collectivist culture meant that individuals were reluctant to present opinions which were not representative of the whole group even where they may have been useful to the engineer. In addition, the power distance between the elders and ordinary members of the community meant that many members of the community did not feel it was their place to contribute opinions to the project.

As previously established by Reed and Smout (2005) gaining the opinions of a wide range of different groups within a community is vital to project success, to ensure it meets the needs of everyone including harder to reach groups such as the poorest and the disabled. Notably, the chief and elders who provided the majority of opinions were male and older. Water collection is often carried out by the women and younger members of the community. As far as sanitation is concerned, younger members of the community and women have different problems to face from the older men. This led to the risk that the project would not meet the needs of everyone in the village. The

chief and elders, while having the best intentions for the project, may not have full understanding of the issues faced by the women and children.

Participation requires redistribution of power to allow the less powerful members of a community more control over their own development. Hofstede notes the paradox of participation in cultures which score high for power distance index. This has serious implications for foreign engineers who are reliant on the participation of a range of groups from a community to ensure their designs meet the needs of all including the women, children, disabled and poorest individuals.

Management Structure

At the case study project the management structure applied by the engineer, based on assumptions about how organisations should work which originated in the engineers cultural background, proved ineffective. It was not possible to negotiate directly with members of the community in order to organise work; all work had to be organised through a leader of the community. When the chief was away it would perhaps been more effective to turn to the next most senior member of the community and ask him to organise the community to work on the project, rather than speaking directly to the community.

Like Low and Shi (2001) it was found that a lack of understanding of the local culture led to an inability to motivate individuals to work. Findings also support Enshassi and Burgess (1991) and Rabbat and Harris (1982) as misunderstanding the local cultural context was found to impact on the ability of the project manager to manage the local workforce effectively. Understanding the local culture better would have made selecting an appropriate management structure possible.

Relevance for Other Projects

The advantage of using a case study as the basis for research is the detail and depth of understanding that can be achieved about a particular project in a particular context. The disadvantage is that it is difficult to assess the relevance of findings for other projects conducted in other contexts.

Using Hofstede's cultural dimensions to explain cultural misunderstandings has the advantage that it suggests boundaries within which findings may be applicable, however. At Emem it is thought that commitment from the chief was an important factor for project success due to the organisation of the community as an 'extended family'. Therefore where other communities operate as an 'extended family' commitment of their chief (or alternative 'grandfather' figure) is likely to be equally crucial.

Likewise, it can be argued that issues around communication and participation may be experienced in other contexts where communities have a high power distance index or a collectivist culture. In these circumstances the engineer is likely to have to think carefully about how the opinions of different groups within the community can be reached to input their ideas into the design of systems.

Alternative Analysis

It is possible that there are other ways to analyse the events that occurred at Emem; it is not suggested that this interpretation is the only viable one. However, it is useful to see that there are different explanations of actions when viewed through an alternative lens. For example, using Hofstede's dimensions suggested that there may be an alternative explanation for the difficulties encountered with getting the community

motivated to work once the chief left the village, other than the engineer's initial perception that the community had lost interest in the project. This is useful for increasing understanding and tolerance between cultures, and would have significantly reduced the engineer's frustration had she been familiar with the work of Hofstede prior to the project.

Whilst much of the work of Hofstede rings true when considered in the light of the project at Emem, some observations were harder to corroborate with his theory. West Africa is in theory more feminine that Great Britain, yet the segregation of roles between men and women appeared more distinct. As discussed above, recognising the differing roles within a community is important for engineers so that they design effectively for all groups within the community. Whilst understanding the dynamic between women and men in the community was important for the water and sanitation project at Emem, the impact was unexpected in consideration of the masculinity scores assigned by Hofstede for the two regions.

CONCLUSIONS

The aim of this paper was to contribute to understanding of the ways in which cultural differences impact on the work of engineers in cross-cultural contexts. At the case study project it was found that cultural differences between the project engineer and community led to frustration and issues for management of the project. In particular, differing cultural perceptions led to difficulties with communication and participation, and problems arose when the management structure selected by the engineer proved inappropriate for the local cultural context.

The use of Hofstede's cultural dimensions as a framework for understanding issues that occurred during the project was helpful as it provided the means through which cultural problems could be examined from another perspective. This was found to increase tolerance and understanding of events previously experienced as frustrating.

This research has implications for other engineers working in cross-cultural contexts, especially where they work in a foreign culture which exhibits a larger power distance between authority and subordinates, a greater tendency towards collective rather than individual outlook or is more uncertainty adverse than their own culture.

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DO YOU FEEL WHAT I FEEL? EMPOWERMENT CONTAGION IN PROJECT TEAMS

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Psychological empowerment, described as constellation of experienced cognitions manifested as sense of meaning, competence, impact, and self-determination has been identified as an important motivating force in teams with performance consequences for individuals and teams. Prior research have therefore sort to identify factors from the individual-, team-, project- and organisation-levels that impact empowerment cognitions with the hope of providing concrete targets for promoting psychological empowerment. One constituency that has been overlooked is the likelihood that psychological empowerment in teams may be capable of being transmitted from one team member to another. This paper reports a study investigating whether psychological empowerment cognition in project teams is contagious. Using survey responses from 380 individuals, nested in 115 project management teams, we test the psychological empowerment contagion hypothesis using analysis of variance, interrater agreement and hierarchical linear modelling as proxies. Analysis of variance indicates that the between-team variance of team psychological empowerment is statistically significant and substantially larger than the within-team variance. Several measures of interrator agreement also show considerable agreement (consensus) within teams, further confirming the prevalence of psychological empowerment in teams. Team psychological empowerment also has a significant positive and independent impact on individual psychological empowerment, even after controlling for the impact of variables previously identified as influencing psychological empowerment. Team members who reported higher levels of team psychological empowerment were also more likely to experience higher levels of individual psychological empowerment themselves. Psychological empowerment is contagious and can be transmitted from one team member to another. These findings supplement the traditional sources of antecedents of empowerment and suggest that team members play an important multiplier role in engendering feelings of psychological empowerment both consciously and unconsciously.

Keywords: contagion, Hierarchical Linear Modelling (HLM), project team, psychological empowerment

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Tuuli M.M. and Acquah S. (2012) Do you feel what I feel? Empowerment contagion in project teams *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 563-574.

INTRODUCTION

Empowerment has attracted the interest of both researchers and practitioners recently. Conceptual developments have begun to shift beyond dimensionalisation, to identifying antecedents and consequences of empowerment (c.f. Seibert *et al.* 2011). Factors that impact empowerment cognitions from the individual-, team-, project- and organisation-levels have been highlighted (e.g. Seibert *et al.* 2011, Tuuli and Rowlinson 2010a) with the hope of providing concrete targets for promoting empowerment in different work settings. One constituency that appears to have been overlooked is the likelihood that empowerment, and psychological empowerment in particular in teams, may be capable of being transmitted from one team member to another. In other words, is it likely that psychological empowerment is contagious, capable of being transmitted, like a virus, from one team member to another? While the contagious nature of psychological empowerment has not previously been examined specifically, researchers have explored contagion effects of other related concepts, such as motivation (c.f. Wieseke *et al.* 2011), emotion (c.f. Bakker *et al.* 2001 and Bakker *et al.* 2005), epidemics (c.f. Worthen 1973), burnout (c.f. Bakker and Schaufeli, 2000, Bakker *et al.* 2005), risk perception (c.f. Scherer and Cho, 2003), learning (c.f. Pressey *et al.* 2011), financial markets (c.f. Inci *et al.* 2010) and community protests against construction projects (c.f. Teo and Loosemore, 2009, 2010a, 2010b, 2011).

This study sets out to examine if psychological empowerment cognition is contagious in project teams using a Hong Kong sample. The psychological empowerment contagion hypothesis is tested using analysis of variance, interrater agreement tests and hierarchical linear modelling as proxies, concluding that psychological empowerment is contagious and can be transmitted from one team member to another. In the sections that follow, psychological empowerment is explained, followed by a discussion of contagion theory and why psychological empowerment may be contagious. The results of the tests of emergent hypotheses are presented and discussed.

PSYCHOLOGICAL EMPOWERMENT

Psychological empowerment is a constellation of experienced cognitions manifested as sense of meaning, competence, impact and self-determination (Conger and Kanungo 1988; Spreitzer 1995a). According to Spreitzer and Quinn (2001, p. 13-14) psychologically empowered individuals and teams "see themselves as having freedom and discretion (*self-determination*), as having a personal connection to the organisation (*meaning*), as confident about their abilities (*competence*), and as able to make a difference in the system in which they are embedded (*impact*)". Analysis of individual level psychological empowerment (*individual empowerment*) predominates in the extant literature on empowerment (e.g. Spreitzer 1995a, 1995b).

As a result of the growth and pervasive use of teams to accomplish tasks, however, researchers have begun to conceptualize and examine psychological empowerment at the team-level (*team empowerment*) (e.g. Mathieu *et al.* 2006). Analogous team-level conceptualization of psychological empowerment has therefore emerged (e.g. Kirkman and Rosen 1997, Mathieu *et al.* 2006). Mathieu *et al.* (2006, p. 98) define team empowerment as the "team members' collective belief that they have the authority to control their proximal work environment and are responsible for their team's functioning". Kirkman and Rosen (1997) take a multifaceted view and proposed a four-dimensional structure of team empowerment comprising the team

members' shared perception of *potency, meaningfulness, autonomy and consequences.* These dimensions are parallel to the individual empowerment dimensions developed by Spreitzer (1995a). In contrast to individual empowerment, team empowerment focuses on collective perception. It is therefore critical to note that team empowerment is not simply the aggregation of individual empowerment to the team-level, but represents a distinct team-level construct with no meaningful existence as an individual-level construct. From the foregoing therefore team (psychological) empowerment and individual (psychological) empowerment are conceptually distinct. We therefore hypothesize that;

H1: Individual and team psychological empowerment are empirically distinct constructs.

CONTAGION THEORY

Contagion theory is premised on a disease metaphor (Monge and Contractor, 2003) and seeks to explain network members' knowledge, attitudes and behaviour based on their exposure to the attitudes, information and behaviour of others (c.f. Rogers and Kincaid, 1981). It helps explain how exposure to contact may lead to social influence, imitation and mimetic behavior (Pressey *et al.* 2011). Some of the earlier works on the notion of contagion theory were in the medical innovation diffusion studies by Herbert Menzel and his colleagues (c.f. Menzel and Katz 1955, Coleman *et al.* 1966), in which they examined the sociometric process that took place when a new pharmaceutical product was released for sale and the impact that new entity showed in a definable geographical area (Worthen 1973). They concluded that there was a contagious process, analogous to disease epidemic, involved in how the medical innovation spread through social channels, resulting in simultaneous adoptions of the drug by a socially close-knit group of physicians (Menzel and Katz 1955). Contagion theory does not require that there is intent to influence the transmission of behaviour, emotions and actions, or even an awareness of influence; only that communication, interaction or contact takes place (Scherer and Cho 2003).

Contemporary literature is replete with studies testing or applying contagion theory in relation to several concepts, e.g., epidemics (c.f. Worthen 1973), emotion (c.f. Bakker *et al.* 2001 and Bakker *et al.* 2005), motivation (c.f. Wieseke *et al.* 2011), burnout (c.f. Bakker and Schaufeli 2000, Bakker *et al.* 2005), risk perception (c.f. Scherer and Cho 2003), learning (c.f. Pressey *et al.* 2011), financial markets (c.f. Inci *et al.* 2010) and community protests against construction projects (c.f. Teo and Loosemore, 2009, 2010a, 2010b, 2011). From a social network perspective, the idea of social contagion suggests that due to social influence, individuals adopt the attitudes or behaviours of others in the social network with whom they communicate (Scherer and Cho 2003, Burt 1987). From an emotional perspective, contagion is defined as "the tendency to automatically mimic and synchronize facial expressions, vocalizations, postures and movements with those of another person and consequently, to converge emotionally" (Hatfield *et al.* 1994). Other than automatic mimicry or facial feedback, emotional contagion can also occur via a conscious cognitive process of "tuning in" to the emotions of others (Bakker *et al.* 2001). Based on this perspective Bakker and his colleagues have examined burnout contagion and the underlying processes among intensive care nurses, general practitioners and teachers (c.f. Bakker and Schaufeli, 2000, Bakker *et al.* 2005).

It has also been suggested that motivation could have contagion effects similar to that found with regards to emotions and burnout. This is captured under the *motivation*

spill over phenomenon, defined as the transfer of different components of motivation from one person to another (c.f. Wieseke *et al.* 2011, Chen and Kanfer 2006). The notion of motivation spillover is supported by social learning theory which posits that individuals learn from significant others by observing the behaviors of others (Bandura 1977).

PSYCHOLOGICAL EMPOWERMENT CONTAGION IN TEAMS

Among the various concepts examined with regards to contagion theory in the literature, the contagion effects of motivation offers the clearest evidence in support of an expectation that psychological empowerment will also have contagion effects. As Bandura *et al.* (1980) point out, seeing or visualizing significant others performing tasks successfully can raise perceptions of efficacy, because observers infer that they may be able to master comparable tasks. Like motivation, psychological empowerment is reliant on cognition and is often the result of response to external stimuli. Davis and Luthans's (1980) social learning framework for organizational behaviour explicitly incorporates cognitions, emphasizing that cognitions can be acquired through social learning. This view of acquisition of cognitions through social learning is consistent with contagion theory perspective of the transmission of emotions, behaviours, actions, etc.

From the foregoing, it appears reasonable to assume that the mechanisms involved in psychological empowerment contagion processes are similar to those involved in the various contagion processes described above involving motivation, emotion, burnout, epidemics, risk perception and financial markets. First, project teams exhibit conditions that can be described as necessary for the development of a 'climate for contagion'. Drawing on Anderson and West (1998), these conditions are (a) individual interaction, (b) existence of some common goal which predisposes individuals toward collective action, and (c) the existence of sufficient task interdependence. These are characteristic features of many project teams and, thus, should support the development of shared perceptions regarding a climate for empowerment among project team members. Such a climate should therefore promote psychological empowerment contagion in project teams.

Second, psychological empowerment contagion may occur through a processes of individual team members becoming psychological empowered (*catching the virus*) as a result of interactions with other team members who express psychological empowerment cognitions. Specifically, this can occur through the confidence they show in their task performance abilities (competence), their influence in the project organization (impact), their commitment and attachment to team and project goals (meaning) and overall the freedom to decide on how best to undertake their tasks (self-determination). Given the motivating nature of psychological empowerment, this view is supported by the motivation spillover phenomenon (Wieseke *et al.* 2011) and from social learning theory perspective that suggests that motivation can be contagious (c.f. Bandura 1997). As LePine and Van Dyne (2001) point out, in work teams, a team member who demonstrates a low level of motivation may generate negative affective reactions among other team members (even un- intentionally), and so decrease team-level motivation, lower morale, disrupt task performance, and alter leader behaviors. However, when team members believe their team is composed of capable members who can collectively accomplish the team's mission, they are also likely to believe they can effectively perform their role in their team, given that their role is highly dependent on other team members' roles (Chen and Kanfer 2006). This

manifestation of empowerment contagion is synonymous with Bakker and his colleagues (c.f. Bakker & Schaufeli, 2000, Bakker, *et al.* 2001, Bakker *et al.* 2005) conceptualization of burnout contagion in terms of the "prevalence of burnout complains among colleagues". We therefore expect that team empowerment can be so pervasive that it positively influences individual empowerment and thereby promote psychological empowerment contagion. Thus, we posit that;

H2: Team empowerment will be positively and significantly related to individual empowerment.

Corollary,

H3: Psychological empowerment is contagious such that team members who report high levels of team empowerment also experience higher levels of individual empowerment.

METHOD

Sample

Project management teams of construction organisations who work together on the same project their organisation is involved in Hong Kong were the source of the data for this study. The first administration of the questionnaire yielded 232 responses. A second administration to contact persons from whom one or no questionnaire was received in the first administration, yielded a further 150 responses, giving a total of 382 individual responses nested in teams from 115 organisations, a 23% response rate. A missing data pattern analysis resulted in the exclusion of 2 responses for excessive missing data (>50%) (c.f. Hair *et al.* 1998). The effective sample size for the analysis was therefore 380 individuals nested in 115 project management teams.

Overall, 53% of the respondents are older than 40 years, and 94% fall under the ranks of middle-management (40%), senior management (41%) and director level (13%). This distribution corresponds favourably to the target population of management-level staff. Males make up 89% of the sample, nationals of Hong Kong and China combined make up 82% and persons of Chinese ethnicity make up 87%. Average tenure in the construction industry is 17 years. In terms of education, 89% have a Bachelors degree or higher. Eighty-two percent of the organisations employ 50 or more people.

Measures

Individual psychological empowerment was measured with the 12-item scale developed by Spreitzer (1995a), which measures the 4 sub-dimensions; *meaning* (α = .85), *competence* (α = .84), *self-determination* (α = .80) and *impact* (α = .85). Sample items include "The work I do is very important to me" for the meaning dimension and "I am confident about my ability to do my job" for competence.

Team psychological empowerment was measured with Kirkman *et al.*'s (2004) 12-item scale (α = .93), which measures the 4 sub-dimensions; potency, meaningfulness, autonomy and impact. Sample items include, "My team feels that its tasks are worthwhile" (meaningfulness) and "My team makes a difference in this organization" (impact). In this study we equate team psychological empowerment, which measures team members' collective belief of the prevalence of psychological empowerment in the team, to the manifestation of psychological empowerment contagion. This mirrors similar contagion conceptualisations in previous research. For example, Bakker and his colleagues (c.f. Bakker & Schaufeli, 2000, Bakker, *et al.* 2001, Bakker *et al.* 2005) conceptualise and measure burnout contagion as the "prevalence of burnout complains

among colleagues". To the extent that psychological empowerment prevalence is demonstrated, empowerment contagion can be inferred.

All the above measures were anchored with a 5-point Likert scale. A number of control and demographic variables were also measured. *Gender*, *age*, e*ducational*, *ethnicity*, *nationality* and *tenure* were measured using single item questions. Organisational characteristics such as *firm age* and *size* were also measured. We also controlled for the effect of the four different types of teams from which data was collected; contractor teams (Team Type 1-CM), client teams (Team Type 2-Client), consultant teams (Team Type 4) and teams that played a dual role of client's representative and designer/Architect (Team Type 3-Dual). Given the tendency for individuals to "fake good" in self-report surveys, we also measured *social desirability* using the 10-item short version of the Marlowe-Crowne 33-item scale of socially desirability, proposed by Strahan and Gerbasi (1972).

Data Analysis Strategy

No single data analysis technique is appropriate for testing all the three hypotheses proposed in this study. We used confirmatory factor analysis to test the first hypothesis while analysis of variance (ANOVA) and multiple interrator agreement measures were used as proxies to specifically assess the contagion hypothesis of psychological empowerment (i.e. Hypothesis 3) following the work of Bakker and his colleagues (c.f. Bakker & Schaufeli, 2000, Bakker, *et al.* 2001, Bakker *et al.* 2005). Analysis of variance and interrater agreement demonstrate consensus of the prevalence of a phenomenon and can therefore be used to infer the presence of contagion effect. The cross-level relationship proposed in the second hypothesis was analysed using Hierarchical Linear Modelling (HLM, Bliese and Hanges 2004).

RESULTS

Descriptive Statistics and Correlations

The reliabilities and dimensionality of all multi-item measures were assessed by exploratory factor analysis. The scale items loaded as hypothesised or meaningfully and the measures also exhibited acceptable reliabilities (see the "Measures" section above for details of values of α). The descriptive statistics and zero-order correlations among the variables show that all correlations are below .80, the threshold of very high correlations when multicollinearity is obvious. The correlations between the social desirability measure and team type 1-contractor and team empowerment variables are higher than the threshold of between -.20 and +.20 suggested by (Mitchell and Jolley 2001), an indication that social desirability bias strongly influence these measures and thus warrants controlling for in the analysis.

Tests of Hypotheses

For the cross-level analysis (i.e. test of hypothesis H2), age, gender, education, nationality, ethnicity, firm size and age, tenure and team type as well as social desirability were included as control variables due to their possible confounding effects on the relationship (c.f. Spreitzer, 1995b).

Tests of Hypothesis H1

Confirmatory factor analysis was used to establish the empirical distinctiveness of the individual and team empowerment as a direct test of hypothesis H1. The fit of a hypothesized model in which there were 2 second-order factors, corresponding to the 2 facets of empowerment, was compared with an alternative model where one second-order factor was specified. The analyses were performed using Amos 16.0 statistical

analysis software. The results show that the hypothesized two-factor model fit the data well, $\chi^2(1017, N = 380) = 2895.97$, relative noncentrality index (RNI) = .82, comparative fit index (CFI) = .88, root-mean-square error of approximation (RMSEA) = .07. As expected, the alternative model in which all 8 dimensions loaded onto one second order factor fit the data significantly worse, $\Delta\chi^2(2, N = 380) = 104.89$, $p < .001$, RNI = .82, CFI = .87, RMSEA = .07. Taken together, Hypothesis H1 which posited that individual and team empowerment are empirically distinct constructs, is supported.

Tests of Hypothesis H2

Prior to testing Hypotheses H2, a *null model* (i.e. a model without predictors, a requisite first step in HLM analysis to decompose the variance in the outcome variable) was run with individual empowerment as the dependent variable, (i.e. model *1a* in Table 1). The results provide evidence of significant within-team ($\sigma^2 = .47$, $p < .001$) and between-team ($\tau_{00} = .08$, $p < .01$) variance in individual empowerment. This information was is used to calculate the interclass correlation coefficient (ICC), a measure of non- independence and, thus, an indication of the proportion of the variance in the outcome variable that is attributable to team membership. The calculation gives an ICC of .17 (or 17% of variance), confirming the presence of non-independence in the observations and justifying the use of HLM to test the hypothesis involving individual empowerment.

Model *2a* (Table 1) with only the control variables as predictors was then run next. Only gender ($\beta = -.26$, $p < .05$) and firm size ($\beta = .28$, $p < .01$) significantly influence individual empowerment. An examination of the zero-order bivariate correlations, however, shows that gender and individual empowerment are not significantly related ($r = .08$, *ns*) while firm size and individual empowerment are actually negatively and significantly related ($r = -.19$, $p < .001$). This suggests that the regression findings pertaining to the effect of gender and firm size on individual empowerment may be *spurious* as a result of *suppressor effects*. The spurious nature of the regression findings on gender effects is the *classical suppression* scenario (c.f. Cramer, 2003, Cohen and Cohen 1983), where an independent variable (the suppressor) has no association with the independent variable but correlates positively with other independent variables in the model thereby acquiring a negative regression coefficient when entered together in the same model. The case of firm size is the *negative or net suppression* scenario (Cohen and Cohen, 1983), where the sign of the regression weight of the independent variable is the opposite of what should be expected on the basis of the correlation with the dependent variable. Thus, in interpreting the results in such circumstances greater weight is normally placed on the zero-order correlation (Cramer, 2003). Based on this logic therefore the significant regression finding for the link between both gender and firm size and individual empowerment are rejected for being spurious. Although the control variables together account for 7% of the variance in individual empowerment (lower part of Table 1) no significant finding in terms of any single control variable is discernable.

Table 1: HLM Analysis of Empowerment Inter-relationships

Variables	Individual Empowerment		
	1a	*2a*	*3a*
Gender		-0.26*	-0.06
Age		-0.06	0.02
Education		0.08	0.03
Nationality		-0.09	-0.04
Ethnicity		-0.28	-0.13
Tenure in industry		0.01	0.01
Firm Size		0.28**	0.28**
Firm Age		0.00	0.00
Team Type 1 (CM)		0.27	0.31*
Team Type 2 (Client)		0.11	0.28*
Team Type 3 (Dual)		-0.09	0.11
No respondents		0.03	0.04
Social Desirability		0.04	-0.00
Team Empowerment		-	0.81***
Random Parameters			
σ^2	.47***	0.47***	0.13***
τ_{00}	.08**	0.04	0.11***
R_1^2	-	0.07	0.56
ΔR_1^2(Unique)	-	0.07	0.49
Deviance (-2LL)	838.97	769.28	312.8***

NOTE: *p < 0.05; **p < 0.01; ***p < 0.001.

Finally, models *3a* (Table 1) was estimated to directly test Hypothesis H2. The results indicate a highly significant relationship between team empowerment and individual empowerment (β = .81, p < .001), with team empowerment explaining 49% of the variance in individual empowerment. Thus, Hypotheses H2 is supported.

Tests of Hypothesis H3

A one-way analysis of variance (ANOVA) was computed with team empowerment as the dependent variable. This compared the within and between team variance of the 115 teams from which data was collected from. The results indicate that the between-team variance is significantly and substantially larger than the within-team variance (F(64, 315) = 17.735, P < 0.001). This implies that there is considerable *consensus* within teams about the prevalence of psychological empowerment. This lends support to the preliminary analysis that showed that there is a significant between-team variance in individual empowerment (τ_{00} = .08, p < .01), equivalent to 17% of variance. In other words 17% of the between-team variance in individual empowerment can be attributed team empowerment. To further confirm consensus of the prevalence of psychological empowerment and justify aggregation of the team empowerment, two categories of indexes were calculated using the R software (available at www.r-project.org); James *et al.*'s (1984) interrater agreement index

($r_{WG(J)}$) and Burke *et al.*'s (1999) Average Deviation indexes (i.e. AD_M and AD_{Md}). Significance tests show that there is acceptable agreement or consensus among team members regarding the prevalence of psychological empowerment, supporting aggregation (i.e. $r_{WG(J)} = 0.96$, $p < 0.01$; $AD_{M(J)} = 0.44$, $p < 0.01$; $AD_{Md(J)} = 0.36$, $p < 0.01$). Taken together therefore, Hypothesis H3 is also supported.

DISCUSSION AND IMPLICATIONS

This study set out to examine if psychological empowerment cognition is contagious in project teams. First, the findings lend empirical support to the theoretical distinctiveness of individual and team psychological empowerment constructs. This enabled us to assess the influence of team empowerment as providing an external stimulus that influences individual empowerment and thereby promote psychological empowerment contagion.

With regards to psychological empowerment contagion, the analysis of variance results indicate that the between-team variance of team psychological empowerment is statistically significant and substantially larger than the within-team variance. This implies that there is considerable agreement (consensus) within project teams regarding the prevalence of psychological empowerment. In addition, the results of the HLM analyses show that team empowerment make a statistically significant and unique contribution to explaining variance in individual empowerment, even after controlling for the impact of variables previously identified as influencing psychological empowerment. Team members who reported higher levels of team psychological empowerment were also more likely to experience higher levels of individual psychological empowerment themselves. These findings are consistent with those found by Bakker and his colleagues with regards to the contagion effect of burnout among intensive care nurses, general practitioners and teachers (c.f. Bakker and Schaufeli, 2000, Bakker *et al.* 2005). In accord with assertions by Bandura (1977) and Chen and Kanfer (2006) and more recently by Wieseke *et al.* (2011), psychological empowerment exhibits similar spillover effects as motivation. To the extent that team members perceive a prevailing high level of psychological empowerment among their team members (i.e. team psychological empowerment), the results show that this tend to influence high individual psychological empowerment cognition. Psychological empowerment is therefore contagious and can be transmitted from one team member to another. These findings supplement the traditional sources of antecedents of empowerment and suggest that team members play an important multiplier role in engendering feelings of psychological empowerment both consciously and unconsciously. With team empowerment contributing nearly half the variance in individual empowerment, project managers have a clear target for engendering individual psychological empowerment in project teams.

CONCLUSION

Prior research have identified factors from the individual-, team-, project- and organisation-levels that impact empowerment cognitions (e.g. Seibert *et al.* 2011, Tuuli and Rowlinson 2010a). This study suggests that team members are a key constituency for engendering psychological empowerment but who may have been overlooked. The contagion hypothesis of psychological empowerment therefore exposes an important antecedent of psychological empowerment in team member empowerment. Future research may focus on the precise processes responsible for psychological empowerment contagion to find answers to questions with regards to whether empowerment contagion is a result of conscious or unconscious processes. In

a similar vein, measuring specifically susceptibility to psychological empowerment can be used to further demonstrate empowerment contagion in accord with Bakker and his colleagues (c.f. Bakker & Schaufeli, 2000, Bakker, *et al.* 2001, Bakker *et al.* 2005). Lastly, this study adds to the studies of Teo and her colleagues (c.f. Teo and Loosemore, 2009, 2010a, 2010b, 2011) in demonstrating the applicability of contagion theory in construction management research.

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HUMAN RESOURCE MANAGEMENT AND SKILLS

ARCHITECTS IN SPAIN: A PROFESSION UNDER RISK

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A review of the literature reveals that Architecture as a profession has been already studied in countries which belong to the Anglo-American model of professionalization: Australia, Canada, the UK and the USA. However, there is a paucity of work with respect to the situation in Spain, a geographical context with specific cultural, social and economic features, which belongs to the Continental model of professionalism. The study of state-specific professions, taking into account cultural contexts, shows international similarities and variations, besides it informs about constraints and opportunities existing in our national systems. In an attempt to address this research gap, we aim to depict Spanish architects' experiences and concerns regarding work, career and professional life. An interpretive approach is used, within the qualitative paradigm, to analyse 38 semi-structured in-depth interviews with Spanish architects of different age, gender and employment setting. Open questions explored reasons for choosing the architectural profession, career drivers and obstacles, and the realities of their working lives. Findings show that although most rewards and stressors derived from the profession are similar among countries, the Spanish context has particular features which result in interesting differences. Families influence students when choosing a career in architecture, social capital is among the factors helping their careers the most, while women also identify as barriers other aspects related to gender and work-family balance. Due to the economic recession currently afflicting Spain, participants describe a rather discouraging description of their situation and outline the lack of prestige and status associated with the profession.

Keywords: architecture, diversity, professionalism, qualitative research, Spain.

INTRODUCTION

From early on, the sociology of the professions was prone to study the professions as a universal phenomenon unaffected by time and space heterogeneity. Hence, what were peculiar traits of specific professions in particular geographical and historical contexts (law and medicine in Britain and America in the 19th century) were considered as universal features of professionalization (Faulconbrige and Muzio 2012). The so called decentralized Anglo-American model, characterized by the freedom of self-employed practitioners operating in a market for services to clients, and self- regulated

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Navarro-Astor E.and Caven V. (2012) Architects in Spain: A profession under risk *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 577-587.

by a professional institution in charge of education, examination and licensing, became global (Evetts 2008).

Later on, the Continental model of professionalism, corresponding to European societies (including Spain) with a strong interventionist state and a large and powerful civil service apparatus, was considered. The state is directly involved in the institutionalization and regulation of professional expertise and is the main end-user of professional and technical services in a number of contexts (Faulconbrige and Muzio 2012). Although convergence between both models now renders this distinction partly obsolete (Evetts 2011), it is important for understanding current differences in the realities of professionals' work in different countries.

At present, the fact that professional occupations are different between nation-states and contexts are constantly changing is well accepted (Evetts 2011). Some authors have also pointed out that various actors have played historically different roles in the establishment and regulation of professional occupations while also influencing the realities of work and understanding of professional´s duties and responsibilities (Burrage *et al.* 1990). In addition, they defend the study of state-specific projects in order to show international similarities and variations. Besides, acquaintance with different national systems and their cultural contexts "helps to inform us about the constraints and opportunities existing in our own" (Davenport 2000: 78). Research approaching the influence of cultural diversity on the realities of work in the architectural profession, is still at an incipient stage. This supports the case in favour of this paper, which sheds light on Spanish architects' work. It is also the foundation for a future direct international comparison with the UK and France.

Thus, the aim of this paper is to explore and depict Spanish architects' experiences and concerns regarding their work, career and professional life. Beginning with a review of the literature related to the architectural profession, we continue with a discussion of the particular sociological origins and the structure of the profession in this country, together with an overview of the economic context. Then we describe the qualitative research methods used and we discuss the findings. Finally, the contribution of this paper is highlighted showing that although most rewards and stressors derived from the profession are similar among countries, there are particular social, cultural, political and economic features related to the Spanish context which result in interesting differences.

BACKGROUND OF THE ARCHITECTURAL PROFESSION

Existing research into the architectural profession has focused on individual countries, for example: the USA (Anthony 2001); France (Champy 2008, Chadoin 2007); Australia (Willis and Hanna 2001); Canada (Adams and Tancred 2000) and predominantly the UK (Imrie and Street 2009; Cohen *et al.* 2005; Sang *et al.* 2009a and 2009b; De Graft-Johnson *et al.* 2005; Fowler and Wilson 2004; Caven 2006). Caven and Diop (2012) have been the first researchers to conduct a comparative cross-national study regarding architects in France and the UK, while the case of global architects and architecture firms has also been studied (Faulconbridge 2009). Literature review suggests that Spain has not often been the setting for research studies about architects. In fact, only the recent works authored by Sánchez de Madariaga (2010) and Agudo and Sánchez de Madariaga (2011), focused on female architects, and Luque (2009 and 2007), analysing the state of the profession through surveys addressed to registered architects have been found.

Most of these empirical studies have focused on women and the lack of equality in architecture (Anthony 2001; Adams and Tancred 2000; Willis and Hanna 2001; Fowler and Wilson 2004; Caven and Diop 2012), the 'feminization' of the profession and resulting 'depreciation' in status (Chadoin 2007), and why women leave (de Graft-Johnson *et al.* 2005). A dearth of research has also dealt with motivations for entering the profession and remaining (Caven 2006; Sang *et al.* 2009b; Caven and Diop 2012), with job satisfaction and work purpose (Sang *et al.* 2009a; Cohen *et al.* 2005) as well as with ways of managing the profession (Champy 2008).

THE ARCHITECTURE PROFESSION IN SPAIN: ORIGINS, STRUCTURE AND ECONOMIC CONTEXT

In Spain, the origins of the profession are craft-based rather than arising from the arts (Wilkinson 1984), architects' predecessors did not belong to a guild and their training took place on the job. They usually began as stone cutters or masons, rising in the workmen´s hierarchy to the position of "aparejador" or supervisor, and becoming master-builders in the last stage of their training. Finally, as masters of works, they were responsible for the design and proper execution of the building. Appointments for important buildings such as cathedrals were the basis of a solid reputation, and they used to hold only one such position at a time. However, at the beginning of the 16th century, the master developed more varied works and was often absent controlling other projects, leaving the building in the hands of his supervisor. "By this time, the master of the works was beginning to estrange himself from the rest of his trade and to become an architect in the full sense of the word" (Wilkinson 1984: 132).

Spanish professional associations developed at the end of the 17th century. The "Hermandad de Nuestra Señora de Belén" was created in 1682 under the name of the architect´s patron saint (Belén), resulting in the "Sociedad Central de Arquitectos" in 1849, which is nowadays the "Consejo Superior de Colegios de Arquitectos de España" (CSCAE), an umbrella organization for the professional bodies (Roldan 2011). The first Royal Academy of Architects, initially called "Academia de las tres artes", was founded in 1744 in Madrid, later becoming "Real Academia de Bellas Artes de San Fernando", it represents one of the first references and education systems for the profession and remains the basis for the present schools of architecture.

According to Roldan (2011), other academies were created later on in different Spanish cities: Valencia (1765), Barcelona (school in 1775 and academy in 1850) and Valladolid (1783). In 1875, with the "Moyano" law, the teaching of architecture was passed from the Academies of Fine Arts to the Superior Technical Schools. Architectural education is nowadays offered at 31 schools of architecture with 30,149 students enrolled (Rubio and Gómez 2011).

According to Mirza and Nacey (2010: 12) Spain stands out as the third country with the largest number of architects in Europe, 50,000, following Italy (145,000) and Germany (100,500). Analyzed as a proportion of the population, the Spanish 'density' of architects is 1.1 - measured as number of architects per 1,000 population –which is above 0.9, the average European density. However, architects´ supply keeps growing at a speed of 3,000 per year (Rubio and Gómez 2011). Architectural practice to this day remains regionalised since around half of all Spanish architects are employed in Madrid and Barcelona (Rubio and Gómez 2011).

Recent data from the CSCAE reveals that in November 2011, there were 50,205 registered architects, 71 % male and 29% women. In terms of the gender divide, Spain

seems to reflect greater equality than other countries such as the UK or France with 14% and 22% of registered women respectively (Caven and Diop 2012). However, in Spain, women entered the profession later, and they concentrate, in a higher percentage than their male colleagues, in the professional categories of salaried, civil servants or teachers, clearly showing horizontal segregation (Agudo and Sanchez de Madariaga 2011).

Just before the start of the civil war in 1936, the first woman architect, Matilde Ucelay graduated in Madrid (Sánchez de Madariaga 2010). Together with many other republican architects, she was disqualified from practising and during the Franco regime women´s presence in any professional field was reduced. Following the transition to democracy in 1977-78 the number of women in architecture rose dramatically, representing now a critical mass of students of 57% - a fourfold increase from 1977 to 2007 (Sánchez de Madariaga 2010). The late entry of women to the profession in Spain may account for the higher numbers as Mirza and Nacey (2010: 2) identify that in countries "where the architectural population is young, a higher proportion are women" which is indeed confirmed by Sánchez de Madariaga (2010) who found that the majority of Spanish women architects are aged 25-35. In general, it is a relatively young profession, with an average age below 43 (Luque 2009).

As regards the mode of practicing, in 2007, 68% of registered architects worked as "profesional liberal" with their own practice, 22% were associates or salaried, 8% civil servants in the public sector and around 2% were devoted to teaching (Luque 2007).

A different perspective can be obtained by analyzing surveys of the recently created "Sindicato de Arquitectos de España- SArq" (Arquitects´ trade union) because it includes non registered architects among its 1,050 respondents (SArq 2011). The average gross annual salary of architects is 15,842 €, while for professionals working abroad is 24,564€ (SArq 2011: 5). Overall, salaries are poor with 18.2% earning between 6,600€ and 15,000€ per year; 17,6% between 15,000€ and 21,000€ and only 1.9% earn over 39,000€. Due to the present economic downturn, 63,1% confirm that their salaries have been reduced and 26.7% are unemployed. The SArq survey also acknowledges the existence of a widespread illegal practice among Spanish architectural practices: 24.4% of participants are currently working as "false self-employed" and 70.6% confirm having done so before (SArq 2011: 3). This is an illegal category of workers which conceals an employee-employer arrangement simulating a commercial exchange between business and customer. Under this category the architect is not hired but has to carry out all kind of tasks – including site control- with no social rights, unemployment benefits, and sick or maternity leaves, being also subject to employers in matters concerning paid holidays, working schedules, overtime, exclusivity and intellectual property rights (SArq 2011: 3).

Spain experienced a huge 'building boom' over the past decade (Naredo and Montiel 2011) and the rise of construction has been described as a "tumour" (Bielsa and Duarte 2010). This unprecedent growth had important positive consequences for architects' work, because since the passing of the Law 38/1999 of "Ordenación de la Edificación" (Town Planning and development Act), both the figure of the architect as Project Director and of the building engineer as Project Execution Director are needed for the correct execution of construction projects, making up a team called "Dirección Facultativa".

However, the economic environment in which architects work has changed a lot since 2008. European construction output fell back by an estimated 7% in 2009, and a further 8% in 2010 as a result of the continuing economic crisis right across Europe, Spain was one of the countries hit most severely (Mirza and Nacey 2010: 3).

METHOD

This work is part of a larger comparative study focussing on international comparisons with the work of architects in the UK and France. Our aim is to examine architecture as a "lived experience", and so we use the same qualitative methodology and tools as in previous publications (Caven and Diop 2012, Caven 2006). Using in-depth biographical interviews participants were allowed to discuss the issues most salient to them related to their professional careers. The interviews explored reasons for choosing the architectural profession, factors which have helped or hindered their careers as well as the realities of their working lives, analyzing pressures and satisfactions. The topics were designed to be flexible areas for discussion instead of question and answer type subjects. We tried to "inter-view" in order to construct knowledge in the "inter-action between the interviewer and the interviewee" (Kvale, 2007: 1). The interview guide did not include any specific questions related to gender equality.

In reference to the sampling strategy, 38 architects were selected via the membership list of the professional regulatory body (Colegio Oficial de Arquitectos) of two Spanish regions: la Comunidad Valenciana and Castilla la Mancha. Both regions show a mixture of contexts for architectural works from urban to rural and public and private sector projects. The principle of saturation was applied for determining the sample size.

Interviews were conducted face to face by two native speakers between February and April 2011. They varied in length between 30 and 120 minutes, the majority of them were conducted at the participants´ architectural practice, some at the researchers' offices, 3 at cafeterias and 1 at the interviewee´s home. All interviews were, with the permission of the participants, recorded and transcribed prior to analysis. Data was analysed following the conventions of content analysis (Kvale, 2007).

The sample consisted of 38 architects, of whom 20 were men and 18 women. Their ages ranged from 27 to 60: 4 respondents were under 30; 14 between 30 and 40; 9 between 41 and 50; and 11 were over 50. 34.2% were childless, while 23.7% had between 2 and 4 children, 34.2% had two children; and 7.9% had one child. In relation to their mode of practice, a wide range of occupations has been studied: full-time employees in local public sector authorities, full-time salaried professionals at construction companies, principals of partnerships, sole practitioners, "false self-employed" and university lecturers. One of the older men was retired, but he was included because of his wide experience in different professional fields. Reflecting the current Spanish economic situation, 4 women architects were unemployed when the interview took place.

In line with the profile of European architectural practices (Mirza and Nacey 2010: 44), the size of the 16 practices participating in this research is clearly skewed towards small firms: 4 are one person firms, 11 have between 2 and 5 architectural staff, which includes principals, partners and directors, associates, salaried architects and technical staff and one was a bigger practice with 14 staff. Other organizations represented in

this research are public and private Universities (Schools of Architecture), small and medium town Councils and construction companies.

FINDINGS AND DISCUSSION

Why to become an architect?

The majority of participants did not rationally plan a career in architecture nor did they have much direct interaction with practising architects with whom they could have learnt details about the profession. Of the 38 respondents, four have architects as parents which can give some insight into what is involved. Typically, the response to being asked why they chose architecture as a career was along the lines of "I did not know what it was, what it involved, where it led, where I would arrive, I knew nothing. That was all, it is as simple as that". (Male, age 50)

Only 6 of our participants report that architecture was all they had ever wanted to do from early childhood, whereas 35 cite being good at drawing and sciences (maths, physics) and 14 identify the mixture of technique and humanities offered by the study programme as the main reason for becoming architects. It was the expected contents of the university degree what attracted them to the profession, more than the architect´s work, which many of them ignored, not having family background or contacts in architecture.

In comparison with previous works, a new motive, showing the importance of the family institution in Spanish culture and society, is revealed in our research. Confirming that "Spaniards are collectivists when it comes to family, expressing pride and interdependence in their families" (Cabrera and Carretero 2005: 8), almost half of the participants argue that they have been influenced and pressured by their families in their career choice or that parents directed their interests. In fact, some would have preferred studying a different degree such as Fine Arts but it did not have enough prestige at the time and they were not allowed by their parents. On the contrary, another was forced to start Civil Engineering "due to my parents´ bad influence" and changed to Architecture the following year. Others point out that, with their choice, they tried to make their parents happy: "For my family, financing my studies meant a real effort. So I could not choose Fine Arts because they thought it had no future. I decided to study architecture as a form of respect towards them and I do not regret it". (Female, age 42)

Unsurprisingly then, most Spanish architects had little prior understanding of the nature and culture of the construction industry which was not made evident during their architectural training. All participants noted that their studies had not prepare them well for the realities of work in general, and for actual site-based work in particular (Sang *et al.* 2009b).

Career facilitators and barriers

When asked about factors helping their careers all architects point out the importance of their social capital, that is, their professional connections, people they knew that had helped them in getting clients. This is true not just for self-employed architects, but also for architects working in the civil service and even for those working at the University. This support the fact that recruitment methods in Spain are relatively informal, favouring personal contacts, unsolicited applications and internal advertising (Cabrera and Carretero 2005). In the light of our interviews, the strategy of "pulling strings" seems to be pervasive in the Spanish architectural labour market. Family members, friends, former clients, colleagues at work or even ex-teachers have been

facilitators for our participants: "My dad was a developer and I knew people from the construction sector. He introduced me to a quantity surveyor who was a family friend and he allowed me to meet people. That was my beginning and my facilitator. For some of my University colleagues who didn't have connections, the process was much longer. At the time I had 400 houses being built, they had only done the refurbishment of just one house". (Male, age 58)

The economic situation was highlighted either as driver or obstacle, depending on the direction of the economic cycle. Older participants clearly remember the various economic downturns they lived trough and their negative influence in their studios. One reflects:

"I have experienced the economic downturn of the 70's, the one of the 90's was also tough. In the 80's there were also some difficult years but we survived. During the economic crisis of the 90's there wasn't too much work, we had difficulties, but this is the worst, this is a financial one with structural consequences in construction and real estate markets. Nobody has escaped. We had lots of work every year and now there is no urban planning, no industries, no housing, nothing. We even have projects with building permissions that we have not been able to develop". (Male, age 59)

The most striking result among the evoked constraining career factors is related to the lack of gender equality in Spain. Although the interview guide did not include any specific question aiming at surveying opinions about gender diversity, expressions such as "being a woman" and "work-family balance" appear as negative aspects among women. Gender barriers existed both within the firms and in the wider working environment involving clients and construction site workers.

In the first place, at a micro level, we found examples of women complaining about male employers being discriminatory and paternalistic when supporting traditional gender roles at the studio. As a 35 year old interviewee explains: "Had I been a man, I´d have had access to certain parts of the job, it would have been easier for me to go on site, or to carry out projects with more autonomy. My bosses were the ones controlling the building site, my work had to do with the plans, and I stayed at the practice... because we (women) are supposed to be tidier and calmer". (Female, age 35)

Another woman also mentioned how male architects she had worked for preferred to hire women, since they thought "we are not as competitive, we complain less, are less ambitious, work harder and are more faithful". Workloads were always divided and while women ended up drawing the plans and projects, men were in charge of the social relationships with clients and of the site control. In agreement with Agudo and Sánchez de Madariaga (2011: 167), women architects "are pushed into the background, becoming invisible for the client, taking on the work inside the practice with little attention" and maintaining occupational segregation.

Secondly, at a broader level, several women reported not enjoying work on building sites. A 58 year old interviewee, recalls with bitterness her first experiences on site in the 80´s: "Women do have a handicap there, you would go on site and they would start whistling at you, and you are supposed to be the site director. I suddenly started disliking the site". Still, according to the words of a 27 year old participant, things on Spanish sites seem to remain unchanged nowadays, since construction workers do not take a woman seriously: "you are just a beautiful face for them and that is all". This Spanish result differs from the situation in the UK, where workmen are (in the main) prevented from whistling or calling out (Caven and Diop, 2011: 223).

Client organisations were also seen as problematic in perpetuating gender stereotypes. A 43 year old Spanish respondent was restricted to designing small projects because a developer "would not place his investment in the hands of a woman, especially if she is young, that was an obstacle I felt I could not overcome, I always had to resort to my male colleagues at the practice". Our interviewee here felt her career opportunities were being restricted as she was not being given an opportunity to prove herself.

Rewards and stress factors

Both Spanish men and women architects obtain intrinsic rewards as a result of creativity and by seeing something they had projected being built; from positive feedback coming from clients, colleagues or bosses, and from good relationships and the joy of working with others. These accord with English and French architects (Caven and Diop 2012) and there are no differences between men and women.

Sources of stress in the Spanish profession are the combination of heavy workloads, tight deadlines and long working hours (10 to 11 hours a day) which, in Spain, due to the long lunch break imply finishing work at 9 or 10 at night. The result is the impossibility of balancing work and family life, with negative consequences for career development: "my professional life was completely cut short, there were projects I could not carry out because I was not there the whole day". (Female, age 42)

Difficult working conditions are also evoked when participants recall having to frequently work over night and during the weekend and when referring to economic instability. This is specially the case for the self-employed and practice owners who, due to the present economic downturn, complain about not having a fixed salary every month and having to wonder "what is going to happen the following month": "When you count on stability you can evolve continuously in your life. You might buy a bigger apartment or you can plan your future. We can´t, we are always scared, how are we going to educate our children?". (Male, age 38)

The fact that Spain fits with the Continental model of professionalism mentioned earlier is confirmed by the pervasiveness and involvement of the State, influencing architects' work. Thus, political pressures appear as a negative aspect for those architects working in public authorities such as town councils. They acknowledge difficulties in relationships with politicians in the Civil Service: "The political colours of the Civil service make your career really difficult"; they mention having been pushed to change the direction of reports, and that it is just their signature what is needed. More clearly: "The majority of politicians' interests are spurious, and so they manipulate you, they try to use you, you are a qualified pen to do what they want, as long as it is legal". (Female, age 43).

Additional grievances are directed towards the plethora of rules and regulations relating to building form and performance, nationally materialized in the Spanish Technical Building Code (approved with Real Decree 314/2006, of March 17th) and different regional and local legislation. Likewise, their practices are increasingly legalized and under threat of litigation due to risk and responsibility matters. This is all seen as a bureaucratic burden generating additional work and many times, the scope for creative endeavour is very narrow.

Besides, they are demotivated because their aesthetic decisions are too influenced by the client and by the constructor, leaving them with little autonomy. It emerges then that "architects work in a state of heteronomy, having to defer to the client and their demands rather than working as autonomous artisans" (Faulconbridge 2009: 2543).

A loss of respect towards the profession and downgrading are also highlighted and with them, certain confusion with their professional identity is developed: "Socially I believe architects are losing a huge position in society and we are not aware of it as a group. Nowadays we are the least respected people, everybody seems to know about architecture, everybody has the right to give an opinion and even question you, the Civil Service is not helping, we are the silliest of the world". (Male, age 50)

CONCLUSIONS

Spanish architects, like architects everywhere, obtain intrinsic rewards from the creative aspects of their work. Stress factors are also common and relate to time pressures, long work hours and work-life balance. However, due to Spanish idiosyncratic working hours and a familialistic welfare regime, the incidence of work-family conflict might be greater than in other countries.

Taking into account that the Continental model of professionalism, which influenced Spain, was closely connected to the growth of the state and to state bureaucracies (Evetts 2008), government presence and strong influence can still be felt in many aspects. For example, pervasiveness of the Spanish State in architects' work routines emerges through political pressures. A further exploration of this particular issue might be of interest for the research community.

The importance of the family institution in Spanish society is revealed when participants point out having been influenced and pressured by their families in their career choice. Social capital and networks of influence, rather than personal merit, emerges as one of the main career drivers for Spanish architects, something which has not been acknowledged in previous research on the profession.

In relation to gender, despite there being more women registered in the professional body and studying architecture than in other countries, this 'critical mass' has not served to improve their situation, as they report high levels of discrimination and find it difficult to progress in their careers. The gap identified in the literature review, together with the results of this exploratory paper and comparison with works in the UK, clearly show the need for further specific analysis of the situation of Spanish women architects.

Due to the economic recession currently afflicting Spain, with strong impact on construction activity, the findings show a rather discouraging description of the situation for most architects: unemployment, widespread job insecurity and exploitation under the form of "false self-employed". They appear as relatively powerless victims against demands for regulation, increased bureaucracy, transparency and accountability. In addition, we reveal the lack of prestige and status associated with a profession which once had autonomy in the design process and nowadays has become a "heteronomous profession".

Spanish architects clearly face an uncertain future with an oversupply of professionals, the situation is not helped by the professional bodies' refusal to collate transparent statistics nor participate in European sector studies such as those commissioned by the Architects' Council of Europe. Without such support their situation is unlikely to improve.

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JOB SATISFACTION OF PROFESSIONALS WITHIN THE GHANAIAN CONSTRUCTION INDUSTRY

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Job satisfaction plays an important role in the overall productivity of any given industry. Despite its importance, little attention has been paid to white collared construction workers. This paper reports on a descriptive study that investigated the job satisfaction of construction based professionals within the Greater Accra Region in Ghana. Data was collected using a sample survey from 35 construction firms, 11 consulting firms, 2 client organisations, 3 management consultants and 5 construction management firms within the Ghanaian construction industry. Response data was subjected to descriptive statistics and subsequently ranking analysis were used to examine the relationship between age and job satisfaction. The results indicated that 'relationship with supervisor' and 'relationship with workmates as the highly ranked factors leading to positive worker satisfaction whereas 'quality of life' and 'personal health' were the least ranked. The factors leading to negative job satisfaction were 'lack of motivation' and 'job dissatisfaction'. On the other hand, 'lack of alertness' and 'lack of confidence' were deemed to have minimum effect. The research limitation of this study is that the survey population consists of construction professions drawn from Greater Accra Region only; as such the findings may not be representative of all construction professions. The originality and value of this study is that little is known about the job satisfaction of the white-collared workers or construction professionals within the context of the Ghanaian construction industry. Given that the success and productivity of the construction industry is linked to the workforce and general 'quality of life', identification of factors affecting job satisfaction can therefore be used by construction organisations in shaping their human resources practices for construction professions. Furthermore, the results of this study can help management in general on how to minimise the negative job effects arising from lack of job satisfaction

Keywords: construction professions; job satisfaction; Ghana

INTRODUCTION

The construction industry plays a critical role in the national economy. In additional to accounting for approximately 10% of the country's gross domestic product (GDP), and being oone of the largest employment providers in the developing world, according to Ahadzie (2009), the construction industry in Ghana contributes to the

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Yirenkyi-Fianko A. B. and Chileshe N. (2012) Job satisfaction of professionals within the Ghanaian construction industry *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 589-599.

economic socio-economic development by providing significant employment opportunities at both non-skilled and skilled levels. Despite the important role the industry plays in the nation, decent working conditions and resulting improved worker satisfaction are key to sustainable productivity in the industry. Cotton *et al.* (2005), states that the industry is also one of the least safe industries, with a high frequency of accidents resulting in financial losses, injuries, disabilities and deaths. It can thus be argued that the success (productivity) of the industry can be linked to the workforce and the general 'quality of life' and identification of job satisfaction.

The job satisfaction plays an important role in the overall productivity of any given industry. Given the growing concern within the Ghanaian construction industry about the aspect of the performance, quality of work, and workforce issues, little attention has been paid to younger workers especially those based on site. More so given the importance of the industry to the GDP, the 'quality-of-life' of all the workers is an important dimension for productivity. Job satisfaction is also an issue of importance for both the employer and employee. This is because many studies have shown that employers immensely benefit from satisfied employees because they are more productive. As observed by Uwakweh (2005), foremen occupy critical positions in construction operations as they are the link between management and the workforce.

The aim of this research is to investigate the job satisfaction of professional staff working within the construction industry. The specific objectives are to: (1) establish the level of job satisfaction that professionals working for constructional-related organisations have; and (2) evaluate whether the age of the workers influences their perceptions of the job satisfaction. This research focuses on the current perception of job satisfaction of constructional professions based within the Greater Accra Region in Ghana. The study does not include the site based or blue collared works such as bricklayers, electricians, joiners, plumbers, labourers or steel fixers.

The paper is structured as follows: The literature is reviewed to identify to provide background information on job satisfaction, and establish the gap in knowledge through the number of studies prevailing within the international and Ghanaian context. The research methodology adopted, and the theoretical conceptualized framework is discussed thereafter. The sample characteristics, survey results and discussions follow after the research methodology. In the end, the summary, conclusions, theoretical contributions, summary of the findings, practical limitations and implications for future studies are discussed.

LITERATURE REVIEW

General review of job satisfaction studies

A number of studies in developing and developed economies, on job satisfaction have been undertaken. These are summarised in Table 1. Despite the wealth of the selected studies on job satisfaction, little research has been undertaken within the African and construction industry specific context. In particular, only four Ghanaian specific studies were identified. These are as follows: Bennell (2004); Fugar and Salaam (2007); Obeng-Odoom and Ameyaw (2011). Of these studies, the existing literature on job satisfaction in Ghana is largely concentrated on the educational sector Bennell (2004), Bennell and Akyeampong (2007). No study to date has focussed solely on the job satisfaction of professionals (white collared) within the Ghanaian construction sector. Its worth noting that a study by Obeng-Odoom and Ameyaw (2011), while, undertaken among the surveying professions, its aim was focused on the process of

becoming a surveyor in Ghana. According to Wan and Leightley (2006), job satisfaction directly influences an organisation's competitive advantage. This implies that every organisation that wants to excel, must ensure that they put in the right measures to ensure employee satisfaction.

Table 1. Summary of selected studies on job satisfaction

No	Focus of study	Authors
1	Exploring the relationship between job satisfaction and demographic factors	Abdulla *et al.* (2011); Bowen and Cattell (2008); Chileshe and Haupt (2010); Clark *et al.* (1996); Okpara, (2004); and Oshagbemi (2000a)
2	Impact of mentoring on employees' job satisfaction	Ameyaw (2011); Lo and Ramayah (2011); Obeng-Odoom and Ameyaw (2011)
3	Specific studies on construction workers and job satisfaction	Ogunlana and Chang (1998); Fugar and Salaam, (2007); Chileshe and Haupt (2010); Huang and Lu, (2011),
4	Motivational levels of professionals	Bowen and Cattell (2008); Onukwube (2012); Oyedele, (2010)
5	Effect of foremen on construction apprentice	Uwakweh (2005)
6	Specific linkages between practices such as human resources (HR), total quality management (TQM) and job satisfaction	Groot and van den Brink (1999); Grund and Sliwka (2005); Lim and Bing (2012); Ooi *et al.* (2007).

Kim (2001) also noted that employees' satisfaction with their jobs may have strong implications for improving the quality of work produced. A study by Ooi *et al.* (2007) aimed at exploring the linkages between TQM practices and job satisfaction revealed that teamwork, organizational trust, organizational culture and customer focus are positively associated with employees' job satisfaction. Lim and Bing (2012) found that organisations Human Resource (HR) practices such as career opportunities, nature of their jobs and overall working environment to significantly influence the job satisfaction of professionals. Earlier studies such as Groot and van den Brink, (1999) which aimed at analysing the relationship between allocation, wages and job satisfaction established that satisfaction with the job content as the main factor explaining overall job satisfaction. Job satisfaction is an issue of importance to the construction industry where construction processes involve various kinds of people with various ideas, experience and skills with different interests (Dey and Ogunlana, 2004).

Job satisfaction studies within the African context

The construction industry can justifiably claim to be one of the most important industries that play a vital role in maintaining the infrastructure which underpins our current civilisation (O'Reilly, 1993). Unfortunately, not much attention is given to construction site workers (Abdullah *et al.* 2011), although the success of projects that lead to national development depends on them to a large extent. The construction workers in Nigeria as stated by Abdullah *et al.* (2011), in a survey, ranked satisfaction with co-workers as the highest job satisfaction factor, and the pay package as the lowest. Personal characteristics such as age, gender, income, education and experience have been found to be strong predictors of job satisfaction (Okpara, 2004; Onukwube, 2012). However, the study by Okpara (2004) although conducted within an African context, and Nigeria to be more specific, was based on a sample of managers drawn

from the information technology (IT) sector. The differences between the working environment of IT and the specific labour intensive nature of the site-based construction work requires separate studies to ascertain the factors and effects of job satisfaction.

Job satisfaction studies within the Ghanaian context

In Ghana, not much research has been done on Job satisfaction in the construction industry. A study by Fugar and Salaam (2007) aimed at investigating the job satisfaction of construction workers on construction sites on the Kwame Nkrumah University of Science and Technology (KNUST) campus in Kumasi; found that they [workers] were neither satisfied nor dissatisfied when all aspects of the job were considered. They observed the same neutral result when the intrinsic satisfaction of workers was assessed. However, their results indicated a slight positive feeling on the extrinsic satisfaction of the construction workers on the KNUST site. These results although very useful cannot be generalised because all the projects considered were from one source and in one location, KNUST. A lot of construction firms are not based in Kumasi unlike Accra where most of the construction firms are based and major construction works take place.

RESEARCH METHODOLOGY

To investigate the impact of job satisfaction among the professionals within the Ghanaian construction sector, the following research methodology was employed in the study.

Research Conceptual Framework

Job satisfaction as defined by Wan and Leightley (2006) is how much employees like or dislike their work and the extent to which their expectation concerning work has been fulfilled. According to Kim (2001), job satisfaction is an emotional reaction to an employees work situation. Understanding job satisfaction is therefore critical to every organisation's success and this continuous to be a major topic of research interest. Figure 1 illustrates the relationship between the independent variables and dependent variables.

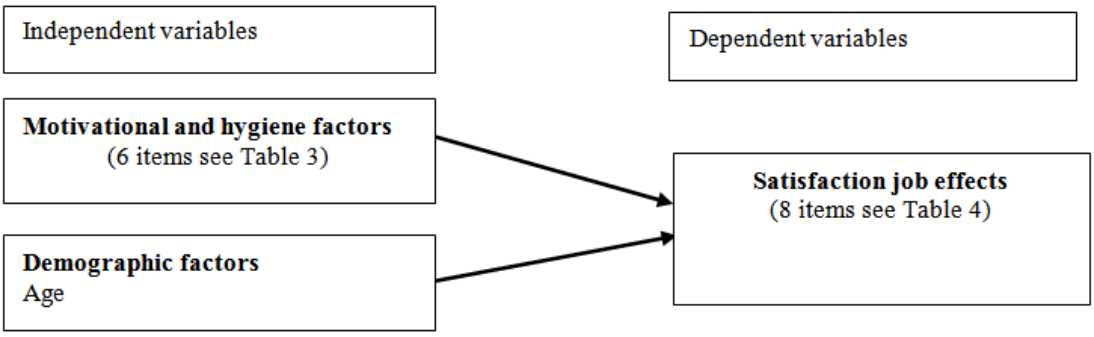

Figure 1. Research Model

Measurement Instrument

The data collection instrument used was a self-administered structured questionnaire. A pilot survey as advocated to be necessary by (Gill and Johnson, 2010) was made by administering the questionnaire to construction professionals in Ghana. Based on the feedback, the necessary corrections were made. The data collection instrument as used

in Chileshe and Haupt (2010) is grounded in Herzberg's *et al.* (1959) work of two factor theory.

The questionnaire was divided into three main parts, as follows: demographics, job satisfaction survey and job effects. The first part which is the demographics, sought information pertaining to age, type of work, years of service in construction and current employment position whereas the second part was the job satisfaction survey which was designed to measure job satisfaction of construction workers. Each item in the job satisfaction instrument was measured on five-point Likert-type scale that varied from a range of (1) representing very poor satisfaction to (5) representing very excellent satisfaction. Thus, (3) on the scale of measure represented indifference, i.e. neither poor nor excellent. Oshagbemi (2000a) used the same approach in his study which sought to investigate the impact of length of service on job satisfaction. It comprised six items, namely: (1) personal health; (2) quality of life; (3) personal development; (4) relationship with workmates; (5) relationship with supervisor; and (6) satisfaction with occupation.

The third part of the questionnaire sought to measure the effects of job satisfaction. Each item in the job satisfaction effects instrument was measured from a range of (1) representing minimum (never) to (5) maximum (all the time). It comprised eight items, namely: (1) poor recognition of abilities; (2) job dissatisfaction; (3) indifference; (4) lack of alertness; (5) lack of motivation; (6) dejection; (7) lack of confidence; and (8) poor self-image. Usage of likert-type scales is highly recommended. According to Hartley and MacLean (2006), these scales offer an efficient method for capturing a wide range of variance in self-reported attitudes and behaviours (as is the case in this study).

Data Analysis

This paper seeks to investigate job satisfaction of construction based professionals within the Greater Accra Region in Ghana and to identify the variables affecting the relative aspects of work in the Ghanaian construction industry. The method of data analysis adopted for this research was as used in Chileshe and Haupt (2010). While the Chileshe and Haupt (2010) adopted the analysis of variance (ANOVA), and separate independent t-test, in additional to descriptive statistics, as the focus was to ascertain the impact of age on the job satisfaction, this study only used the descriptive statistics which included the standard deviation, frequency and mean ranking analysis because of the limitations of the sample size, as no statistical conclusions could be drawn based on the age as out of 56; only 15 respondents indicated their age as greater than 40. Uwakweh (2006) used a similar approach in arriving at a decision not to use gender-based analyses in the examination of the motivational climate of construction apprentice. The *Statistical Package for Social Sciences* (SPSS) computer program was also used to analyse the data generated by the research questions.

The overall reliability of the process factors, namely the job satisfaction factors comprising the six items as measured by the coefficient cronbach alpha was 0.807, and the eight items representing the effects of negative job satisfaction had the value of cronbach alpha coefficient of 0.890. Both values exceed the acceptable threshold of 0.7 as suggested by Nunnally (1978), thus indicating the high internal consistency of the questionnaires.

CHARATERISTICS OF SAMPLE

100 questionnaires were sent to white collared (professionals) construction workers in the Greater Accra Region. A total of 56 respondents completed and returned the

questionnaires with response rate of 56 per cent. The response rate was therefore deemed adequate for the purpose of data analysis. Akintoye and Fitzgerald (2000 cited in Odeyinka *et al.* 2008) argue that this is way above the norm of 20-30 percent response rate in most postal questionnaire of the construction industry.

The respondents comprise 12 (21.4 per cent) were quantity surveyors, 6 (10.7 per cent) were engineers, 5 (8.9 per cent) were project managers, 4(7.1 per cent) were architects, 2 (3.6 per cent) were managing directors, 4(7.1 per cent) were Site managers, 5 (8.9 per cent) were clerk of works and the remainder, 18 (32.2 per cent) fell into the 'others' category comprising various professionals. Structured questionnaires were distributed through purposive sampling. According to Kelly *et al.* (2003), such an approach or technique of purposive sampling is normally appropriate when a specific population is identified, and only its members are included in the survey. This is applicable in this study as the study was confined to specific construction professionals working for organisations within the Greater Accra, Ghana.

Some data relative to the experience and tenure of the respondents was also sought. Experience, being defined as the length of service in the construction industry (number of years) and tenure as the period of time spent in present employment. Relative to the experience, the majority 18(32.1%) of the respondents had worked for less than 5 years; 17(30.4%) worked for more than 5, but less than 10 years; followed by 11-15 years (16.1%, n = 9); 16-20 years (8.9%, n = 5); and only a minority 2 (3.6%) and 5(8.9%) fell into the 21-25 years and more than 25 years category respectively. In relation to the length of service in present employment (tenure), the majority 28(50.0%) of the respondents had worked for less than 5 years; 14(25.0%) worked for more than 5, but less than 10 years; followed by 11-15 years (10.7%, n = 6); 16-20 years (8.9%, n = 5); and only a minority 3 (5.4%), more than 25 years category respectively. The importance of ascertaining the construction experience, tenure and professional background of the respondents was to ascertain whether these demograghical variables had an impact on the overall job satisfaction.

Profile of respondents by age

Table 2 provides the breakdown of respondents according to the age

Table 2. Breakdown of respondents by age

Age	Frequency	Percentage
Less than 40 years	41	73.2
> 40 years	15	26.8
Total	56	100.0

Sector of respondents

Relative to the sector of the industry, the majority 35(62.5%) of the respondents were drawn from contracting firms, followed by 11(19.6%) consulting organisations, 5(8.9%) construction management and 3(5.4%) management consultants. Only a minority 2(3.6%) were from client organisations.

SURVEY RESULTS AND DISCUSSION

Image of age on job satisfaction

In Table 3, means and standard deviations of the six job satisfaction items are also presented for the full sample, older and younger constructional professions. As can be seen from Table 3, the older construction professionals were slightly satisfied with their jobs (mean score = 4.044) when compared with their younger counterparts (mean score = 3.850). The older workers ranked 'relationship with workmate's as the most important job satisfaction factor (mean score = 4.267). The younger construction professionals rated 'relationship with supervisor' as being the most important (mean score = 4.325). This finding is hardly surprising, and it also confirms Uwakweh's (2005) observation, albeit from the blue-collared perspective, that foremen occupied critical positions in construction operations as they were the links between management and workforce (Uwakweh, 2005 pg. 1320). Similarly, a study by Abdullah *et al.* (2011) on the construction workers within the Nigerian context ranked satisfaction with co-workers as the highest job satisfaction factor.

Table 3 Descriptive statistics (mean, standard deviation) for items on the job satisfaction factors, for the full sample, and by age.

Job satisfaction factors	Total sample *n* =56	Older workers (> 40 years old) *n* =15			Younger workers (< 40 years old) *n* =41		
	Mean[1]	Mean[1]	Standard deviation	Rank	Mean[1]	Standard deviation	Rank
MF_1 = Personal development	3.786	3.933	1.163	4	3.732	1.073	4
MF_2 = Personal health	3.393	3.933	1.099	5	3.195	1.166	6
HF_1 = Relationship with workmates	4.232	4.267	.704	1	4.220	.652	2
HF_2 = Relationship with supervisor	4.273	4.133	.834	3	4.325	.525	1
HF_3 = Satisfaction with occupation	4.109	4.267	.799	2	4.050	.783	3
MF_3= Quality of life	3.618	3.733	1.099	6	3.575	1.129	5
Overall job satisfaction score	**3.901**	**4.044**			**3.850**		

Notes: MF = motivational factor; HF = hygiene factor; [1]Mean score based on Likert scale where 1 = very poor and 5 = very excellent satisfaction

Interestingly, this finding contradicts the earlier studies of Hinzelman and Smallwood (2004) which ranked personal development and quality of life as the two most important job satisfaction factors. The low ranking of 'personal development' by both younger and older professional workers confirms the findings of a study by Obeng-Odoom and Ameyaw, (2011) among the surveying professions. In the main, the study revealed that while professional surveying training in Ghana was effective, nevertheless, it was still narrow. Although senior surveyors were found to provide mentoring to probationers, they still engaged in poor labour practices; and probationers did obtain professional training. The low ranking of 'quality of life' (mean score = 3.733, rank = 6th) can be explained in Dey and Ogunlana's (2004) which linked the uniqueness and complexness of projects, and open environment as contributory factors in controlling the working environment/conditions for the construction workers both on site and in the office.

Effects of job satisfaction
The mean scores and their standard deviations, and rankings of the eight job satisfaction effects are reported in Table 4.

Table 4. Descriptive statistics (mean, standard deviation) for items on the job satisfaction effects items, for the full sample, and by age.

Job satisfaction effects	Total sample[2] (*n*=55)		Older workers (> 40 years old) *n* =15			Younger workers (< 40 year old) *n* = 41		
	Mean[1]	Rank	Mean[1]	Standard deviation	Rank	Mean[1]	Standard deviation	Rank
Poor self-image	1.696	6	1.707	0.980	5	1.667	1.047	5
Lack of confidence	1.625	7	1.585	0.921	8	1.733	0.884	4
Indifference	1.709	5	1.675	0.971	6	1.800	0.862	2
Lack of motivation	2.125	1	2.146	1.424	1	2.667	1.280	1
Job dissatisfaction	1.893	2	2.000	1.072	2	1.600	0.986	7
Lack of alertness	1.518	8	1.585	0.805	7	1.333	0.617	8
Dejection	1.768	3	1.756	1.067	3	1.800	0.862	2
Poor recognition of abilities	1.732	4	1.756	1.241	4	1.667	1.113	6

Notes[1]: Mean score based Likert scale where 1 = minimum (never) and 5 = maximum (all the time); [2]: List wise number of respondents

As can be seen from table 4, the younger and older workers ranked 'lack of motivation' as the most important job satisfaction effects. The sample applies to 'poor self-image' ranked 5th both groups. Interestingly, the two groups had different views on the ranking of 'indifference' with the younger workers mostly affected by that (mean score = 1.800, rank = 2nd), whereas the older construction professionals were slightly satisfied with their jobs when compared with their younger counterparts. When compared to the studies conducted among the construction sited based workers in South Africa (Chileshe and Haupt, 2010), "poor recognition of abilities" (mean score = 2.912) and "lack of alertness" (mean score = 2.615) were ranked as having the most negative impact by the younger and older workers respectively.

LIMITATIONS

Some limitations of the research need to be acknowledged. The sample size is relatively small (56), comparable to other studies that have looked at worker satisfaction levels within the construction industry (Hinzelman and Smallwood, 2004; Chileshe and Haupt, 2010). The second limitation relates to geographical location of the respondents. These were drawn from a random sample of construction professional based within organisation in the Greater Accra Region, therefore, this study cannot be generalised statistically for the whole of Ghana as it was constrained geographically.

CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

The purpose of this research is to investigate job satisfaction of white collared (professions) construction workers within the Greater Accra Region in Ghana and to identify the variables affecting the relative aspects of work in the Ghanaian construction industry. This research also explored the impact of the job satisfaction on the eight attributes of job effects. Results suggest that based on the overall sample, workers ranked the 'quality of life' and 'personal health' as being poor and 'relationship with supervisor' and 'co-workers' as being excellent. 'Lack of motivation', and 'Job dissatisfaction were reported to be the negative effects of Job satisfaction. This paper contributes immensely to the knowledge pool of existing literature and it provides insight on the measurement of job satisfaction within the Ghanaian construction sector, an area previously under-researched. Management, managers, professionals, policy makers and academics will find this study useful, as it enriches literature on job satisfaction in the African context, developing economies as well as in the construction industry.

This study contributes to this knowledge gap. The literature review established that, while a lot of research has been carried out in the area of worker and job satisfaction in various industries especially in the developed economies context, unlike the African and developing economies, not many studies have been done on job satisfaction especially in the construction industry. This study should be extended, with a larger sample size to include the effects of the different professions on job satisfaction; secondly the site-based blue collared workers could be included in the sample as well.

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HOW IS JOB SATISFACTION IN SPANISH BUILDING ENGINEERS INFLUENCED BY TRAINING?

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In business environments, training is one of the most important issues for human resource management. Through appropriate training, enterprises can rely on competent and motivated employees, ready to meet technological and strategic requirements. The aim of this study is to investigate training activities for building engineers developed by Spanish construction companies. But it also aims at analysing the effect of training on job satisfaction. A qualitative methodology has been applied, by means of semi-structured interviews to 34 building engineers. ATLAS-ti software has been used for the analysis of the interview contents. Findings reveal that, with the exception of a large company, no planned training has been developed in order to satisfy building engineers' needs. If any, there is initial training for management systems, as well compulsory training on risk prevention. Additionally, most engineers follow their own training courses, in order to update knowledge or improve promotion opportunities. Finally, the effect of training on job satisfaction tends to be positive, with increasing effects when it improves work post performance.

Keywords: human resource management, job satisfaction, qualitative research, training.

INTRODUCTION

Specialized literature reveals that human resources represent the most important and variable factor of the production process, besides being a vital and strategic element for any organization whose target is to improve its productivity and competitiveness (Kazaz and Ulubeyli 2007). Thus, the implementation of policies and practices related to human resources, such as those regarding selection, recruitment procedures, training, incentives and assessment, is closely related to the overall performance of the company, which implies that human resources become a beneficial source of competitiveness (Osman *et al.* 2011).

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Fuentes-del-Burgo J. and Navarro-Astor E. (2012) How is job satisfaction in Spanish building engineers influenced by training? *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 601-610.

Different researches consider training one of the most important issues in the field of human resources (Loosemore *et al.* 2003, Porret 2007). This is so because training is an essential factor whenever availability and suitability of skilled workers, able to adapt themselves to the technological and strategic needs of the company, are required (Porret 2007). On the other hand, training is also essential to ensure that employees get the appropriate skills to carry out their work successfully (Loosemore *et al.* 2003, Osman *et al.* 2011). Companies involved in effective training programmes are better equipped to recruit workers more satisfied with their job and, consequently, more committed to the company. Moreover, while satisfied workers are generally willing to accept the objectives and values of the organization (Schmidt 2007), lack of training or training that does not fulfil workers' expectations and needs will generate negative attitudes (Schmidt 2009).

Until now, the study of training actions has mainly focused on large organizations. Some researches highlight the fact that small companies seldom offer training or opportunities for the development of their human resources (Petrescu and Simmons 2008, Wang *et al.* 2010), or that the quality of training is better in large companies than in small ones (Georgellis and Lange 2007). It is generally believed that small companies lack either the time or the financial resources to develop their human resources, although there are studies that show just the opposite (Rowden 2002).

What calls our attention is that most studies on human resources training have focused their research on large companies, despite the fact that the economic driving force in many countries is generated by small and medium companies (Pajo *et al.* 2010), which in the past decade were also the main source of employment in the world (Wang *et al.* 2010). Furthermore, research on this topic has been very limited or nonexistent for the Spanish construction industry.

In the Spanish context, at an institutional level, although social agents have made efforts to design policies promoting training, Spain features lower levels of investment in training than most European countries (Cabrero and Carretero 2005). On the other hand, at an organizational level, firms tend to select HRM practices, including training, on a pick-and-choose basis. This implies that most training has been carried out in an informal fashion, has tended to be reactive, focusing on short-term results and with little systematic assessment of training needs. This Spanish preference for management improvisation is due to "a low future orientation, and to the combination of high power distance and low institutional collectivism" (Cabrero and Carretero 2005, p. 11).

In a more recent bibliographic review on human resources management in Spain, Rodríguez and Martínez (2010) also found that training culture was scarcely developed. Investments on training were selective and limited, and generally geared towards the training of senior management teams. As for several decades labour costs had been the main competitive advantage of the country, most companies paid little or no attention at all to the development of their human resources.

In the light of the continuous technological advances the construction industry is undergoing, professionals in construction companies are being forced to constantly update their practices, because, sooner or later, failure to modernize would lead to obsolescence. Another aspect to be remarked is the change in legislative rules and regulations concerning the project, the design and the construction itself, for in its turn, this change implies modifications in the way gauging, building, and control of construction works is carried out. In Spain, a clear example of this was the

enforcement of the Technical Building Code, in 2006, which brought along a whole legislative change for each building unit: structures, enclosure elements, installations, etc.

In order to fill a research gap, the aim of this study is to explore training strategies developed by small and medium construction companies for building engineers, as well as the effect of this training on job satisfaction. The study has been carried out in the Castilla- La Mancha Autonomous Community, using a qualitative methodology. Following the definition from the European Commission (Commission of the European Communities 2003), construction companies within the geographical context of our research can be classified as SMEs. In the year 2008, 1,564 companies employed less than 10 workers; 1,651 less than 50, and 145 employed less than 500 ("Instituto Nacional de Estadística" 2012, National Institute of Statistics). This means that our results are mainly focused on construction SMEs.

VARIABLES OF STUDY

Job satisfaction

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 (Bravo *et al.* 2002, Navarro *et al.* 2010). Here we will use the definition provided by Spector (1997, p.2), according to which job satisfaction is how people feel at work, including a variety of aspects related to it. It can be understood as an extension of what people like (satisfaction) or dislike (dissatisfaction) about their job. Job satisfaction can be approached either as a general and global feeling about work in general, or as a group of attitudes related to different and specific labour issues.

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 or concepts (Schmidt 2007), in this research only training activities developed by construction companies will be considered.

Training

Employees' training can be understood as a process aiming at learning, improving and developing knowledge, attitudes and skills. In this way, either job performance can be improved (Akhavam Tabassi and Abu Bakar 2009, Loosemore *et al.* 2003, Schmidt 2007), or attitudes and social behaviours in disagreement with the company's objectives and the job's requirements modified (Schmidt 2007).

According to Loosemore *et al.* (2003), the main objective in training is a permanent change in the behaviour of employees, in order to achieve improvements that meet the company's needs. Furthermore, Owoyemi *et al.* (2011) found out that several authors defined training as the company's ability to develop the necessary skills and knowledge that would enable workers to perform present and future tasks. In this sense, the training process requires a planned, systematic and cyclic programme of actions that allows the identification and successful solving of the training needs, not only of the individual but of the enterprise itself (Porret 2007, Raiden *et al.* 2009).

Various studies and surveys show that training and opportunities for learning new things are influential factors on job satisfaction (Schmidt 2007, Slattery *et al.* 2006). Rose (2005) and Petrescu and Simmons (2008) have confirmed this positive relationship for British employees. Different workers such as shop floor employees in

the automotive industries in Malaysia (Dawal *et al.* 2009) or women in the USA construction trades (Dabke *et al.* 2008) have also shown the positive influence. In Spain, the same result has also been found for construction professionals (Navarro-Astor *et al.* 2010), but the sample in this case included architects as well as building engineers, and companies participating in the research were not just SMEs.

RESEARCH APPROACH

With the help of the "Colegio Oficial de Aparejadores, Arquitectos Técnicos e Ingenieros de la Edificación" (Building engineers´ professional body) in the city of Cuenca, a request for participation in the study, including the objective of the research, was sent via e-mail. It was addressed to licensed building engineers working as site managers in construction companies. Only four of them answered directly that first e-mail; the rest of the interviews had to be arranged by asking these first four participants, or even our own colleagues, the telephone numbers of engineers they knew working as construction site managers. In this way, we applied the snow-ball technique until a 34 individuals sample was reached. Participation of professionals was facilitated by arranging interviews according to personal time-place convenience. Interviews, with an average duration of 60 minutes, were carried out in the following places: researchers' office in the Polytechnic School (38%), offices/building site huts in place of work (38%), and cafeterias (24%). The provinces where participants were working at the time were Cuenca (53%), Albacete (26%), Ciudad Real (12%), Toledo (6%), and Guadalajara (3%). For identification throughout transcriptions, participants are assigned a number.

The sample consisted of 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. In relation to family status, 65% were married, 3% had a partner, and the 32% of the rest were single. 27% of the married participants had no children, while 46% had two children, and 27% just one. All of them had a degree in Building Engineering. 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. In relation to company size, 10% of participants worked at micro companies (less than 10 workers), 39% at small (less than 50 workers), 41% were medium (less than 251 workers) and for the remaining 10%, the number of workers ranged between 250 and 1,000.

Interviews were recorded for later transcription, on which the final document writing would be based. For the analysis of this document the ATLAS-ti software programme was used. This allowed identification of citations and codes through which information could be found and compared. The analysis of answers has let us identify common patterns, but we have also tried to provide descriptive information of how questions were perceived by each participant (Fellows and Liu 2008). Since we followed Glaser's methodology, no preconceived assumptions were established at the beginning of the research. Thus, inductive analysis was applied to the survey contents (Hunter and Kelly 2008).

The exploratory analysis derived from this methodology allowed the finding of regularities, which in turn allowed 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 theoretical model (Charmaz 2006).

RESULTS

Company training provision

Few building engineers report complete lack of training while at work. Two of them belong to micro companies, another two to small companies, and one of them to an enterprise with more than 250 workers. This situation was due to the size of the company, the low volume of work carried out, or to the long distance between place of work and town where training took place, which prevented course attendance.

The common pattern for the rest of responses is that neither planning nor uniformity matter. In medium-size companies (50 to 250 employees), there are cases where initial training is offered on the use of organization management system software, especially if it is available within the company. Some compulsory courses on labour risk prevention may be also offered. This supports those highlighting that organizations in construction restrict their training to mandatory requirements which have been imposed upon the employer by legislation (Loosemore *et al.* 2003).

Only one larger company, employing more than 250 people, has been reported as offering a comprehensive training programme. They provide technical, management, planning, computing courses and the like. At the beginning of the year the company advertises different courses that can be selected according to personal needs.

The policy in some organizations between 10 and 50 workers was to offer payment for attendance to courses in which building engineers were interested: "We are free to say: 'listen, I'm taking this course', because the company has paid us lots of courses, …You would say: 'listen, look, there is a course on this and that"; and the boss just said: 'don't worry, register, and we'll pay". (Nº 15)

There is a shortage of training actions in micro companies, in which training, if any, seems to be mainly oriented to site management or management software used by the company. Training carried out in these companies is clearly less than in the rest. None of them pay or subsidize training carried out by building engineers at their own expenses.

Courses defined by Loosemore *et al.* (2003) as off-the-job courses, are the most common. They cover areas ranging from management software and quality control to installations, construction, environmental management or specific software such as PRESTO or Microsoft Project, with a predominance of choice for technical and technological subjects rather than for management. Nevertheless, courses on labour risk prevention are at the top of all training programmes, since companies are obliged by legislation to provide a minimum specific training on the matter (Dirección General de Trabajo 2007). This fact accords with research that shows how institutions and regulation may in fact underpin improvements in employment and working conditions (Hannon 2010).

Some participants reported their opportunity to attend courses organized by "Fundación Laboral de la Construcción" (Construction Labour Foundation). According to the IV General Collective Agreement of the Construction Industry, 0,25% of the company's wage bill must serve to allocate funds for this foundation. The purpose of this foundation is to guarantee the provision of services to both workers and companies covered by the Collective Agreement (Dirección General de Trabajo 2007). The disadvantage of this option is that the employee has to pay attention to the courses offered by the Labour Foundation, in order to apply through the company. But companies seldom inform their workers about such training.

"That, all those from the Labour Foundation are paid by the company, but also because they have some money for training, which is taken away from the workers' wages. So it is the company who has and coordinates training…because they can't say no, because the training is there, but that's the problem, that if you don't do anything neither does the company". (Nº 25)

With the exception of large companies, which usually offer training both on management systems and labour risk prevention, the common characteristic of construction enterprises is precisely their lack of planned training, with respect to both contents and objectives. Training seems to be left to the discretion of the building engineer, according to his own interests or the courses on offer.

Training on building engineers' account

Showing building engineers' interest and motivation to learn , more than half of the participants followed training courses on their own account. These courses ranged from short courses on technical specialization, organized by the professional bodies, to Master courses. Most of them dealt with health, safety and labour risk prevention. Seven interviewees were also following a university degree.

A strong personal drive was always behind training on their own account, that is, a desire to be updated, to increase abilities and competences, but also a desire to improve new job opportunities, should companies sacked them. In any case, what they all wanted was to broaden their employability capacities (Navarro-Astor and Fuentes-del-Burgo 2011).

A few participants (around 9%) reported training opened to them the opportunity to find a better job, because they were not happy working as site managers: "If you want promotion, to leave the building site cesspit, apart from a degree, you need something else" (Nº 10).

Factors hindering training

Three types of barriers to training have been identified by building engineers. They are not mutually exclusive and may come up together.

On the one hand, there are factors related to working conditions, such as continuous overwork and distance between place of work and residence. This implies lack of time for proper training.

On the other hand, there exist specific obstacles related to the companies themselves, such as size, lack of training investment and training actions, but also narrow-minded employers. In relation to the latter, participant Nº 14 reported: "but somehow my company´s policy is: "I´m not going to offer you any training, because once you´ve got it you´ll leave". Other examples show that employers believe time devoted to training is unproductive: "it´s hard to release people from a project, even if it implies leaving just half an hour earlier… even though the person is making an effort to participate in training. Training is hard" (Nº 17).

Finally, building engineers' human personal factors are also highlighted. We can mention, for example, those concerning "work-life-training" balance, since participants have to leave out their family life and personal interests in order to participate in training activities.

Influence on job satisfaction

No uniform response has been provided with respect to the effect of training on job satisfaction. 18% of the participants reported personal individual training had improved their job satisfaction. The same opinion was shared by 26% with respect to training provided by the company. Finally, 6% declared feeling personal satisfaction with the knowledge acquired through training actions.

Due to lack of training offered by their employers, building engineers upholding the view that training could be beneficial for the companies, acknowledged feeling uneasy and a lack of understanding: "I believe they should offer some training, it´s also good for companies to have trained people" (Nº 28). The following fragment also illustrates this fact: "it is in their own interest, training workers has a positive impact in the company, …, it would be really satisfying that the company would train us or would give us some extra money for training" (Nº 22).

On the other hand, 18% recalled that their favourite training was training that could be applied to their job, a result supported by other researchers (Osman *et al.* 2011, Rowden 2002). This refers to the nature of the training and whether it involves the provision of underpinning knowledge that enables workers to better understand the nature of activities they undertake and provides them with a platform from which they can go on to exercise higher-level skills (Hannon 2010) . Our participants enjoyed the possibility of being able to solve new problems or communicating with other professionals involved in project execution, being aware of what people talk about when facing different work site units: "You do like to be trained on aspects that you are required to develop at work afterwards" (Nº 24).

In this sense, their assertions reinforce the principle that training should be carried out in order to increase the skills needed by the employees while at work (Raiden *et al.* 2009).

Finally, other reasons for participating in training are the need for knowledge updating or getting ready for professional promotion, but also because of the very joy training experiences can bring: "I like to be trained, I´d like to participate in training a lot more, the more training the better" (Nº 2).

CONCLUSIONS

Despite the limited size of the sample and qualitative approach applied to the research, it can be assumed that training in small and medium-sized Spanish construction companies is not a general practice. By 'general' we mean both the level and sense assumed by human resource management literature. In most cases, if any, there is initial training for building engineers involved in management systems within the companies.

Training programmes in Spanish construction SMEs are not sufficient or well planned. This may be due to a lack of formal human resource departments. With few exceptions, training provision is limited to compulsory training on risk prevention, as required by law, or to training offered by the professional body and similar entities. In any case, programmes like this can hardly meet either the present or future needs of enterprises. This situation, along with investment constraints, does prevent training from properly fulfilling its function.

In general, training is left, at best, to the choice of the building engineer. Companies do not provide any specification of needs. By doing this they fail to meet the

psychological expectations of employees and stand to lose their most able and ambitious personnel to their competitors in an increasingly competitive marketplace for good people.

It has also been found that most participants use their own resources to continue training through Master and technical courses. They continually look for knowledge updating and improvement of skills related to their work post. But training also increases opportunities for promotion or change of job. When companies offer inadequate training or it is non-existent, building engineers are forced to make up for it at their own expenses enrolling in available courses around their working area or in internet courses.

Finally, more than half of building engineers state that training affects positively job satisfaction. Like in other studies, it can be confirmed that both training provided by enterprises or specific courses taken individually do always affect positively job satisfaction.

What has been stated above, or even other factors more closely related to building engineers themselves (personality, employability, updating of knowledge, professional training and development), may explain why the majority of participants take responsibility for their own learning.

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THE SOCIALISATION OF OUTSOURCED EMPLOYEES IN FACILITIES MANAGEMENT: A RESEARCH AGENDA

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There have been several attempts made to understand organisational socialisation in the wider construction industry, but there is a paucity of related research in the FM field. Little research has established the degree of congruence between outsourced employees and the FM companies they work for, and the part they play in the delivery of organisational goals and objectives. Today's outsourced employees are not always aware of the important role they play in service delivery and are not typically socialised by either the service provide or the client organisation. Socialisation can help them make this connection. This will increase the opportunities of service providers and clients to maximise the productivity of the employee in achieving their major aim as a company – customer satisfaction. There is an exploration of the concept: 'FM cultural fit' which is the ability of outsourced employees to integrate into the organisational culture of the client organisation. 'FM cultural fit' is important to ensure that outsourced employees are able to understand the client organisation and deliver on their company goals in addition to fulfilling the terms of their contract. It is a concept based on the application of organisational culture and socialisation theory to FM. This agenda details the important factors and forms the basis of a larger research project, so the methodology only shows the expected process before data is collected. The agenda establishes the dynamics that exist between the four interwoven players (service provider, the client, the employee and the customer) and how these relationships affect/effect efficient service delivery and customer satisfaction. It also shows the importance of an organisational socialisation process for contracted staff to enable them deliver at maximum capability.

Keywords: customer satisfaction, facilities management, organisational culture, organisational socialisation, service delivery.

INTRODUCTION

Facilities management (FM) has grown far beyond the initial borders of caretaker to involve a wide variety of duties one is which is managing the outsourcing of contracts in today's offices (Cotts *et al.* 2010). This is due to the increasing need for permanent

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Tucker M.P.; Ogungbemi Y.O. and Noor N.M. (2012) The socialisation of outsourced employees in facilities management: A research agenda *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 611-620.

staff to concentrate on the core objectives of the organisation and to cut down avoidable expenses. Outsourcing non-core services such as maintenance has made it easier for organisations to keep their facilities in top shape and improve their output but it also introduces outsourced employees who in most cases have no understanding of the company's goals. Such situations can affect the perception and satisfaction of customers if they are not happy with service provision as all employees are seen as members/staff of the organisation.

This has created the issue of need for outsourced employees that are socialised in the same manner as their in-house colleagues, but little research shows that this is a reality. There is therefore a need to research what is currently available in this area and how to improve current practices. If outsourced employees are socialised, they will fit better in the client organisations they currently provide service to. This paper first discusses the novelty of the research area, research aim and objectives. Next, it gives a theoretical background on organisational culture and socialisation and their relevance to FM and outsourced services, after which it attempts to justify "FM cultural fit". The rest of the paper proposes a detailed methodology after which it concludes.

Novelty of research

A detailed research of concluded studies has shown that no prior study has been done in applying a generic socialisation theory to FM or outsourced staff in FM. Outsourced staff is a vital part of the facilities management sector and are an essential key in attaining quality service delivery and ensuring customer satisfaction. They form the bedrock of the service staff; cleaners, maintenance engineers, caterers, security and increasingly front desk/customer care. They are more often than not competent in their various fields and understand their duties but how prepared are they for the set-down cultures that exist in the companies they are outsourced to?

This research's main question thus: *Is there a widely accepted and established socialisation process for FM companies and business organisations to ensure that outsourced FM staff understand company culture and are able to portray this understanding when dealing with customers?*

Research aim

The background discussed above shows where the gaps in the industry are. Therefore, the aim of this study is: *To develop a research methodology that will be adopted in investigating the research question stated above***.**

Research objectives

To achieve the research aim set out above, the following research objectives will be met.

1. Understand organisational culture and organisational socialisation and its application to Facilities Management.
2. Examine the role of outsourced services in FM and understand the need to socialise outsourced FM employees.
3. Introduce a plan of work which will be critical to answering the research question.

LITERATURE BACKGROUND

Culture

Culture is not an easy term to define, mostly due to the different meanings it has in diverse contexts (Edgar and Sedgwick 2002). A useful definition in this context is "A pattern of basic assumptions-invented, discovered or developed by a given group as it learns to cope with problems of external adaptation and internal integration."(Schein 1985) Societal culture expresses its own purposes and meanings through work and communication (Edgar and Sedgwick 2002). It is what becomes accepted as the norm for everyone under its influence and provides the standard by which they relate to their environment. Culture is the underlying bedrock that defines a society and provides the moral, social, religious, economic and physical guidance for everyone connected to it. It is a particular way of life, usually of a people (Storey 1993) and affects how they work, think, relate and even their relaxation periods and methods to a great extent. It becomes embedded in our natures and often unnoticeable which is why anthropologists often spend several years with a people in an attempt to understand and document what drives them.

Culture is so ingrained in humans that what we see as our reasoning pattern is really internalised culture (Hall 1976). We are as unaware of it as the next person is unaware of theirs and we all carry these internalised patterns of thinking, feeling and acting throughout our lifetimes (Hofstede 1991). Culture is such a powerful tool which when adapted and adopted with purpose, changes the way everyone under the influence of that culture think. Culture follows us wherever we find ourselves; school, social gatherings and work. How culture affects us at work is discussed next.

Organisational culture

The current wave of interest in organisational culture dates back to the 1980's (Alvesson 2002). The possibility that managerial issues could be easily resolved by successfully managing the people in that organisation was an exciting one which CEO's and managers pursued wholeheartedly. Organisational culture thus became a fad which gave birth to several theories and models on organisational behaviour. Everyone taking up a new job comes with different expectations, goals, attitudes and ethics which are borne of the culture they have acquired from birth up till their last place of employment. (Buelens *et al.* 2006; Cox 1994). They are also highly likely to meet an already established culture at their new place of employment except where that company is a new start. Thus, organisational culture is made up of more than one subculture as there are likely various sets of professionals with varied backgrounds working in any given organisation (Brooks 2009). This leads every organisation to establish for itself whether consciously or otherwise a governing and overriding pattern of work that enables them work on similar wavelengths and deliver their set goals.

There is no agreed definition of organisational culture by the various researchers who have done work on the subject. The business, anthropological and sociological perspectives adopt different approaches to culture and therefore organisational culture. Brooks (2009) argues that strong cultures exist in organisations which exhibit a close relationship between themselves and their environment. The best societies therefore had the strongest cultures and routines which held them bound in the system passed

down in time. This system would then form the basis from which business and financial decisions can be made.

Schein (1985) also defines organisational culture as existing on different levels:

- The core at which lie people's assumptions and beliefs which influence our 'common sense' view of the organisational world.
- Cultural values which lie at the intermediate level; and,
- At the surface, culture manifests itself as behaviour.

For the purpose of this research, organisational culture will be defined as a dynamic and complex system of social patterns that govern the mechanism of core beliefs and assumptions, values and behavioural rituals by which an organisation relates with itself and external bodies. 'Dynamic and complex' because of the layers of culture that are blended together to become the 'mechanism of core beliefs' or an internalised code of conduct. 'Values and behavioural rituals' are the criteria by which the organisation and its staff assess themselves and others. This cultural behaviour is not automatically imbibed and can only be learned. The degree to which an employee inculcates this culture is known as cultural fit. Newly employed staffs are able to integrate into the organisation through training and managerial interventions (Brooks, 2009) and by watching more experienced employees. The greatest risk to company success both financially and socially is a dilution of its traditional method of getting results. Socialisation of new recruits is currently the best way to preserve these traditions.

Organisational socialisation

Socialisation provides new recruits with a set pattern of behaviour they can emulate to enable them blend into the organisation. (Buchanan 2010) in essence, organisational socialisation is the key to ensuring a seamless entry of newly employed staff. (Ge *et al.* 2010). Several theories currently exist on the best socialisation process for employees (Saks and Ashforth 1997). Not all of these models are applicable to the outsourced employee. Feldman and Wanous have the models best suited to the study as they have designed processes which are neither too long in time length as Buchanan and Pascale; based on the punishment-and-reward system like Porter *et al.*; or believe both sides will lay false expectations like Schein.

Table 1: Table depicting organisational socialisation models theories.

Organisational Socialisation Models	**Degree of adaptability to study.**
Buchanan's Three-Stage Early Career Model (Buchanan 1974).	This model bases organisational socialisation on a 5-year plan which will not be practical in the ever changing field of FM.
Feldman's Three-Stage Model(Feldman 1976a, 1976b)	Feldman's model is one of the most applicable to the facilities management sector as its stages can be adjusted to fit the outsourced FM staff.
Pascale's Seven Stage Model (Pascale 1984)	Pascale's model is not for the typical outsourced employee who is placed to do a specific duty in an organisation for the duration of a contract.
Porter, Lawler, & Hackman's Three Stage Model (Porter *et al.* 1975).	This model will not be applicable as it focuses on just the reward and punishment of behaviours and uses this as its key socialisation method.
Schein's Three-Stage Socialisation Model (Schein 1978).	This model is impractical as it expects the laying of false expectations by both parties. In FM, the contract should be honoured by the FM company, the client and the outsourced staff.
Wanous' Integrative Approach to Stages of Socialisation (Wanous 1980)	This model picked the best points from the other models and makes it stages succinct. It also fits the scenario of the outsourced staff and can be adopted for this study.

FM and outsourced services.

The service sector in the UK is currently responsible for 77.7% of the national GDP which includes financial and health services, public, private and the 'third' sectors (CIA World fact book 2012). With that overwhelming percentage and the need for efficient management of their physical premises, these organisations seek avenues to maximize output from their facilities while reducing running costs (Kurdi *et al.* 2011). This explains the need for an efficient facilities management system. Facilities management is a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process, and technology (IFMA 2007). (Tucker and Pitt 2008) have defined it as: "the integration and alignment of the non-core services, including those relating to premises, required to operate and maintain a business to fully support the core objectives of the organisation". FM has evolved to become a component of the business value chain, providing most services which directly relate to business indicators e.g. customer satisfaction (Becker 1990).

FM typically covers the non-core but crucial services of the organisation. To better monitor these services and reduce costs, these services get outsourced to the service provider with the most favorable contract (Kurdi *et al.* 2011). Staff involved in these non-core services have roles: clean office premises, fully functional facilities and friendly staff which when successfully managed, often improves customer perception (Tucker and Pitt 2009; Chiang, and Birtch 2009).

'FM Cultural fit'

Most organisations prefer to outsource these non-core services to professional service providers and concentrate on hiring employees who have a direct impact on their goals (Booty 2006). This often results in outsourced employees from different providers who likely have no idea what the company's goals are and who might come into the company with pre-ingrained culture in them from their employers. They have most likely imbibed the culture of their employer (the service provider) and the culture of other client organisations they have worked with over the course of their careers. This further shows the importance of socialisation.

Whilst Coyle-Shapiro and Morrow (2005), believe the employee's commitment to their contracting organisation might actually improve their commitment to the client organisation, there is still a need to socialize the newly outsourced employee. Research done by Tucker and Pitt (2009), show that the customers who rate "people involvement and cultural fit" as '*good*', tend to rate service delivery as '*good*'. While these customers might not realize what this means, the service organisation is made aware that the employee's degree of efficient and effective service in the organisation directly affects customer perception of service received. This means that there is a 'knock on effect' that can be controlled by the employer to a great extent.

The discrepancy in the cultures of these two organisations (the service provider and their client) may cause the outsourced employee to deliver below target and find it difficult to integrate with the client organisation where an in-house colleague blends in with relative ease. Outsourced employees in most cases, cannot answer customer enquiries about issues that are related to the company's core business. Worse, they might not be able to direct the customer to anyone who can help. This difference in the degree of congruence between an outsourced FM employee and the client organisation will be termed 'FM Cultural Fit'. A higher 'fit' level will make it difficult or even impossible for outsiders to distinguish between the in-house and the outsourced employee. A lower 'fit on the other hand, will make it glaring that an employee has been outsourced from a service provide and has not/is yet to be socialised by the client organisation. 'FM Cultural Fit' will be used to determine if the discrepancy between both organisational cultures is been managed, how it is being managed and if the management is done by the FM organisation or the client organisation. The current gap identified above in the field of facilities management shows the importance of employee management as a key to achieving KPI's (Key Performance Index) and delivering quality service as agreed in a contract and as expected by the customer.

RESEARCH METHODOLOGY

Research is an investigation conducted with the aim of understanding phenomenon or solving a problem. Research results need to be valid, descriptive, and informative before they can be applied to social or organisational problems (Miller and Salkind 2002). To achieve this, a proper and systematic research design which will ensure successful functioning of the research process needs to be developed (Maxwell 2005).

Research design and strategy

The literature study has revealed questions which when answered, will revolutionize the perception of the outsourced customer in service delivery.
The subject area being novel, poses the first hurdle of scarce relevant journals. Relevant literature will be derived from the subject matter and the study sector. There should however be relevant data gathered once the research commences.

The purpose of this concurrent, mixed methods study will be to explore the socialisation culture that exists in FM companies and client organisations for outsourced employees. The research theory demands a pragmatic approach from which we shall infer/induce patterns based on previous research (Creswell 2009). The unpredictability of the results led to the adaptation of an exploratory approach to gathering data. The question survey will cut across FM companies, their clients and employees.

Further research will involve simultaneously conducted semi-structured interviews and questionnaire surveys to determine what is obtainable and to develop a working theory. A flowchart detailing the research methodology can be seen below.

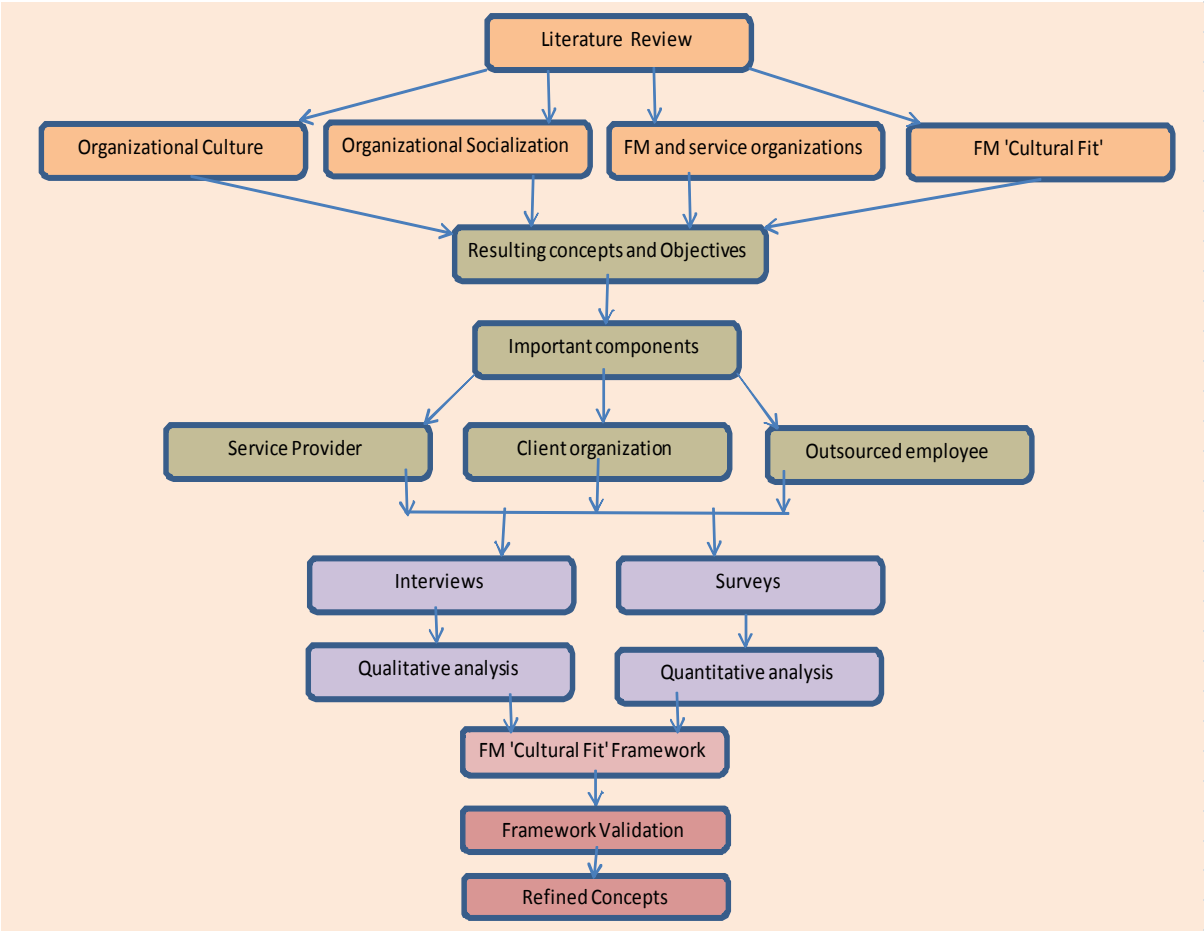

Figure 8: Research Methodology

The qualitative and quantitative stages will be conducted together to produce data. A detailed research strategy which also reflects the target population is shown below.

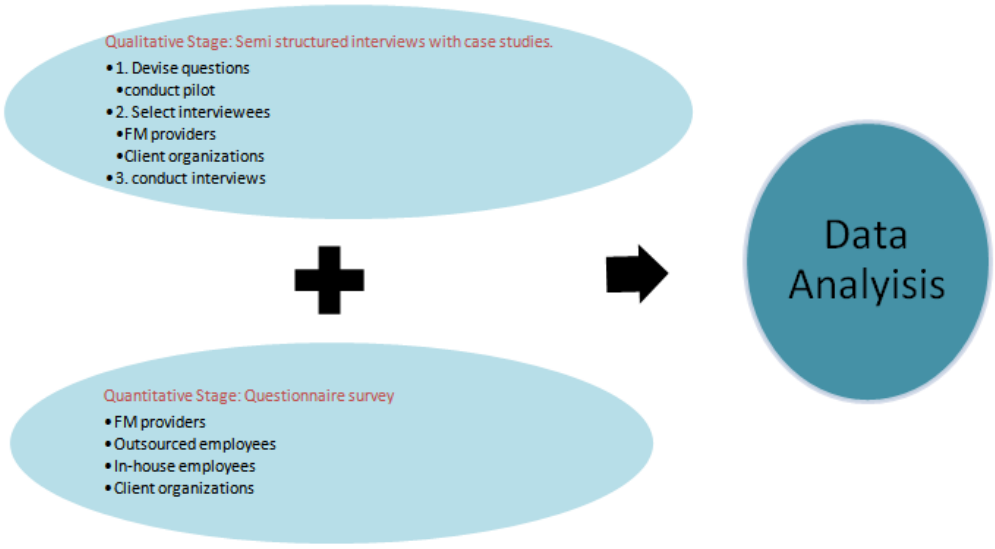

Figure 9: Research Strategy

Work packages

The work packages have been divided into 3 sections for ease of execution as revealed in the appendix 2. The first stage covers the literature review and the first data collection round. The second stage covers the second data collection round as well as an analysis of the data to produce the proposed framework. The third and final round will involve the validation of the proposed framework and the final write-up which will be submitted to Liverpool John Moores University.

Study population and sample

The focus population of the research is the British Institute of Facilities Management (BIFM) whose members' work in various sectors of the economy which will ensure unbiased results. The sample size was calculated using a 95% confidence level and a confidence level of 5 which gave a sample size of 372. This sample will be the minimum number of surveys expected back to ensure valid data.

Data collection method

Primary data used for this research will be collected from various sectors in the economy through members of the BIFM who work in Facilities Management units of target organisations. The research problem requires a pluralistic approach as one method is unlikely to provide a holistic solution which can be implemented in the FM industry. A detailed study of the research questions shows that the concurrent mixed research method will be most appropriate for this study. Interviews and questionnaire surveys will be used at the same time to gather data which will be used to develop a framework for application.

Data analysis

The research will be conducted in the order shown above and the results collected at each stage will determine the direction of the next stage in the aspect of objectives and question structure. The results will be analysed using NVIVO for qualitative and SPSS for quantitative to test assumptions and make comparisons (Field 2009). This

paper introduces the need for the socialisation of outsourced employees in FM and provides a theoretical base. It has only presented the first stage of the study and is yet to collect data for analysis. It is hoped that the results of further study can be adapted for the use of FM organisations in the various sectors.

CONCLUSION

An organisational socialisation gap currently exists in the Facilities Management industry which affects the outsourced employee; a crucial part of organisational KPI's and customer satisfaction. This paper is a review of initial findings made for a more detailed research on the best way to correct and adjust this deficiency in FM. There will therefore be a concurrent mixed methods research carried out in due course to test and validate the study aim and objectives discussed above. Further research is expected to improve the cultural fit of outsourced employees who work in the Facilities Management sector which will have a positive ripple effect on the FM industry.

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IMPROVING PROJECT PERFORMANCE THROUGH WORKER PARTICIPATION IN ALLIANCE PROJECTS

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Worker participation has a direct influence on construction project performance and is a major factor of productivity in construction. Alliance principles emphasise the significance of developing a culture for innovation with worker participation. Therefore, this study identifies the existing worker participation practices and their limitations in a typical alliance project. The study uses the case study approach with semi-structured interviews with alliance management and a questionnaire survey with middle level management to assess their perceptions on worker participation. The study reveals that regular worker performance appraisals, worker training and provision of project performance information to workers are important worker participation practices required in an alliance project. The way project teams are acknowledged and rewarded to increase participation also appears to be an area that considering the selected case study project can be developed further. In addition it would seem advantageous for the project to build worker participation practices from the very beginning rather than midway through a project.

Keywords: alliance project, bottom-up approach, case study, worker participation.

INTRODUCTION

A current trend in construction aims at an effective integration of key stakeholders which positively contribute to a project's performance. Consequently, there is evidence of increased relational type contracts in construction. However, many relational type contracts have not been as successful as expected (Maqsood, Walker, & Finegan, 2007) because they have not fully addressed the needs of the business, people and processes. Due to the labour and knowledge-intensive nature of the industry, the people factor plays an important role. However, involving and empowering individuals of the wider project team has not been an extensively researched topic especially in relational type construction projects.

Additionally, Egan (1998) stated that the construction workforce is undervalued and frequently treated as a commodity rather than the industry's single most important asset. Morton (2002) stated that the workforce could be a main source of productivity improvement which could be equally effective as the adoption of new systems. Moreover, Mossman (2009) pointed out that since only site operatives create value for end users, it is vital to engage them in site management tasks. Since workers are close to a process, they often have suggestions that can be used to improve the process.

Recently, researchers have shown an increased interest in improving construction practices by applying core principles of current production management theories such

Vilasini N and Neitzert T.R(2012) Improving project performance through worker participation in alliance projects *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 621-630.

as total quality management, lean and business process re-engineering. These concepts require the increased participation and autonomy of employees as a necessary component for improving the efficiency and effectiveness of organisations (Eriksson, 2010). Despite of the improvement initiatives offered by those concepts, there is an absence of an explicit consideration of the human resource implications of adopting production management theories in the construction management field (Green, 2002).

Alliance principles declare that participants need to develop a culture of innovation. Innovation is one of the important key performance indicators for most of the alliance projects (Love, Davis, Chevis, & Edwards, 2011) and one of the main themes of alliancing is continuous improvement. Worker participation positively affects innovation and continuous improvements. However, worker participation practices in alliance projects have not surfaced yet in the scientific literature and these practices are not explained in any alliance manuals or guidelines. The work presented here is part of an on-going doctoral research study which tries to explore the improvement opportunities in alliance contracts with a lean perspective. The aim of this paper is to identify a spectrum of worker participation practices in alliance projects and how to improve those practices.

The paper is organised as follows. After this introduction section, the next section gives an overview of the worker participation practices in construction and alliance projects. Then, after presenting the research methodology, the study reviews the existing worker participation practices in a selected alliance case study project. The analysis focuses on finding different procedural and organisational practices to improve collaboration of the wider project team to the advantage of a project. Finally, after the discussion of a questionnaire analysis more general conclusions are drawn.

LITRERATURE REVIEW

The people factor and process improvements are positively related themes because worker participation has a significant potential to improve project performance (Maqsood *et al.* 2007). Though worker participation has been a well-researched area, its understanding has been limited in project management research and especially in construction. The omission of the people factor within the construction context was pointed out by many authors. Hence, the following sections deal with the worker participation practices in construction with the view of exploring the current practices in new alignment methods specifically in alliance projects.

What is worker participation?

A worker participation culture was initiated through a worker suggestion system (Fairbank & Williams, 2001). At present different terms exist to explain a worker participation culture since it is constantly being renewed by researchers and practitioners. However most of the terms are referring to similar principles with varying practices. Basically, it is a culture that gives workers the opportunity to participate in substantive decisions, the skills to make this participation meaningful, and the incentives to encourage skills acquisition (Appelbaum, 2000). The identified worker participation practices in previous literature are classified into five variables (power, information, reward, knowledge and relationship) as shown in Table 1 which will be used as a guide for assessing worker participation in an alliance project.

Level of worker participation in construction projects

The construction site workforce is one of the most important variables to project progress (Morton, 2002) because of the high labour and knowledge intensive nature of

the industry (Richards, 2006). Despite the importance of the people factor, due to the temporary nature of construction projects (Eriksson, 2010), the industry believes that people development and participative approaches are not important (Green, 2002). Furthermore, the fluid organisation and fragmented nature lead to weakening the relationship between management and workers which is a crucial for worker participation. Conversely, the industry informally relies on the contribution of workers to transfer experience from one project to the next. Therefore workers' insight is important in developing new projects and continuous improvement in current projects.

There are numerous examples of worker participation being used successfully in other industries, but less in construction (Briscoe & Dainty, 2005). Worker participation in problem solving groups occurs in only 21% of construction cases(Green, 2002). There is a large volume of published studies describing the motivation of construction workers are minimal (Ng, Skitmore, Lam, & Poon, 2004). The high labour turnover in construction is caused by little opportunity for training and it will ultimately affect skills shortages. Consequently the lack of labour skills and high labour turnover are also denoted as major reasons for low productivity in construction. Therefore the implementation of people development and participative approaches will enhance the ability of organisations to retain employees (Yankov & Kleiner, 2001). In the short term the resignation of a trained worker from a company can be considered as a loss to the company, but such training will improve the industry as whole.

In summary, the worker participation practices are essential for construction. Yet, the industry has neglected to take advantage of its workforce, which means there is a considerable amount of untapped productive potential waiting to be released.

Level of worker participation in alliance projects

After recommending reintegration of fragmented functions through different reports, Egan (1998) and Latham (1994), a significant number of collaborative agreements have emerged. These innovative project delivery systems especially alliancing offer many advantages over traditional project delivery systems. The alliance projects identified key elements which are required to promote collaborative relationships among project participants like high performance teams, reward and risk sharing schemes and problem solving systems (Hauck, Walker, Hampson, & Peters, 2004).

Alliance projects are adopted for high risk and large projects. For large projects, each management level needs to delegate authority to their subordinate which requires trust with subordinates. These bottom - up practices are the source of new ideas which will be a competitive advantage to a project. However, findings disclose that worker participation practices exist in alliances but these practices mainly focus on the management level and less on the operational level (Cheung & Rowlingson, 2005). The alliance literature is also more concentrated on the highest level of the organisation where goal alignment and good relationships are crucial. However, a bottom-up support is also critical to maintain relationships in alliances.

Despite the above gaps existing in the alliance literature, recent alliance projects have also revealed worker participation practices such as the provision of training and more flexible quality of work life issues which address the needs of both management and workers. The Australian National Museum alliance project used a new organisational framework with solution building teams to encourage the suggestions for encountered problems (Hauck *et al.* 2004). This project used an innovative workforce performance review which was developed based on time, cost, design integrity and quality indicators of the main alliance (Walker, Peters, Hampson, & Thompson, 2001). The

agreement included the performance based payments made upon five performance indicators, which were measured weekly for all site workers. For operational level worker participation practices, numerous examples were cited in a waste water treatment plant alliance project (Cheung & Rowlingson, 2005). This project conducted a full day workshop arranged for all operational staff with an alliance coach at the pre-alliance stage. The case study project identified the importance of building strong relationships with the operational levels that are carrying out the actual site work and implemented a few new practices such as the induction programme and informal social occasions. The Manukau Harbour Crossing Alliance Project in New Zealand also adopted a reward system for the project team for process improvement suggestions (Alliancing Association of Australasia, 2011).

Additionally, continuous improvement through worker participation is a core lean principle which identifies the inability to utilise the knowledge and skills of employees as the eighth waste. This waste involves losing time, skills, ideas, improvements and learning opportunities by not listening to workers. Lean theory suggests improving participative culture by different tools like improvement suggestions, rewarding mechanisms and multi-skilling.

In summary, worker participation practices are required in high risk and complex projects with a high level of technology. There is a trend in construction projects of an increasing implementation of such practices. However, these practices vary with the alliance management and project teams. Therefore this study provides details of best practices to implement for construction projects which could be used as a guideline for future alliance projects. The worker participation practices listed in previous research studies have been reclassified to refer to alliance projects.

RESEARCH METHOD

The study aim is to gain an insight into worker participation practices in an alliance project. The used methodology is a grounded, triangulated approach. The worker participation practices in alliances were investigated initially through observation in the case study project. The second phase of the research was to investigate improvement opportunities in worker participation practices and the validation of solutions through interviews with the alliance leadership team and questionnaire surveys with the middle management.

The literature, interview and observation findings were used to formulate the questionnaire. The targeted participants were from the alliance project management as they are usually responsible for facilitating change within the project team. While workers are a vital part of the change, the research attempted to consider worker participation issues from the management perspective. The respondents of the questionnaires were asked to rate the importance of identified worker participation practices from literature review and interviews. The layout and design of the survey followed the principles of on-line survey development, as outlined by Lumsden (2007). A total of 30 copies of the surveys was distributed, of these a total of 18 were returned. Of the 18 questionnaire sampled, 30 % were from project engineers, 50 % were from site engineers, and 20 % were from supervisors. The average work experience in construction of respondents engaged in the questionnaire survey is 8.7 years, with about 54% of respondents having experienced more than one alliance project. Five interviews were conducted with members of the alliance leadership team.

FINDINGS FROM THE CASE STUDY

Background of the case study project

The project studied is a motorway replacement in New Zealand. The project is delivered by seven parties and a national government agency via an alliance approach. Several processes were identified within the project by a larger research programme undertaken by the authors to investigate improvement opportunities of the project. Initial process mapping identified that 53% of the workers' time at the alliance project is spent on waste activities which need to be eliminated. These results were fairly similar to other studies identified by Horman & Kenley (2005) which are conducted under traditional project delivery systems. Therefore, the authors believed that to eliminate waste activities there should be high levels of commitment from all employees. Consequently, current worker participation practices in alliance projects are examined and improvement opportunities are sought in the next sections.

Questionnaire finding

The importance of worker participation practices to the particular alliance project was identified as shown in Table 1.

Table 2: The importance of worker participation practices

Area	Practices	Mean	Rank
Relationship	Treat the entire workforce as equals	3.94	5
	Conduct social activities	2.89	9
Knowledge	Formal appraisal system to assess training needs	3.67	7
	Supervisors trained in people management skills	3.89	6
	Employees have job training opportunities	4.28	2
Reward and recognition	Regular employees performance appraisal	4.17	4
	Employees receive performance related rewards	2.17	11
Information sharing	Management gives project information to employees	4.39	1
	Standard job related induction programme	4.22	3
Power	"Feedback box" to make suggestions	2.11	12
	Worker involvement in lesson learned workshops	3.28	8
	Requests for employees' ideas and input	2.56	10

There are only four factors that registered a mean of above 4.0 on a scale between 1 and 5. These factors mainly focus on information sharing, training and development of workers. Moreover, another four factors only managed to register a mean score of less than 3.0. These factors concern 'power' and 'reward and recognition'. Overall, the most important worker participation practices were related to the 'information sharing' area while the lowest scores were related to the 'power' area.

Interview and field work findings

The various participation practices used by the case organisation are explained in the following section. These practices are typified by exclusion of the operative levels of the project and are aimed mostly towards middle management.

Relationship management

Relationship management is a key element in the project's high performance plan which is closely linked with the actual project plans. Several project celebration events were held to acknowledge all the project teams, including sub-contractors, for their efforts to attain key project milestones. A celebration of milestone achievements was used to recognise the workers' efforts and also to communicate project progress. All the site and office staff are required to attend weekly 'one team' sessions and all are inducted on alliance principles, values and behaviours. In the questionnaire analysis, treating the workforce equally is identified as a quite important practice but conducting social activities was identified as moderately relevant. However, Greasley *et al.* (2005) found that most workers prefer social activities and it will improve their motivation through a team belonging feeling.

Knowledge management

The case study project is investing significantly in employee training which is in line with the Druker, White, Hegewisch, & Mayne (1996) study recommendations. Most of the employees received training opportunities depending on job requirements. A novel approach called 'Keep, Stop, Start ' was adopted to determine ineffective practices that should stop, effective practices that should continue and beneficial practices that should be implemented by the wider project team. Training needs are considered for the alliance leadership team to the foreman level. Most of the respondents rated such knowledge management practices as important factors.

Reward and recognition

An effective rewards and recognition program is a key practice of a participative culture. The middle management was assessed based on the achievement of project performance indicators and the monthly updated achievements are reported on notice boards. Therefore employees who produce remarkable results are recognised in a meaningful way with integration into the project performance. Approximately half of the questionnaire respondents identified performance appraisal as an extremely important practice but evidently there is no such defined system for the site operatives. For example, giving an award of recognition to the 'crew of the month' will inspire enthusiasm among workers (Nesan & Holt, 1999).

Furthermore, in order to be truly effective, appraisal programs should be linked with reward and recognition to the employees who contribute to project success. However, interview findings show that there are no performance related rewards available in the project and 60% of the respondents declared such reward mechanisms are not a vital practice to improve worker participation. Druker, White, Hegewisch, & Mayne's (1996) study indicated that 45% and 21% of construction organisations provide performance related pay to the managerial level and the worker level respectively.

Decision and suggestion making for process improvements

Several steps have been taken to support innovation namely pre-start meeting, lesson learned workshops and suggestion box system. The questionnaire analysis found that 61% of the process leaders adopted a participative decision style to make decisions to resolve complex project issues. Greasley *et al.* (2005) noted that there is a positive correlation with the role of leaders and the psychological sense of empowerment held by the workers. The findings show that the project engineer, site engineers and supervisors are the main groups to participate in process improvement decisions and less participation of site workers and sub-contractors exists.

The suggestion box system can result in process improvements and worked as one of the main vehicles for worker participation. However, the suggestion box system was implemented and failed in the particular project. The main reasons for the failure given in the questionnaire were lack of follow up and lack of interest. Moreover, in the interviews it is identified that there are frequent informal communications with the workers and foreman to discuss improvement opportunities on site. Greasley *et al.* (2005) pointed that some managers asserted that workers could perceive this consultative approach as weaknesses of management. Therefore, there is little room for new issues to be discussed through pre-start meetings and suggestion boxes.

Information sharing

Weekly sessions called ‘one-team’ sessions are conducted for all office and site staff. The 'one-team' sessions have had many agendas over time such as project progress and safety issues of the entire team. While most of the subcontractors' representatives were attending 'one-team sessions' regularly, it is uncertain how this information transfer happens to subcontractor management who are working off site. The questionnaire respondents identified such information sharing session as the most important areas for successful worker participation and as a missed opportunity of not implementing in the initial stage of the project. However, Raiden, Dainty, & Neale (2008) claim that team briefings in construction were infrequent and ineffective.

DISCUSSION

Process improvement is mainly governed by people because every employee has a significant potential to improve not only their own processes, but those of others as well. Therefore there should be a positively oriented organisational context that encourages employees to participate fully in process improvements. Although, alliance projects often have a high performance plan which creates the basis for positive organisational change but no actual procedures and practices are presented. In general, alliance projects tend not to define those practices in advance but leave it to the alliance team to find the best way. Thus most of the practices are implemented on an ad-hoc basis. Therefore this study summarises the important worker participation practices that emerged from this study (Figure 1).

The concept of a high performance plan tries to get meaningful contributions from the project team through developing high levels of positive connectivity, an operating environment with defined behaviours and people development. The identified worker participation practices are mainly classified into two areas namely top- down and bottom-up approaches. Each identified practice from the study is listed under five constructs which are used in Table 1.

In the case study a high performance plan created a participative culture. Especially periodic performance appraisal and training ensured the employees' growth. Nevertheless, some of the different participative practices adopted at different project stages failed or faded during the project. For example, the "suggestion box" system was given up in the early stages of the project. This is mainly due to lack of time and energy invested into an initiative and according to Fenton-O'Creevy (2001) such a condition is not necessarily a symptom of a negative initiative. The middle management resisted the suggestion box system stating the alliance culture already removed the communication barrier and workers can discuss process issues directly with their management. Alternatively an important part of a 'suggestion box' is contribution recognition, which helps to build workers' self-esteem and motivation.

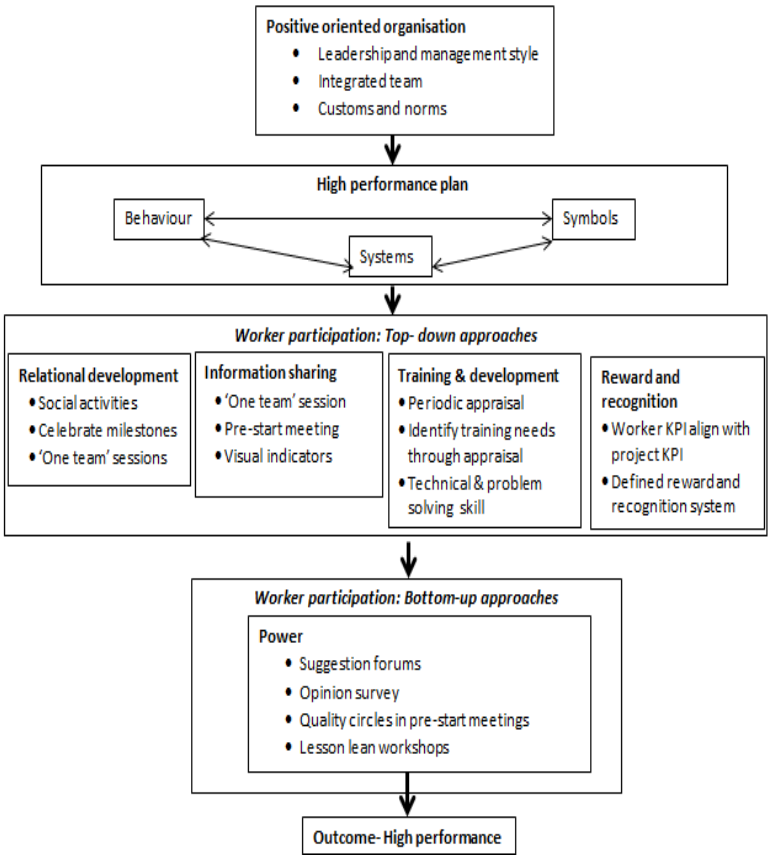

Figure 10: A conceptual model of the main practices associated with worker participation in alliance projects

Conversely, 'one team' sessions implemented to share project performance details among the wider project team, were introduced during the middle stages of the project. This practice gained more recognition among the project team and respondents rate it as the most important practice. Such a system will enhance the team belonging and according to Tabassi and Bakar (2009) team belonging is a powerful motivator for construction workers. Therefore the advantages of such practice were forgone in the early stages of the project.

The project implemented systems like 'pre-start meeting' and 'one team sessions' to improve communication and acquire suggestions but still there is a lack of input of the on-site operational level. Most of the process owners were focused on safety and schedule only and there was little focus on process improvement discussions. Even though the aim of these tools is to improve worker participation, there was hardly found any two-way communication between operatives and middle management. Each pre-start meeting should include a time slot whereby inputs from workers are encouraged and sought. The site operatives refrained from opening up and hesitated to come forward with their suggestions which could be due to the lack of recognition. Hence, constant encouragement through a recognition system, visual indicators of performance and continual feedback seems to be required to overcome these obstacles.

CONCLUSIONS

The literature suggests there is a necessity to implement soft human resource management policies based on worker participation and commitment to improve the construction industry performance. The research findings support the construction

literature, which suggests alliancing projects encourage a high level of connectivity among project teams and serve as vehicles to improve open participative practices. However, certain worker participation practices in alliance projects have not been subject to widespread assessment through empirical research. As a result, alliance participants can lack knowledge and confidence in implementing worker participation schemes. Therefore through a case study project a number of important successful worker participation practices were identified. However, the practices found were executed in different phases of the project, but to obtain the maximum outcome of these practices, they should have been implemented in the initial stage of the project. Getting the culture right at the beginning and inducting people effectively are important. Furthermore, the results revealed that a significant amount of informal participation is present in an alliance and resistance can exist against formal worker participation and reward systems. In order to implement successful worker participation systems, the project needs to have supporting staff which could be realised through project team selection and training geared towards a high performance culture. This means that alliance project organisations need to appreciate the implications of worker participation to effectively identify and integrate the project resources and technologies, and dynamic capabilities for successful worker participation. This research, in broad terms, provides insights into worker participation practices in construction alliances and specifically recommends application of those practices in the early stage of projects in an appropriate way. Also, it recommends worker participation initiatives should become management's daily routine, rather than considering them as extra activities.

ACKNOWLEDGEMENT

The authors are grateful to the New Zealand Transport Agency and the Northern Gateway Alliance - Newmarket for granting permission to publish this paper.

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INTER-ORGANISATIONAL RELATIONS AND SUPPLY CHAIN MANAGEMENT

LEARNING HOW TO EAT AN ELEPHANT: IMPLEMENTING SUPPLY CHAIN MANAGEMENT PRINCIPLES

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There have been a range of calls for the construction industry to address perceived structural failings and adopt supply chain management best practice models. However, many studies in the construction sector report poor uptake. A possible reason for this is a failure of companies to implement their supply chain improvement programmes effectively. Such changes may involve companies adopting new approaches, new processes and new ways of working. In order to manage this daunting undertaking, the role of managing new knowledge and sequencing activities is important. Hence, the purpose of this paper is to investigate the anatomy of a long term supply chain improvement programme in the construction industry. Building on established supply chain management principles, and models of supply chain learning, a longitudinal case study is analysed. Insight is given into the role of learning and the sequencing of activities. The paper contributes by refining established supply chain management frameworks.

Keywords: supply chain management, learning organisation, sequencing, implementation, change management.

INTRODUCTION

Researchers have shown that close integration of supply chains is strongly associated with performance improvement (Frohlich and Westbrook 2001). However, there are very few 'exemplars' of good supply chain practice to be found, even across industry sectors (Childerhouse and Towill 2011). Typically, such exemplars show evidence of moving towards a 'seamless' supply chain, whereby barriers to integration are removed through process improvement (Love *et al.* 2004, Towill 1997a). Many of the arguments for integration have been grounded in business process improvement literature (Frohlich *et al.* 2001), such as business process systems engineering (Watson 1994) and lean thinking (Womack and Jones 1996). In practice, however, the success rate of improvement initiatives are less than encouraging (Kotter 1995).

A common problem is that a complex challenge is dismembered into a series of seemingly simple 'quick fixes'. Poorly thought out local improvement initiatives may

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Gosling, J; Towill, D and Naim, M (2012) Learning how to eat an elephant: implementing supply chain management principles *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 633-643.

actually decrease overall system performance (Owen and Huang 2007). Such studies highlight the danger of extrapolating results from simple systems to more complex ones without appropriate understanding and learning. As de Treville *et al.* (2004) strongly emphasize, dramatic failures often result from ambitious attempts to 'run before learning to walk'. Given the above challenging prognosis, careful thought is required by practitioners as to how they design and implement change programmes, and act as a warning to those enthusiastically seeking to apply reform agendas.

In the construction sector, discourses of change have gathered momentum through successive government reports and academic literature (Egan 1998, Latham 1994). Reform agendas for improving supply chains have been central to these calls for change, through notions of partnering and teamworking, and learning from other sectors. The actual uptake of supply chain management practices within construction appears to be very slow (O'brian *et al.* 2009) . A possible reason for this poor uptake is a failure of companies to implement their supply chain improvement programmes effectively. As noted by Bresnan *et al.* (2006), there remain significant gaps in our understanding of the problems associated with implementation of effective change and learning in construction project organisations to support such radical transformations. Hence, the purpose of this paper is to investigate the anatomy of a long term supply chain improvement programme in the construction industry. To undertake such a dissection, a set of SCM principles that have previously been developed and tested in a range of make-to-stock scenarios (Towill 1997b) and a model of supply chain learning (Bessant *et al.* 2003) are exploited and extended.

LITERATURE REVIEW

Defining the elephant – modifying the 'FORRIDGE' Principles

It has been argued that many modern supply chain principles may be traced back to the classic production distribution systems simulations by Jay Forrester (1961). Furthermore, by integrating the methodologies of industrial dynamics (Forrester 1961), and material flow control (Burbidge 1961), a set of system operation principles have been developed (Towill 1997b). The latter looked to provide a foundation for sound supply chain design, and in doing so established a set of fundamental rules for enabling smooth and seamless material flow. The 'FORRIDGE' principles, a phrase derived from combining the key intellectual influences of Forrester and Burbidge, were originally defined as; control system principle, time compression principle, information transparency principle and echelon elimination principle. A previously implied fifth 'synchronization' principle was later made explicit by Geary *et al.* (2006). Since publication in 1997, the principles have been shown to offer a powerful guide for engineering effective supply chains.

Figure 1 gives a vision for each of the FORRIDGE principles. It is important to note that they provide a set of guiding principles for companies. They may be interpreted and achieved in a range of different ways across industry sectors. We argue that in addition to the five principles documented in the existing literature, a sixth 'Design for X' (DfX) principle, which relates specifically to project related supply chains where complex bespoke products are 'engineered to order' (Gosling and Naim 2009). DfX has become an umbrella term used to imply effective design principles (Kuo *et al.* 2001). Approaches such as design for assembly, design for manufacturing, design for buildability, and design for life cycle are all included in this umbrella (Asiedu and Gu 1998). An integrated design process should enable all elements of the design to be 'fit

for purpose' and 'right first time'. Two enablers of training and learning, as well as supply chain integration have been added.

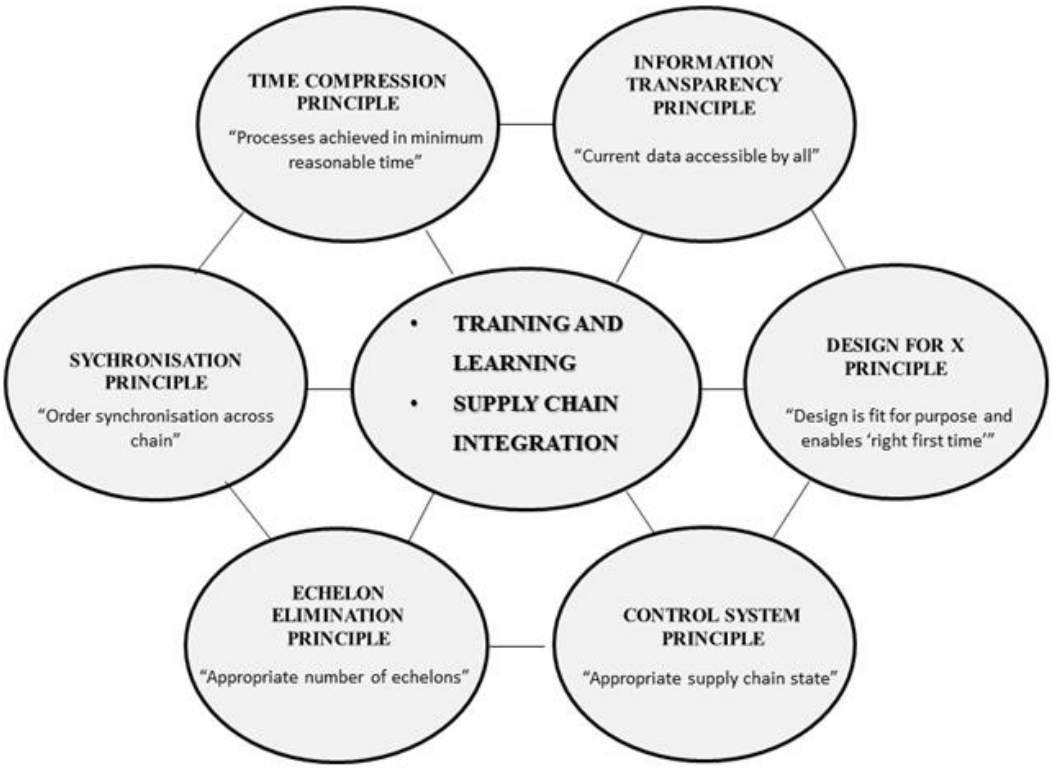

Figure 1: The FORRIDGE principles

Forrester (1961) emphasized the role of feedback and disturbances in manufacturing systems, establishing that the more extended the chain, the worse the dynamic behaviour. At around the same time John Burbidge was developing ideas relating to material flow control exploiting cycle time compression, synchronization of orders throughout the supply chain, simplified product structures and streamlined component flows within the factory (Burbidge 1961). The FORRIDGE principles united these different intellectual threads into a succinct set of principles (Geary *et al.* 2006, Towill 1997b, Towill and Childerhouse 2006).

Individual principles have been substantiated by many researchers, including time compression (Treville *et al.* 2004), information transparency (Smaros *et al.* 2003) and control (Dejonckheere *et al.* 2003). McCullen and Towill (2001) have comprehensively shown that the application of the principles as core features within a business process re-engineering (BPR) programme have substantially reduced demand volatility in a real world supply chain. Furthermore, there has been simultaneous reduction in inventory levels and variability. These principles have since been incorporated into a vision-principles toolbox model, and subjected to statistical testing across a range of real world supply chains (Towill *et al.* 2006).

Learning to eat the elephant - managing and implementing change

Innovation of the scale encouraged by the FORRIDGE principles is often disruptive. A primary concern in effecting change in supply chains is that the level of co-operation required between organisations in the supply chain is often far from guaranteed (Towill and Childerhouse 2011, Treville *et al.* 2004). A proposed starting

point is to perfect processes under direct control (Treville *et al.* 2004). Operationalising this requires separating internal initiatives, which do not require any collaboration, and external initiatives, which require substantial collaboration. Once the knowledge is developed from internal initiatives, it is then possible to move more confidently onto external activities and interfaces (Towill *et al.* 2011).

Furthermore, companies often have limited resources and investment available for effecting such changes. One suggestion is to limit an innovation programme to no more than 2-3 major efforts at a time (Hammer 2004). The logic here is that undertaking all planned activities at the same time, eating the elephant in one go, would consume too many resources and create too much disruption. Similarly, a protracted implementation period with small activities performed sequentially over a long time period, gives 'opponents' an extended opportunity to sabotage efforts. Breaking a large scale implementation into a series of 'limited releases' creates momentum and dispels scepticism (Hammer 2004). Figure 2 integrates the above thinking to identify a range of sequencing options for implementing a supply chain improvement programme. The proposition advanced is that our metaphorical supply chain ‘elephant’ is best eaten in an optimal array of bite size chunks.

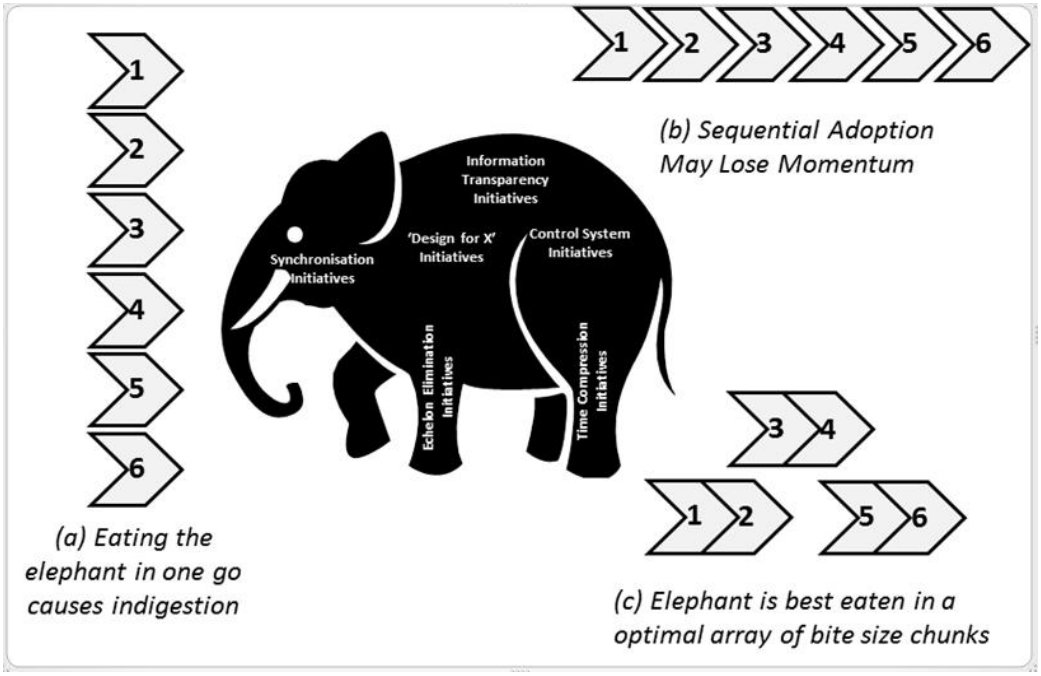

Figure 2: Possible approaches to ‘eating the elephant’

Werr *et al.* (1997) showed that the learning organisation is integral feature of international change management consultancy methods. Organisational theorists have studied learning for some time. Early work by Argyris (1992) emphasized modes of learning and single and double loop learning, and Peter Senge (1990) proposed a range of core disciplines for building the learning organisation. However, a more recent seminal analysis by Ortenblad (2007) showed that Learning Organisation citations were taking quite different, and often conflicting, interpretations of its meaning. Garvin (1993) offers a clear and concise definition to exploit: "creating, acquiring, transferring knowledge and exploiting this to modify behaviour".

The importance of learning does not stop at the boundaries of a single organisation (Bessant *et al.* 2003). This notion is especially important in the context of construction projects, where there is a complex flow of knowledge between project firms.

Performance, therefore, is heavily dependent on inter-organisational learning and development. Bessant *et al.* (2003) coined the phrase 'supply chain learning' to refer to this. They propose a two by two matrix to rationalise different learning types and modes in supply chains. Learning mechanisms can be simple, referring to incremental additions or improvements, through to complex, which are new approaches requiring experimentation and adaptation. They also distinguish between one-to-one dyadic relationships and multi form groupings, which they refer to as network.

RESEARCH METHODOLOGY

There have been a range of calls for more longitudinal research in supply chain management research (Boyer and Swink 2008), as well for a more sophisticated understanding of the impact of time related intervals in the research process (Zaheer *et al.* 1999). Longitudinal research is a "family of research methods which tell us about change" and is concerned with "temporal evolution" (Ruspini 2002: p10). Clearly, a long term initiative of the sort described in the literature review is not small a single event, but a long series of discrete intricately connected episodes that occur over a long time period. Pettigrew (1990) refers to the empirical study of such change programmes as 'catching reality in flight', involving horizontal and vertical levels of analysis.

The most commonly used longitudinal designs are, repeated cross sectional studies, prospective longitudinal studies and retrospective longitudinal studies (Ruspini 2002). In prospective longitudinal studies, the same subjects are repeatedly interviewed over a period of time at discrete points. In retrospective interviewees are asked to remember, and reconstruct events or aspects of events. The focus is often placed on specific 'events' and 'trajectories', which are of interest to the study. In this paper, we focus as an event as a process change or initiative which forms part of a broader trajectory to improve the supply chain. This paper reports the investigation of the supply chain improvement activities of an international consultancy and construction company employing over 3,000 people, operating across 65 countries and with a turnover of £850m (in 2010).

The company was formed in1990, and decided to reform its approach to operations and supply chain management in 2000 in response to a range of different drivers. Pettigrew (1990) suggests choosing a site to demonstrate high or low performance is appropriate justification for studying a change programme. The company has maintained impressive growth since 2000, even during the recession, and has won a range of awards relating to its supply chain practices. Time events were captured through a combination of retrospective and real time analysis, thereby combining two of the designs described above. The research team have been actively researching with the case company since 2007, allowing real time observation of initiatives since this time. Prior to this point, initiatives were captured via retrospective identification.

Data was collected by interviews, observations and archival data. Through a series of interviews and meetings with the operations and supply chain director, informal questioning was used to reveal how and why initiatives were established. A chronology was then established to order and present ideas as a narrative. Feedback on the timeline was then gathered through follow up interviews. The primary focus was on identifying and understanding initiatives that were 'transparently observable'. Observations during company visits were recorded over the period between 2007 and 2012, which formed the basis of a draft timeline of initiatives. This was used to inform

interview questions. Archival data, such as project case studies, internal process documents, and IT systems were examined to give further background.

CASE STUDY FINDINGS

Figure 3 shows the chronology of supply chain initiatives undertaken by the focal company since 2000. The different activities have been classified, as per the colour coding, according to the primary FORRDGE principle that they relate to. It also shows some of the key drivers and influences that have shaped these initiatives over the time period. For the Time Compression Principle, standard bid templates were introduced to reduce workload and lead times for the bid process. Promotion and adoption of modular design principles, as well as offsite pre-assembly sought to reduce process times. Synchronisation principle initiatives include JIT systems developed with suppliers over a number of years to synchronise deliveries with site progress. Cluster management workshops were set up to encourage suppliers to integrate work in more effective ways.

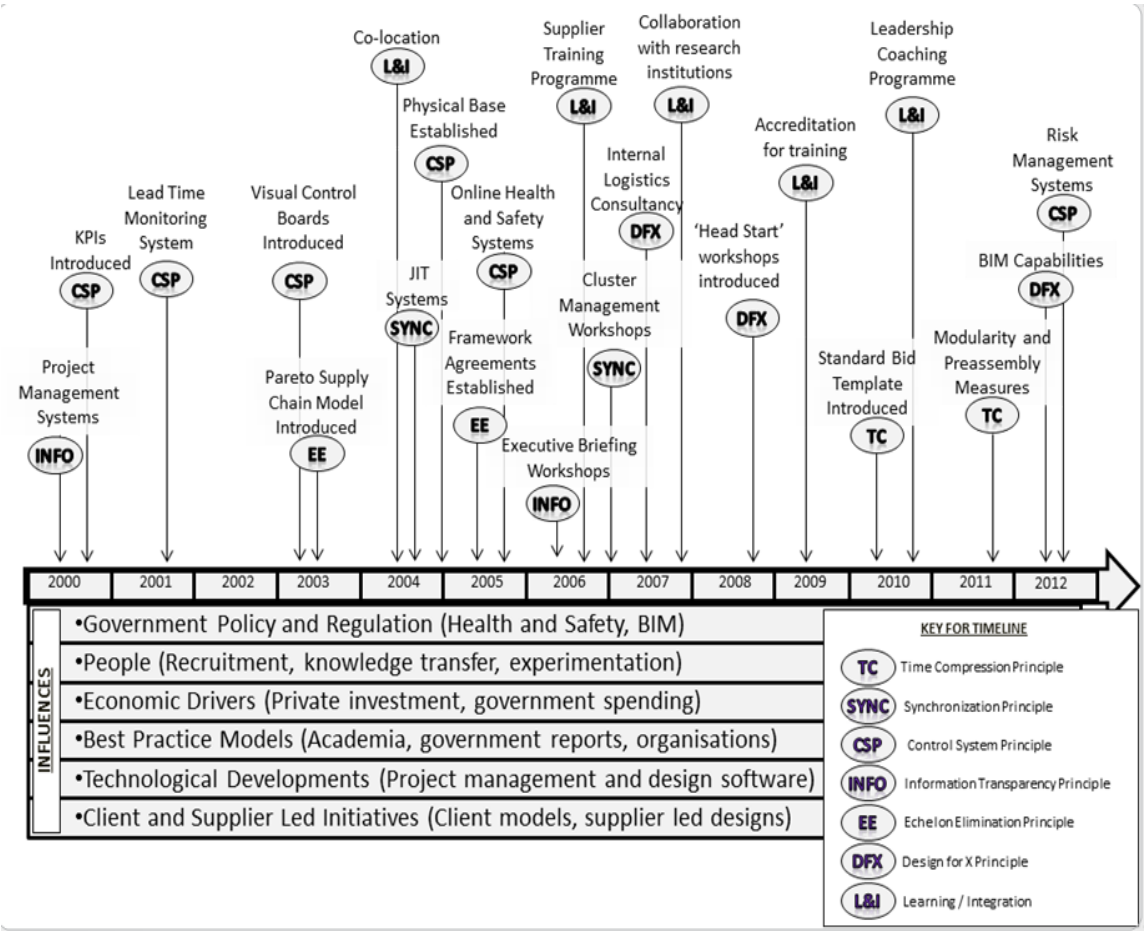

Figure 3: Timeline of supply chain initiatives classified according to the modified FORRIDGE principles

Initiatives that relate to the Control Systems Principle include the design and implementation of a Key Performance Indicator (KPI) System with accompanying visual control boards. IT systems were developed to monitor supplier and project lead times, as well as manage Health and Safety protocols. Importantly, a physical base was established to collate best practice, monitor training and implement best practice across the organisation and supply chain. Finally, more recently, in response to the recession, risk management systems have been implemented. Information

transparency has been improved in a number of ways. Project management systems were implemented early in the timeline, allowing suppliers to see up to date project plans and drawings. These have developed as technology and uptake have got better. Executive briefing workshops were also initiated to give information about upcoming projects and work that may be available in the coming months, therefore allowing supplier to forecast and gain a better understanding of market outlook.

The echelon elimination principle is demonstrated through the development and use of a Pareto supply chain model. This involves supplier rationalisation and a focus on the 20% of suppliers that deliver most of the work for the focal company. Later these are developed into framework agreements: close relationships that apply to both client and supplier relationships. DfX principle initiatives include the setting up of an internal logistics consultancy. This area of the business acts as a consultancy for all projects, and supplier operations. It advises on how to best manage logistics and include such considerations at the design stage. ‘Head start’ workshops have also been initiated to help design clusters work together more effectively, and, more recently, building information management (BIM) capabilities have started to be developed. Finally, learning and integration enablers have also been identified. Such activities include co-location of project teams, supplier training programmes, collaboration with research institutions, accreditation to deliver formal training, and leadership coaching programmes have been developed.

The initiatives presented are analysed further to give insight into sequencing and scope of supply chain learning. Figure 4 exploits the supply chain learning model proposed by Bessant *et al.* (2003) . In mapping the initiatives from the previous section, an additional organisational dimension has been included. This category includes those activities that are 'internal' to the focal company. The majority of the initiatives are complex, and some span across categories. It is interesting to consider the completed matrix in the light of firstly, capturing project specific learning, and secondly, capturing learning at the organisational level (this complex interplay is well explained in (Gann and Salter 2000)). For individual projects, IT systems help to record KPIs and statistics for individual projects, and documented case studies of key successes and learning points both help to facilitate project learning. At the firm level, the establishment of a department within the organisation responsible for promulgating, capturing and exploiting best practice. This relates strongly to the initiative to establish a physical base to manage knowledge and best practice.

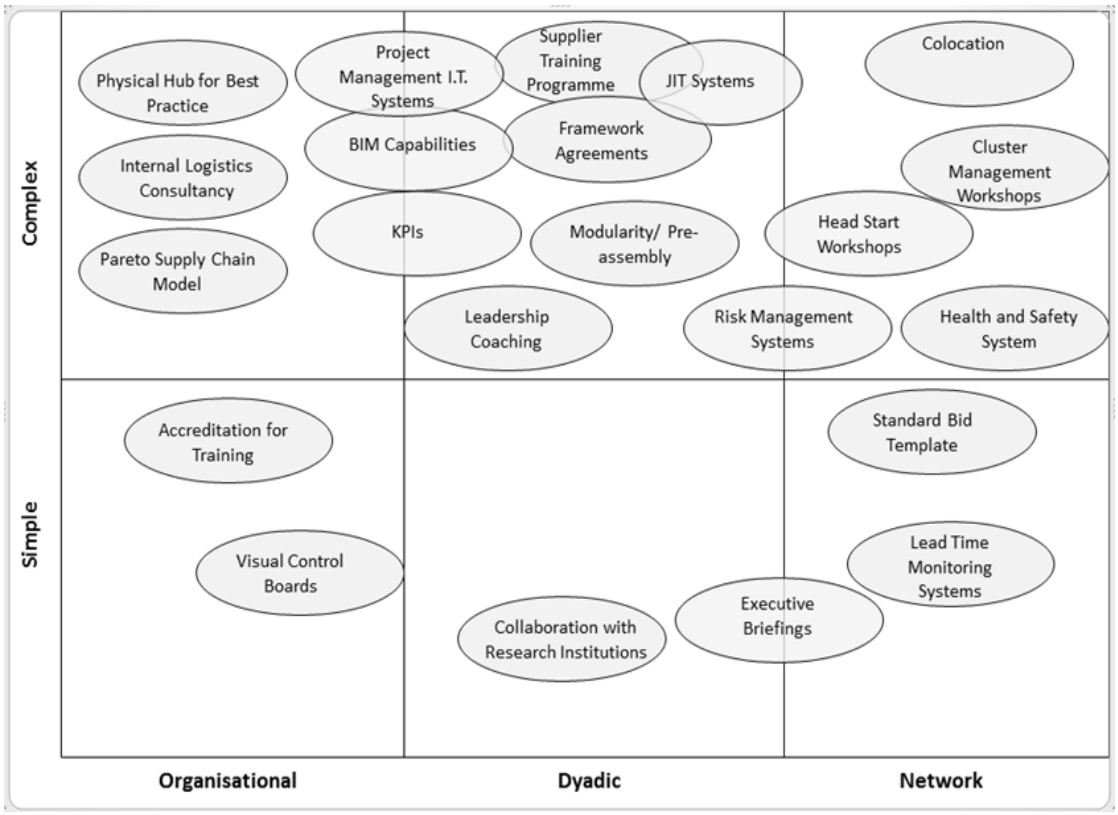

Figure 4: Initiatives mapped onto supply chain learning matrix

An 'idealized pathway' emerges from the figure. Organisations should begin with the internal organisational initiatives identified, as they can be more easily controlled and can be experimented with in a 'safe' environment. Furthermore, the simple activities offer a good platform to learn from before extending to the more complex initiatives. Once the lessons have been learned and the learning form the above has been captured, it may then be possible to move to the dyadic category, where learning can be extended to a selection of close suppliers moving from simple to complex. Finally, network wide initiatives can be targeted.

The final analysis presented in this paper is shown in table 1. It is useful to consider the initiatives in relation to soft systems change models, which categorise issues according to three interacting areas: process, attitudinal and technology (Towill 1991). The initiatives identified are categorised according to these three elements in the table. A large marker denotes a strong relationship and a small marker denotes a weaker relationship. This analysis shows that 16 of the initiatives relate to process, 11 relate to attitudinal, and 5 to technology.

Principle	Initiatives	Process	Attitudinal	Technology
Time Compression principle	Standard Bid Template	✓		
	Modularity / Preassembly	✓	✓	
Synchronization Principle	JIT Systems	✓		
	Cluster Management		✓	
Control System Principle	KPIs	✓		✓
	Lead Time Monitoring	✓		✓
	Visual Control System	✓	✓	
	Physical Base Established	✓		
	Online H & S System	✓		✓
	Risk Management Systems	✓		
Information Transparency Principle	Project Management Systems	✓		✓
	Executive Workshops		✓	
Echelon Elimination Principle	Pareto Model	✓		
	Framework Agreements	✓	✓	
Design for X Principle	Internal Logistics Consultancy	✓		
	Head Start Workshops		✓	
	BIM Capabilities	✓		✓
Learning /Integration	Co-location	✓	✓	
	Supplier Training		✓	
	Research	✓	✓	
	Training Accreditation		✓	
	Leadership Coaching		✓	

Table 1: Table showing classification of initiatives

CONCLUSIONS

A long term supplier improvement programme of a major construction company was investigated and analysed in a number of different ways. The 'anatomy' of this programme was presented as a timeline of improvement initiatives undertaken between 2000 and 2012. These initiatives were related to established supply chain 'FORRRIDGE' principles, which were developed for a construction sector context. The additions to the original FORRIDGE principles help to enrich this established framework. The programme was further analysed by considering it in light of supply chain learning. This gives insight into an idealized pathway for implementing supply chain initiatives, thereby arguing that the elephant should be eaten in bite size chunks, broken up into a series of learning exercises. Finally, the programme was analysed by considering process, attitudinal and technological aspects. Process and attitudinal challenges were the most numerous.

We argue that implementing the FORRIDGE principles, combined with a structured approach to accumulating and capturing supply chain learning, offers considerable opportunity for competitive advantage for those willing to invest. We do acknowledge that there are a range of barriers in achieving the vision that is set out in the FORRIDGE principles, and that the empirical elements of this paper inevitably have limited claims to generalisability, but we do seek to set out an approach to address some of the well documented supply chain failings of the construction industry. The principles may be achieved in a myriad of different ways. It is hoped that the insight given in this paper, the FORRIDGE principles, the initiatives undertaken by a

construction company, and the sequencing method proposed, will be of interest to researchers in the area of construction supply chain management and gives organisations some guidance in designing and implementing their supply chain improvement programmes.

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KNOWLEDGE TRANSFER WITHIN AND ACROSS ORGANIZATIONAL BOUNDARIES -A CASE STUDY IN THE CONSTRUCTION INDUSTRY

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Knowledge transfer is essential for an organization to be competitive and successful. However, as projects are temporary, knowledge is often bound to the individuals in projects rather than to the core organizations. The main research question for this article is: *How can collaboration be used in order to transfer knowledge from one project to another within an organization or with other organizations within a project?* To do this, a theoretical framework of recent literature concerning knowledge management and transfer is used, as well as a case study about an urban development organization working with a rather unique collaboration structure in order to maximize the knowledge transfer from and between different actors. Our method of research has been interviews with a divisional manager and two project managers at an urban development organization. Results from our case study indicate that in the planning phase, knowledge transfer includes collecting feedback and information as well as using a central knowledge platform. During the production phase, face-to-face communication is the most important form of knowledge transfer. After each project, evaluation is essential to collect the experience of collaboration and identify planning errors. Our findings also show that most knowledge transfer occurs at an informal level. The study concludes that several factors affect knowledge transfer in a construction organization. The most essential are the media in which knowledge is transferred and the way information is stored. Taking all factors into consideration, an organization with a decentralized structure and an open and broad-minded culture enables successful knowledge transfer.

Keywords: construction industry, knowledge objects, knowledge transfer, learning boundaries, project organizations.

INTRODUCTION

In the construction industry, projects are delivered by temporary project organizations, put together from different groupings such as design and construction teams. This means that the knowledge in construction companies tends to be contingent,

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Berg S; Legnerot C; Lindström A; Nilsson M; Bosch P and Gluch P (2012) Knowledge transfer within and across organizational boundaries -A Case Study in the Construction Industry *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 645-654.

situational, and otherwise bound to individual and local practices(Styhre and Gluch 2010). The uniqueness and short-term orientation of temporary project organizations creates obstacles in knowledge management that may hinder the development of routines and organizational memory. Knowledge management in an organization implicates the creation, storing, using and sharing of knowledge (Lindner &Wald, 2011). To achieve successful knowledge management, knowledge must be transferred to other parts of the organization, enabling effective project performance and successful project delivery to clients (Gangcheol *et al.* 2011).

Construction organizations often have a lack of natural mechanisms of learning which makes the transfer of knowledge difficult, usually due to geographically dispersed projects or intercultural project teams (Lindner &Wald, 2011). The focus on deliverables in projects and the long-term perspective of knowledge management may often create conflicts of goals, thus making knowledge transfer a lower priority. Knowledge transfer is the process where ambiguous and complex routines are reconstructed and stored in a way that they can be adapted and used in future projects (Hui-Min 2009). In practice however, projects are not commonly thoroughly reviewed at the end (Williams 2008). The purpose of this article is to study why knowledge transfer is important, what makes it difficult in practice, as well as discuss solutions to the problems with knowledge transfer that often arise in the construction industry. The main research question for this article is: *How can collaboration be used in order to transfer knowledge from one project to another within an organization or with other organizations within a project?* To do this, a theoretical framework of recent literature concerning knowledge management and transfer is used, as well as a case study about an urban development organization working with a rather unique collaboration structure in order to maximize the knowledge transfer from and between different actors.

THEORETICAL FRAME OF REFERENCE

Knowledge is a key factor for many organizations(Lindner and Wald 2011) and is used in organizations' everyday practice. Handling knowledge may be seen as an ongoing social accomplishment (Styhre and Gluch 2010). The transfer of knowledge between organizations and within an organization is a complex phenomenon that is an important factor (Easterby-Smith *et al.* 2008) for an organization to retain its competitiveness (Hui-Min 2009). The process of knowledge transfer consists of several steps that start with the creation of knowledge, for example from individual experience. After knowledge creation follows the use, transferring and sharing, and finally the storage of knowledge in a way that it is easy to retrieve for further use (Lindner and Wald 2011). Further down the theoretical framework, we discuss how knowledge is created, knowledge transfer in practice and, finally, factors influencing knowledge transfer.

KNOWLEDGE CREATION

Knowledge is often divided into two different categories: tacit and explicit knowledge. Tacit knowledge is the kind of knowledge that is difficult to explain but is basically known by heart, for example riding a bike. Explicit knowledge is knowledge that could be explained, documented and easily transferred to another person (Clegg *et al.* 2008). The process of transferring knowledge between tacit and explicit knowledge includes four major movements. Knowledge creation in this context is often referred to and explained by the SECI-model, developed by Nonaka and Takeuchi:

socialization, externalization, internalization, and combination (Gangcheol *et al.* 2011).

Socialization (tacit to tacit) comes from just being around other people usually through mentorships, apprenticeships and includes rules of behavior, codes of conduct. The person who is learning learns without ever thinking about its meaning. *Externalization* (tacit to explicit) is done by formulating concepts and creating models to be able to explain how something works. *Combination* (explicit to explicit) is for example how the organizations learn from conversations, meetings and written documents. *Internalization* (explicit to tacit) occurs when something is learned and then repeated over and over again for a long period of time. People stop thinking about their actions and do them automatically, often referred to as learning by doing (Clegg *et al.* 2008).

The most difficult movement of the knowledge process is externalization. Explicit knowledge can be stored in documents and databases, but tacit knowledge cannot. This becomes a problem for many organizations as tacit knowledge is rooted in the actions of the employees and is very valuable if transferrable to the entire organization (Lindner and Wald 2011).

Knowledge transfer in practice

Linking individual perspectives of knowledge to an organizational level is one of the main challenges of knowledge transfer. If an organization wants to use lessons learned in future projects, the knowledge needs to be transferred from the individual to the core organization. The achievement of this is called organizational memory and is what most organizations desire as part of their development(Lindner and Wald 2011). A challenge when transferring knowledge from the individual to the core organization is that all individuals represent and interpret knowledge in different ways (Cacciatori 2008). This aspect of knowledge transfer is difficult in itself to achieve. To transfer knowledge from one organization to another is even more difficult as different organizations have their own cultures and processes, which create multifaceted boundaries that complicate knowledge transfer (Easterby-Smith *et al.* 2008).

Working in projects may complicate some aspects of knowledge transfer, even if it could be beneficial in some cases. Projects are commonly unique and temporary which means there is often a lack of standardized routines. Without standardized routines it is very difficult to receive continuity in core organizational learning and knowledge transfer (Williams 2008). Many authors point to the value of having reviews as milestones during the project rather than only at the end, as cited by Williams (2008):

"Valuable learning experiences take place at the beginning of the project, but are not captured until the post project review at the end."

Most project-based organizations are lacking a functioning system for transferring knowledge and are relying on the informal networks and the social channels of the employees when sharing knowledge within the organization(Styhre and Gluch 2010). In practice the means of this communication is direct contact, phone calls and e-mail. The formal mechanisms the core organization provides are often not used as frequently as the informal ones (Styhre and Gluch 2010).

Essential for successful knowledge transfer is a culture that is positive towards new knowledge (Lindner and Wald 2011). Such a culture may result in project team members that are motivated to teach, learn, and trust in knowledge from other people.

It is also important to have a tolerant environment within the project and organization. There should be a high degree of openness, cooperation, and a positive attitude towards mistakes. In such an organization, it is easier for project team members to tell their co-workers and supervisors when something goes wrong (Lindner and Wald 2011). The organization is then able to reflect over the mistake and limit the risk of doing similar mistakes in future projects. The team members should, in addition, get time for participating in knowledge transfer activities.

Learning boundaries and knowledge objects

The degree of knowledge transfer is influenced by several factors, of which many are interrelated. Knowledge management should be centralized in an organization as it thereby will be easier to legitimate the devotion of time and resources for knowledge transfer (Lindner and Wald 2011). However, the organizational structure should be decentralized to enable both horizontal and vertical communication.

A high degree of absorptive capacity of the receiving group or organization is essential for successful knowledge transfer (Easterby-Smith *et al.* 2008; Bakker *et al.* 2011). The absorptive capacity is the receiver's ability to understand the value of, interpret, reflect upon, store, and use knowledge (Hui-Min 2009). Interrelated to the absorptive capacity is the intra-organizational transfer capability. New knowledge is only fully usable if it is disseminated within the organization and easily accessible for the members (Easterby-Smith *et al.* 2008). The nature of the knowledge being transferred also plays a significant role due to how the knowledge should be used. All kinds of knowledge have different degrees of ambiguity and complexity and must be handled in different ways before being stored and disseminated (Easterby-Smith *et al.* 2008).

Learning boundaries can be barriers for knowledge transfer but at the same time be important for learning. Overcoming learning boundaries is a challenge during knowledge transfer between individuals, groups, and projects. However, overcoming obstacles generates a high level of learning (Scarbrough *et al.* 2004). It is important to identify and consider learning boundaries when analyzing the benefits and development of knowledge transfer within and between projects (Scarbrough *et al.* 2004). Boundaries can be small features that can have a great impact of knowledge transfer. Different individuals and groups might use different language, which hinder the flow of knowledge. They can also represent and interpret the knowledge in different ways due to different means, practices, and interests within a project.

Knowledge objects are often described as artifacts and memories of objects rather than a process. Organizations tend to be focused on good documentation during projects and processes. However the actual usage of the stored knowledge is relatively low, often due to low quality of indexing. Organizations use several types of objects to store knowledge, such as databases for explicit knowledge, project memory systems, and journals kept by the site manager. Also used are platforms, defined as "a set of prescribed processes, entities, operations and resources that are brought together when producing some relatively standardized output" (Styhre and Gluch 2010). These types of objects standardize the processes in some way, which makes it easier to bring knowledge across projects. There are, however, some problems in implementing these objects fully into the construction industry. Construction organizations tend to have a strongly instituted principle to avoid standardized solutions and 'off-the-shelf designs' of buildings.

Most knowledge stored in objects is explicit or "codified", such as databases or documents. However, they should also handle the contexts and social processes behind the documents in order to transfer knowledge in a successful way. In order to retrieve and store this personalized knowledge, different procedures such as personal interaction and workshops are required (Lindner and Wald 2011).

METHOD

In order to examine how knowledge transfer within and between organizational boundaries functions in practice a case study was done. To collect information, three interviews with an urban development organization (UDO) were carried out with employees in different positions in the organization. One division manager and two project managers were interviewed with focus on the interviewees' work with knowledge transfer within and across projects. All interviews took place at UDO's office in a major city in Sweden; they were semi-structured and lasted for approximately one hour each. Finally, the findings from the interviews and the theories found in literature were compared in order to discuss the results and make conclusions.

Case description

UDO is an organization owned by the municipality, and its main mission is to develop old industrial areas in the central part of a major city in Sweden. The development includes the whole chain from the acquisition of land to the development of the area, and selling of properties. During the process, the focus is to create areas that are long-term and sustainable. To accomplish their mission UDO has designed a business model based on close cooperation with different property owners and contractors. This cooperation is carried out through mutual projects driven by shared incentives and goals.

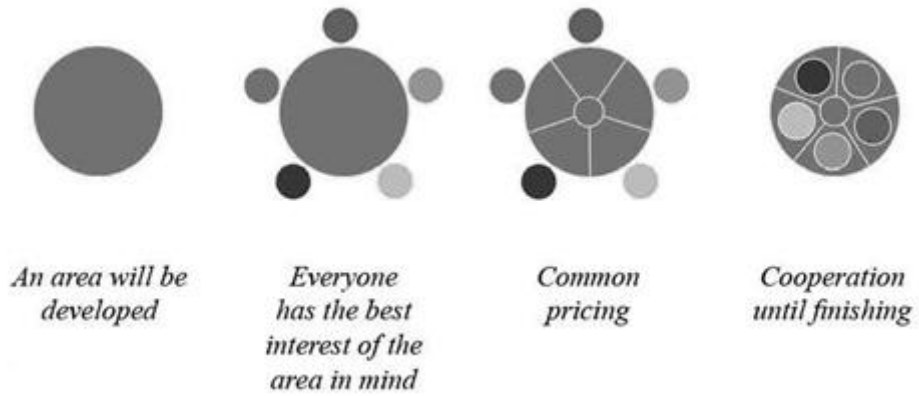

Figure 11: UDO´s conceptual model

The model (see Figure 1) starts with a qualification process where different property owners and builders are invited. UDO and the chosen actors establish a consortium in which they work together with the best interest of the area in mind, not knowing which lot they will be responsible for later on. The area is divided in lots and different types of housing and the actors decide together which lots each actor is going to buy and build. The consortium cooperates throughout the entire production phase. UDO has the managing role in the consortium and the project manager follows a project from planning until the area is populated.

RESULTS FROM THE CASE STUDY

To be able to transfer knowledge successfully, it is important to value experience according to the interviewees at UDO. The Urban Development Organization has worked with its mission for over twenty years and many of the employees have been working at UDO for a long time. For example, the division manager was involved in the creation of their model in the beginning. During this time they have gotten to know the construction industry in the city, formed business relationships and created networks.

Knowledge transfer in the planning phase

Collecting feedback and distributing information are two important factors at UDO in the beginning of a new project. A lot of time and effort is spent at an early stage to investigate pros and cons from previous projects since experience is the key of project evolvement. An essential part of their communication is to involve the affected stakeholders. Internet is an important tool since most information is distributed through UDO's website and blog. To inform the public, 3D-models of the projects are often used as a way of giving the locals a picture of future development.

UDO uses a project-common platform to handle all documents included in a project. By using a shared platform, it is easier to keep information updated and current since there are no transformations of documents between different systems. Instead of sending e-mails, information is uploaded by UDO and the different actors to the platform, which leads to fewer misunderstandings. In addition to the platform, UDO manages it so that the consortium is able to meet regularly to exchange ideas and experience, usually every third week. In the beginning of a project, meetings are held more frequently and as the project evolves, the meetings are held less often.

Knowledge transfer within UDO is often managed internally. To make changes to the more educated staff, education and coaching may go on for several years. For example, one division manager will retire in a few years and his successor has already been chosen. These two now work closely together in order to transfer routines, relationships and market knowledge to the new division manager. Some knowledge is also bought externally, however UDO is not obligated to use the same consultants as before in order to pursue development and knowledge transfer. Apart from this, knowledge is sometimes collected by visiting colleagues at different locations.

Knowledge transfer in the production phase

According to all interviewees, in order to enable knowledge transfer in production, it is important to have regular meetings. There are basically two different kinds of continuous meetings, which are usually held once a month. The first mostly covers checkups on different levels to see that the project is developing according to the planned schedule and cost. The second is held to ensure a safe working environment. Both of these meetings are a good way of communicating both errors and successes of a recent project. All interviewees agree that the best way to communicate is face-to-face. Personal meetings have always been very frequent but nowadays, with new technical solutions of communication, video conferences and video-calls have become more common. According to the project managers, these new media of communication are not as effective as personal meetings. The division manager has therefore made arrangements so that the project managers are able to meet every second week to share their thoughts, ideas and reflections with each other. Protocols are written during the meetings; however these do not include experience-specific

knowledge. In one of UDO's current projects, all companies involved are based in the same city. According to the project manager, this is an advantage because of the possibility to have more frequent personal meetings. In advance of the meetings, the project manager prepares an agenda in which information is distributed among the participants. During the meeting, all actors of the consortium are able to ask questions and share experiences with each other. To gather all parties frequently is often a necessary procedure to make sure that the project and future projects develop in a satisfactory way. As already stated, personal meetings were considered the best way to communicate and UDO organizes formal meetings with a decentralized structure for experience sharing. However, according to the project managers, most knowledge transfer occurs at an informal level. Coffee breaks, lunches and just passing by each other in the corridors are the most frequent methods of transferring knowledge. Thus, it is important to have the staff located in the same building to retain this way of communicating.

Knowledge transfer in the evaluation phase

To ensure a continuous learning and development of UDO and improvements for future projects within the organization, a lot of effort is put into evaluating each project. The experiences of the collaboration are collected and planning errors are identified. According to one of the project managers, planning errors can be detected during every phase of the project. New knowledge is stored in the project manager's memory and to some extent in meeting protocols. The division manager explained that UDO made an effort to create a categorized knowledge-database where it should be possible to make a word search and get information about previous experience of construction solutions, specific for their projects. However, the development of the knowledge-database has stagnated in an early phase and is not usable for the time being.

Every other year, a survey is performed with all actors in the consortium in a certain development area. UDO hires an independent organization to execute the survey and evaluate UDO's role and activities during a project. When the results have been compiled all actors and UDO have a workshop to discuss the results. Due to the project managers' and division manager's thoughts about the importance of face-to-face transfer, these surveys and workshops seem to be a good way to exchange experiences and develop processes within a project.

According to one of the project managers, it is the division manager who is responsible for the knowledge transfer from one project to another. The project managers will, however, apply their own experiences from previous projects when starting up a new one. The project manager feels that he does not always get enough response from his superiors when communicating feedback from a current or previously completed project. It may be difficult for the division manager to enable efficient knowledge transfer if there are no routines to document gained experiences. As long as there is no such documentation, the project development relies on the project manager's own experiences and tacit knowledge.

DISCUSSION

Knowledge transfer can be seen as a constant process of bonding and bridging between different actors. In general it is the face-to-face meetings that work best and the informal mechanisms are more effectively used than the formal ones (Styhre & Gluch, 2010). The project managers pointed that the informal meetings during coffee

breaks or in the hallways are more useful for knowledge transfer that the formal meetings with agendas. At UDO, all employees have their offices at the same floor in the building and the kitchen and coffee machine is situated in the center of the floor. Unless they have a telephone meeting or such, the employees keep their doors open to make it easier for their colleagues to drop by and ask questions. Thereby, UDO is encouraging and enabling informal meetings within the company and creating an open atmosphere.

Consortium and absorptive capacity

As stated in the result, a better knowledge flow between two parties will be enabled if they use the same languages and practices, have the same means and interests within a project, and to some extent share the same culture (Scarbrough *et al.* 2004). UDO is forming consortiums with other actors, which is a good way to create a common language and practices. A high degree of trust between the different parties, and a positive attitude towards mistakes when means and interest are shared, is important for successful knowledge transfer (Lindner and Wald 2011). If the parties trust each other, they will have the courage to tell the others if they have a problem, which may then be identified and treated in an early stage.

To enable open communication between all parties and hierarchical levels within a project or organization, there should be a decentralized decision-making structure (Lindner and Wald 2011). A decentralized structure increases an organization's absorptive capacity as new knowledge can be discussed, reflected over, and interpret to a larger extent. Reflection is crucial for knowledge to be successfully transferred and absorbed. If experiences are only reviewed and not reflected, there will probably not be any higher levels of learning generated. This is particularly important for projects where the knowledge needs to be stored in the core organization and used in the next project for not reinventing the wheel.

Storing knowledge

Knowledge and information in general need to be easily accessible for the involved actors to enable knowledge transfer. The knowledge transfer chain, from creation of knowledge to storing and retrieving (Lindner & Wald, 2011), is a good measure of success. UDO has many routines for the first parts of transferring and sharing the created knowledge but few natural storing and retrieving processes. An indication of this is that the project managers said that they keep most of the knowledge in their memories. In this case, they may be the only ones that have the specific knowledge and are able to transfer it. The future is hard to predict, and it is essential for UDO not to lose such knowledge. Another indicator is that the use of stored knowledge is low in general. This can depend on the type of knowledge that is stored or the actuality of the knowledge. At UDO, most of the stored knowledge is captured in protocols from meetings as meetings are a large forum for knowledge transfer. To be able to use explicit knowledge from protocols, these should be developed or divided into one formal part and one part for knowledge sharing and transfer.

Standardization of knowledge transfer

Standardized routines have an essential part in gaining continuity for knowledge transfer in organizations (Williams, 2008). UDO has several years of experience in planning and developing areas and has during that time established routines for the processes. They often use experience from earlier projects to standardize some parts in

the next. Since UDO works with unique and temporary projects, standardization of all project processes is difficult to achieve.

The use of knowledge objects is another way of standardizing processes for knowledge transfer across and within projects. A common knowledge platform, as the one used in the consortiums or a knowledge database like the one UDO started to develop, are good examples of objects for continuity in knowledge transfer. The consortium platform functions very well in order to transfer knowledge in comparison to the database. At all times, it is important to keep relevant data and documents updated. A problem with the database could be that if it is not updated regularly, implemented in the right way or easily searched for information, the users abandon it. However, if the users find that the database simplifies their work, they might start to use it more frequently. In the end, the knowledge database may become a cultural artifact that is used on a daily basis as a knowledge library. To realize this, it is necessary to make someone responsible for the knowledge database to make sure the content of the database is current and categorized in a way that makes information easy to find.

Knowledge transfer activities

Today UDO uses workshops to analyze feedback from their surveys but the possibilities are much greater. A workshop is a kind of meeting where parties meet and discuss in a less formal climate. This is a useful way of externalization when people meet face-to-face and everyone is able to talk openly. The informal climate makes it easier for the actors to understand the knowledge and the underlying interpretations and to turn the tacit to explicit knowledge. However, it is important to keep in mind that not all tacit knowledge can be externalized into explicit (Cacciatori, 2008). In this case the project manager may act as a debriefer because of his neutral position in the consortium. The knowledge and experience collected during the workshops can be transferred to the core organization if they are documented and stored in a knowledge database. One of the greatest challenges in knowledge transfer is the transfer from one individual to the organization. Individuals represent and interpret knowledge in different ways (Cacciatori, 2008). Having routines for document and store the outcomes of a workshop may be a good way to overcome that challenge. Each of the participants of the workshop can together discuss and formulate from their individual experience. It may thereby be easier to interpret by future users of the knowledge database.

By using workshops and frequent meetings, UDO has a good opportunity for successful knowledge transfer within the consortiums. As stated above, it may also be possible to transfer the knowledge and experiences to the core organization if properly documented and stored. To ensure a correct and consistent storing, one individual or small group should be designated as responsible for the knowledge database. The organ for knowledge management should be centralized (Lindner & Wald, 2011) and considered important within an organization. They should not only be responsible for storing knowledge but also to disseminate it within the organization. Moreover, they should be perceptive to feedback from the project managers and make sure that the stored knowledge is always up-to-date.

CONCLUDING REMARKS

This study has shown that there are several factors that affect knowledge transfer within and across organizational boundaries. It is impossible to point to one that is

more essential for the organization than others; instead this paper has shown that a mix of several different factors is needed for success. In general, an open and broad-minded culture seems to be an important factor for enabling knowledge transfer in organizations. The case study as well as the literature study also points to informal face-to-face meetings as a good way to transfer knowledge. Therefore, it is important to have a decentralized structure, and a culture that allows informality.

Furthermore, the media in which knowledge is stored and transferred has shown to be very important. It needs to be designed in such a way that knowledge is easily found and thus easy to transfer. Knowledge must be available in both a short-term and a long-term perspective, which put high demands on the media used to be stable and flexible. Furthermore, it is not only important to know *how* something should be done. To know *why* something should be done in a certain way is as important as to know how to do it.

Knowledge transfer is a very broad term and so far relatively new in management studies. A single case study is probably not enough to grasp the full meaning and implications with knowledge transfer. However, this paper points to several important factors that should be taken into consideration. The case study also shows how a rather successful urban development office in Sweden works with knowledge transfer within and across organizational boundaries.

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DESIGNING A DYNAMIC NETWORK BASED APPROACH FOR ASSET MANAGEMENT ACTIVITIES

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Transportation networks are important public infrastructures because they enable economic and social activity. Trends in contracting the maintenance of such assets have caused a shift in governance from a public body to market-like arrangements and changed the roles and responsibilities among asset owner, asset manager and service providers. Basic assumption of this research is that collaboration between contractors in road infrastructure is needed and can be stimulated through facilitating joint coordination on a network level, based on a social costs incentive. Based on a literature review design components and possible techniques are identified. Then the concept design and testing methods for a dynamic network-based tool to facilitate strategic infrastructure asset management is proposed.

Keywords: asset management, collaboration, procurement, scheduling, serious gaming.

INTRODUCTION

Infrastructures represent long enduring and shared resources that are used by different actors. Compared to other kinds of assets, infrastructure has specific characteristics, such as a very long lifespan of assets with no resale value and little administration over the current status, consisting of a widely distributed evolutionary networked system with passive elements that requires dynamic and flexible design. Consequently managing infrastructure assets often faces complex uncertainties that are often more compound that those found in other forms of asset management (Altamirano 2010).

Ever since the increase in maintenance of current infrastructure and the growing lack of financial means of governmental bodies, the interest in strategic asset management in the field of infrastructure is increasing (Moon *et al.* 2009, Schraven, Hartmann and Dewulf 2011). The Institute of Asset Management (2011) defines asset management (AM) as 'systematic and coordinated activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their

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Volker , L; Scharpff , J; de Weerdt, M and Herder, P (2012) Designing a dynamic network based approach for asset management activities *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 655-664.

associated performance, risks and expenditures over their life cycles for the purpose of achieving its organizational strategic plan'. The most important actors in AM are the asset owner (e.g. the national government), the asset manager (e.g. the National Highway Agency), and the service provider; a contractor or professional service firm that provides the maintenance and other kinds of construction work.

The main issues in current contracts can be related to their more static nature; contracts are commonly fixed at the beginning of a project and are not sufficiently capable of adapting to changes. Especially in long-term projects, where a lot of (unforeseen) changes occur, current contracts are hardly adequate to ensure a successful result. Moreover, the network aspect of infrastructural maintenance is commonly neglected in current contracting procedures, thereby failing to work towards system optimal asset management.

Due to the fact that individual infrastructure assets such as road segments, are connected in a network structure, a disruption in one part influences the load in another part. Consequently maintenance often leads to a lower overall network performance. Furthermore, the size of the network requires the involvement of a number of service providers. Until now these service providers hardly collaborate since the asset manager centrally coordinates their activities on the network.

This research explores the possibilities of self-regulating this process in order to increase the network performance in a dynamic contracting approach. It is argued that the execution of long-term performance-based road maintenance contracts may benefit greatly from addressing this issue of self-regulation on a network level already in the procurement phase, with a view to the implementation phase. Basic assumption is that collaboration between contractors and awareness about social costs of maintenance in infrastructure is needed and can be stimulated through incentives.

This paper lays out the components of such dynamic contracting and planning concept for asset management activities. We present the design approach for a strategic procurement and planning tool that will facilitate this complicated, uncertain and dynamic process. Based on a literature review the current gaps in theory and practice are identified, a concept for a network-based tool for dynamic planning in asset management is proposed and possible model and simulation techniques for our work are outlined.

One way of characterizing governance strategies sprouts from organization and management studies: contractual governance strategies and relational governance strategies (Poppo, Zheng Zhou and Zenger 2008). Contractual governance can be defined as an established formal, legal, and economic governance strategy; relational governance refers to the developing strength of the social norms present in the exchange and has often been referred to as relationalism (Vandaele *et al.* 2007). Relational governance usually employs a positive link with contractual governance.

This is also confirmed by Eriksson and Westerberg (2011), who claim that construction collaboration is enhanced by the mediating role of joint specification, selected tendering, soft parameters in bid evaluation, joint subcontractor selection, incentive based payment, collaborative tools and contractors self-control in the procurement phase. The moderating role of cooperative procurement procedures is fed by the fact that: existing partnering agreements facilitate joint specification in concurrent engineering; long-term collaboration with a few competent contractors decreases the risk of unsuccessful partner selection; trust based collaboration facilitates the design and use of an effective incentive scheme; and contractor self-

control is based on concern for the client and therefore facilitated by long-term collaborative relationships.

In the development of our dynamic contracting concept five major factors are therefore identified that play an important role: performance based contracting, social costs, incentives, trust, and past performance. These are discussed in the next sections.

Performance based contracting

In the past two or three decades we have witnessed a considerable change in the procurement and realisation of infrastructural maintenance projects. The introduction of Public-Private Partnerships (PPP) in the late 70s and early 80s has resulted in more innovative, risk-sharing contract forms, adopted by governments and public institutions world-wide (Altamirano 2010). Indeed such contracts are expected to offer various benefits over the more ’classical’ regulatory contract - contract approaches that are based on controlling contractors by regulation - such as increased flexibility, more innovation, better performance, and subsequently lower costs.

These benefits, however, are accompanied by a higher level of uncertainty and introduce additional possibilities for opportunistic behaviour. Particularly in the long-term, performance based contracts these undesired effects are likely to arise, resulting in unsatisfactory results or even total failures (O'hare, Leone and Zegans 1990). Moreover, performance based contracts allow for a greater degree of freedom in project implementation. This freedom could result in innovations but could also lead to a misalignment in the objectives of both parties: public institutions seek to optimise social welfare whereas contractors are focussed only on profit. These different interests frequently give rise to conflict, a problem identified already in earlier work on buyer-supplier relationships (Pigou 1912, Jensen and Meckling 1976).

Social costs

Although it is widely acknowledged that the network user has a key part in asset management, its role is commonly neglected or minimised in current contracting procedures (Brown and Humphrey 2005). The overall costs to users can be considered as a kind of social costs (Coase 1960). By incorporating social costs into the contract, contractors can be made aware of the consequences of maintenance on users. From an economic perspective one could argue that actions that hurt society most should cost a contractor more money, allowing the contractor to make their own planning trade-offs. Secondly, sharing of social cost can be introduced to stimulate contractor co-operation in planning correlated activities. This is an opportunity that has not been present in contracting procedures before, and is of important value in our research approach.

Incentive mechanisms

Bower *et al.* (2002) distinguish three main types of incentives in construction: share of cost saving incentives between client and contractor, schedule incentives with a premium for early completion, and technical performance bonuses for meeting other performance targets. The work of Bresnen and Marshall (2000) is based on motivation theories from management and organizational theory, and demonstrates that attitudes towards gain share-pain share arrangements were found to be quite positive and useful in reinforcing collaboration. Yet, other intrinsic and extrinsic sources such as autonomy and the prospect of further work, and the relationship between client and contractor were much more important to the companies and staff members.

The general principles upon which incentive systems should be based include the need to ensure that risks and rewards are commensurably and fairly distributed among the parties concerned and that they are tailored to specific project objectives (Bresnen and Marshall 2000). Rose and Manley (2011) emphasize the need for a procurement strategy that encourages trust, unity, and fairness in project team interactions in addition to financial incentives. They developed and tested four motivation indicators for project success in four large construction cases: goal commitment, distributive justice, process fairness, and interactional justice. It was, amongst others, concluded that financial incentive mechanism design should incorporate flexibility to modify goals and measurement procedures over time, and that financial incentive mechanism benefits are maximized through equitable contract risk allocation, early contractor involvement in design, value-driven tender selection, relationship workshops, and future work opportunities.

Despite the overall believe that incentive mechanisms improve value for money during procurement and project performance during execution, empirical research is scarce (Rose and Manley 2011). For the dynamic contracting concept it will thus be a challenge to combine the best of both worlds and design a concept that meets the needs of the service providers and the asset managers.

Trust

The need for trust between organizations arises from the dependence risk in combination with a lack of control (Laan 2009). This is affected by performance which leads to a dynamic relationship between risk, control, trust, and performance. Trust research has identified three levels of trust: personal, organizational, and institutional trust.

There are three ways to influence trust and opportunistic behaviour (Nooteboom 2006): opportunity control (restriction by limiting the opportunities for action by a contract or hierarchical supervision); incentive control (discouragement by limiting the exploitation of opportunities through reliance on relationships, 'hostage' or reputation effects), and benevolence or goodwill (intrinsic motivation by limiting tendencies toward opportunism based on social norms or personal relations).

The results of a longitudinal study of Badenfelt (2010) indicate that the use of control mechanisms is part of a complex and dynamic socially constructed process that requires on-going discussion and evaluation, and to which informal control mechanisms are central. Even in trust-based collaborative settings, such as partnering arrangements, the contracting parties must pay attention to micro level informal and subtle trust-nurturing actions and control mechanisms. In a network context Klijn, Edelenbos and Steijn (2010) have found that a higher level of trust will lead to outcomes that actors in these networks perceive to be of higher quality. The level of trust will be higher when more network management strategies will be used.

Past performance

Because the selection process of parties takes place early in the project life cycle, it is perhaps one of the most critical undertakings with respect to performance by clients and in direct relation to the success of the project. In this context project success is often measured by the aspects of cost, time, quality, environmental impact, work environment and innovation (Doloi, Iyer and Sawhney 2011, Eriksson and Westerberg 2011). Despite the large interest in the effects of partner selection on project success, research results are still indistinct about the actual factors of influence.

On the one hand scholars aim at identifying a universal set of criteria or the development of decision support systems for contractor selection. For example, the Discrete Choice Experiment of Watt, Kayis and Willey (2010) revealed that past project performance and technical experience (and to lesser extent tendered price and project management expertise to a considerably) are considered to be the most important criteria for actual decision making in procurement situations. Factors that were found to be of considerable perceived importance in previous research, such as workload/capacity, client supplier relations, company standing and experience, seemed to make surprisingly little difference in the choice of a contractor.

On the other hand Doloi, Iyer and Sawhney (2011) have found that the overall project success mainly relies on the technical ability of the contractors in planning and controlling the project. According to their findings a contractor needs to be able to analyse the underlying challenges in execution – a competence which is strongly influenced by the soundness of business and workforce. In this sense performance would improve if contractors are free to plan their own activities.

CONCEPTUAL DESIGN OF DYNAMIC CONTRACTING

The aim of this research is to facilitate scheduling decisions of both the asset manager and the service providers to improve the overall network performance. By connecting a set of asset management activities to a group of service providers, the dynamics and flexibility of asset management is expected to increase while the quality of assets is expected to stabilize or increase on the stated level.

As described in the previous section five design elements have been identified that play an important role in collaboration and project success: performance based contracting, social costs, incentives, trust, and past performance. Initially the concept is developed for a road network and includes mainly schedule incentives based on traffic loss hours, and long term performance based contracts for a designated part of the network. This increases the autonomy and social awareness of the contractors. The level of trust is stimulated through the network based incentive structure. The concept will include a new kind of software which shows the planned activities of all contractors on the network, and supports the service providers in their strategic consideration by calculating all scheduling options available and the consequences for the overall revenues.

In overcoming the gap between strategic and operational issues of asset management, we propose an integrated contracting procedure, linking procurement to construction activities. In the procurement phase the boundaries of the network are defined. Based on the goals and demands specified by the asset manager, the network is divided in segments which are put up for tender. In addition a pricing scheme is announced that captures the social costs of maintenance. The market – i.e. service providers – can submit offers for segments of the road network, basing their prices on the expected cost of maintenance (both their private and social costs in traffic loss hours) given the asset demands. As a result of this phase a group of service providers will be identified, each responsible for a part of the infrastructure, and a set of asset demands and a pricing mechanism that corresponds to the offered prices incorporating the social cost charges. Note that in this phase no actual maintenance plans are developed.

The resulting contract from the procurement phase is used to define the boundaries of the subsequent execution phase in which the actual scheduling of the construction activities is performed. It is now up to the service providers to identify the

maintenance activities that should be performed on their own part of the network and develop a joint, socially (near) optimal schedule for these activities. As we are dealing with long-term contracting in a contingent environment, we propose a periodical scheduling approach. Using one plan for the entire contract duration is unrealistic; infrastructural maintenance is vulnerable to unexpected delays, possibly affecting the entire schedule (Altamirano 2010).

In the dynamic contracting concept for road maintenance the asset user is represented by including the social cost of maintenance in traffic loss hours, which depend on the scheduled maintenance activities over the entire network. Service providers are charged payments relative to their share of the social cost. So causing more congestion on the network means a larger social cost payment. An additional major challenge of this kind of payment is that it implicitly creates dependence between service providers, as the social costs are computed over the joint maintenance plan. The assumption is that by using our social cost as an incentive, the most profitable outcome for the individual agents with the socially optimal outcome are aligned.

MODELLING DYNAMIC CONTRACTING

Because the dynamic contracting model involves social aspects and technical characteristics, we will make use of the insights from organisation science (see previous section) and combine this with more traditional theories and methods such as game theory (Camerer 2003) and mechanism design (Nisan 2007). This enables modelling the system from both the perspectives of the asset manager and service providers, and take the life cycle perspective of assets into account while designing the desired incentives. As mentioned before the concept consists of two parts: procurement of the responsibilities and scheduling of the construction activities. In this section the technical details of the contracting and scheduling model are introduced.

Procuring network based activities

In the procurement phase of the contracting procedure the entire network is procured, allowing service providers to bid on combinations of network segments. Of course, the value for such a combination depends greatly on the segments it consists of. Service providers are most likely more interested in a set of ‘related’ network parts than a random set, for instance because this offers logistical advantages. To capture this ‘added-value’ for related parts, a Combinatorial Auction (CA) is employed to procure (Cramton, Shoham and Steinberg 2006). More specifically, to also consider the multi-dimensional aspect of offers – price, quality, duration, etc. –a Multi-attribute Combinatorial Auction (MCA) is implemented (Suyama and Yokoo 2005, Yokoo, Matsutani and Iwasaki 2006).

In the approach of Müller, Perea and Wolf (2007), bids are scores produced using a publicly known scoring rule and contracting is done based upon that single score. The problem with this however, as also pointed out by Rieck (2011), is that when the scoring function is publicly known, bidders are no longer incentivised to produce multiple quality/price bids. As they contract on a score, they will settle on one (for them) optimal combination of the two. Transferring this to our dynamic contracting approach, the quality/price trade-off is done by the contractors themselves and not by the asset manager. For procurement of public infrastructure this is unacceptable: the asset manager should be able to make its own assessment of price and quality instead of contracting on a score. Therefore an Ausubel-Milgrom ascending price proxy

auction will be used, where bids are composed of price/quality pairs instead of single scores (Rieck 2011). In this mechanism, bidders specify the minimum price for which they want to obtain the contract and a proxy-agent will iteratively bid decreasing (possible multiple) price/quality pairs that offer the potentially highest profit for that contracting in each round of the auction. If the potential profit becomes negative for a bidder (i.e. bid price minus minimum price) he refrains from further bids. The bidding is continued until no better offers, according to the asset manager's scoring rule, are made and for each bundle the bid with the best score is contracted.

Performing maintenance activities

For the next phase of the dynamic contracting model, support is provided for service providers to plan their maintenance activities, preferably in a cost-optimal way. However, a cost-optimal planning for a service provider most likely differs from a socially optimal planning. In the model these two objectives are aligned. Using a mechanism design approach an incentive structure is developed that creates a 'social awareness' at the service provider by showing them the congestion costs. One of the assumptions in the first stage of the concept development is that all service providers are rational agents. These assumptions will be testing and adjusted if needed in a later stage of the development.

Furthermore, the planning problem considers an infrastructural network as opposed to the more commonly encountered single-project asset management contracts. The social cost is computed over the entire network, taking into account all maintenance activity by all service providers. Each service provider is then charged a part of the social cost equivalent to their share of the additional cost they incur (e.g. extra traffic congestion). Therefore service provider revenues depend not only on their individual planning but also on the choices made by other contractors active within the same network. This dependency introduces an additional complexity in the planning of maintenance, as service providers have to co-operate in order to develop optimal joint plans.

To counter these drawbacks, we study a decentralised approach such as the one presented in Jonsson and Rovatsos (2011). Their Best-Response Planning (BRP) iteratively works towards an optimal outcome. In this procedure, service providers initially develop their plans individually, only considering their private cost. Then these plans are combined into a joint plan, which is subsequently improved in rounds. In each round of the BRP, service providers can improve the joint plan by rescheduling their own activities in a turn-based fashion. In contrast to the centralised approach, only the resulting plans have to be presented to the asset manager. Also, the computational complexity of the planning problem is reduced as we only consider a few options at each contractor's local problem. As a price for reduced computational complexity, this method is unlikely to achieve (near) optimal schedules.

TESTING THE CONCEPT

Validation of our dynamic contracting concept will be done in multiple modes of simulation: serious gaming and computer simulation. In both modes, the entire contract procedure will be simulated, although focussing on different aspects. Moreover, the computer simulation functions also as a prototype for the tool that facilitates the procedure.

In the computer simulation the dynamic contracting concept is played by computer agents. This allows us to run a very large number of experiments within a relatively

short time, giving us the opportunity to verify different incentive mechanisms exhaustively. Nonetheless, the quality of the results depends largely on the quality of the input, i.e. traffic data, agent behaviour models. A substantial share of the effort of designing the simulator will therefore be put into acquisition of such data from practitioners and further literature.

In order to study the behaviour of contract partners we will use serious gaming as our research tool (Duke 1980, Axelrod 2003). Gaming has been used in a large number of studies, among others in asset management (Altamirano 2010), as it captures complex system behaviour by involving humans in the actual decision making process (Bekebrede 2010). Traditionally, economic theory (classic as well as new institutional economy) and mathematics would aim at representing human behaviour by means of rules or equations. By including games in our research we mean to get closer to capturing the actual behaviour of humans, even though there are shortcomings attached to gaming as well (Bekebrede 2010). For each of the phases of the concept (procurement and scheduling), a separate serious game will be developed.

The scheduling phase of maintenance activities for the complete road infrastructure network will be tested first. The procurement issues will follow in a later stage. In the first game, which is currently being developed, each player (service provider) is responsible for performing a portfolio of activities in a segment of the network within a period of three years. The individual profit of the service providers relies on the joint amount of congestion caused by these activities. Hence, the players need to collaborate to improve network performance and thus increase their profits. This will affect the level of collaboration and trust between the service providers.

The service providers are supported in this process by the scheduling tool as described in the previous section. The tool shows how the service providers can schedule their tasks and calculates the potential congestion on a network level. By designing different plays, the role of the asset manager on the self regulating mechanism, the role of the tool, and the level of trust between the players will be tested to see which conditions are beneficial for the success of the dynamic contracting concept. The results will be used to further develop and implement the tool in asset management practice.

CONCLUSION

The need for asset management maintenance will only increase in the next decade. This is a particular challenge in times of intensive use of infrastructure assets as a critical link in logistical supply chains, decreasing funds and increasing expected service levels from the users. The literature review shows that both financial and social incentives structures are needed to turn a dynamic contracting and scheduling concept into a success. This research contributes to the need for dynamic and network based maintenance activities by including social costs on a network level, connecting service providers in a new collaborative way.

It will be a challenge to combine the rational assumptions from game theory and auctioning methods perspective to the socially oriented empirical findings of construction research. Applying serious gaming methods opens up the possibilities to find the best of both worlds in testing a concept and a software tool in a protected environment. Explorative conversations with asset managers and service providers imply that a cultural change in construction is required to have a network based maintenance concept implemented. At the same time the potential of the concept for is

well acknowledged. It could, for example, also be applied within the supply chain or facilitate multidisciplinary scheduling on the construction site. Since a lot of serious gaming also focuses on organizational learning and concepts can be adjusted to specific situation relatively easily, this research could contribute to these kinds of applications as well.

ACKNOWLEDGEMENTS

This work was supported by the Next Generation Infrastructures Foundation (http://www.nextgenerationinfrastructures.eu/).

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INFLUENCE OF THE MACRO-ECONOMY ON TRUST IN CONSTRUCTION SUPPLY CHAIN CHAINS

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It has often been claimed that developing trustful relationships across the construction supply chain is likely to yield higher project performance outcomes. However, most recently, it has been suggested that there seems to be an apparent retreat by some of the earlier advocates of the relational agenda through trust development given the economic turbulence. Such claims raise important questions regarding the influence of macroeconomic factors/environment on relationship-based approaches and hence trust development. Was the promotion of such relational agenda purely driven by the burgeoning economy as claimed by some at the time or was this the right direction for the construction industry if higher project performance outcomes were to be delivered to clients? This study aims to explore from literature, the current state of the relational agenda in the UK construction industry with particular emphasis on trust development so as to gain an insight into what the future outlook is likely to be. Literature on trust in construction and other team-based industries are synthesised to identify any links between trust development and themes that relate to or can be influenced by the macro-economy. From this, it is argued that perhaps, the macroeconomic environment exerts a considerable influence on trust. There is a higher tendency for firms to display higher levels of competence trust and relatively lower levels of integrity trust during economic downturns. For high levels of project performance to be maintained, clients may switch between different governance modes underpinned by 'collaborations with and without integrity trust' depending on the project life cycle and macro-economic outlook. This could influence overall procurement and managerial strategies on projects such that the use of transactional approaches could become more prominent during periods of economic downturn.

Keywords: macro-economy, construction supply chains, Trust.

INTRODUCTION

Trust has often featured in construction management literature as a construct which underpins the success of collaborative relationships within construction supply chains (Munns, 1995; Kadefors, 2004; Smyth *et al.* 2010). Construction management researchers have discussed the meaning of trust in the construction project context (Smyth, 2003); investigated how trust develops in construction (Wong *et al.* 2000;

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Manu E.; Ankrah N. A; Chinyio E and Proverbs D.G (2012) Influence of the macro-economy on trust in construction supply chain chains *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 665-674.

Kadefors, 2007; Khalfan *et al.* 2007; Smyth, 2008; Laan *et al.* 2010); investigated barriers to trust development (McDermott *et al.* 2004) and interrogated the value/functional consequence of trust in construction (Munns, 1995; McDermott *et al.* 2004; Smyth *et al.* 2010).

The aim of this study is to explore whether the promotion of relational approaches through trust development was a paradigm driven primarily by the buoyant nature of the UK economy at the time it gained prominence or if there is a genuine acceptance by construction industry players that this is the right way forward for improving project delivery through collaborative working.

The next section discusses trust and how it develops in inter-organisational relationships. This is followed by a synthesis of literature on themes relating to macro-economic factors and how these have influenced the need for and process of trust development across the supply chain on projects. The implications of these macroeconomic influences on the management of construction supply chains are also presented before wider conclusions are drawn.

THE RELATIONAL AGENDA AND TRUST

Promotion of the relational agenda has led to relationship based approaches via trust development being touted as an appropriate strategy for enhancing construction project performance (Munns, 1995; Kadefors, 2004; Kumaraswamy *et al.* 2010; Smyth *et al.* 2010; Cheung *et al.* 2011). Kumaraswamy *et al.* (2008) have referred to trust as an operational derivative of relational contracting whereas Davis and Love (2011) claimed that trust was very key to the assessment, commitment and enduring phases of relationship development. The role of trust in the generic three staged process of inter-firm relationship development has been illustrated in Figure 1.

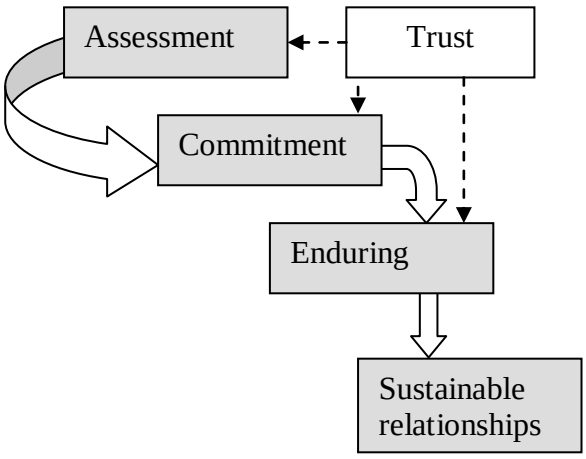

Figure 1: Relationship development process and the role of trust (Adapted from Davis and Love, 2011)

Trust development especially in the construction project context has however been described as a daunting task (Wong *et al.* 2005) and branded an elusive subject by researchers in other disciplines (Atkinson and Butcher, 2003). But if trust is a fundamental ingredient required for achieving sustainable relationships for better collaborative working (McDermott *et al.* 2004), and if its absence is a major failure factor in collaborative relationships (Akintoye and Main, 2007), then it is worth gaining a deeper insight into what trust means, how it develops amongst construction

supply chain members on projects and how this process is influenced by changing macro-economic situations.

Definitions of trust have emerged from different academic disciplines such as economics, psychology, philosophy, sociology and most recently construction management. Though some slight differences exist in the conceptualizations of trust across these different disciplines, the two critical components reflected in most definitions are that trust entails confident expectations and a willingness to accept vulnerability (Rousseau *et al.* 1998). Rousseau *et al.*(1998) suggested that trust should be viewed as a meso-concept that integrates micro-level psychological processes and macro-level institutional arrangements. Trust involves accepting some form of vulnerability based on the positive expectations we develop regarding the behaviour or conduct of others – their integrity or competence (Das and Teng, 2001). Integrity trust has to do with a party's moral obligation and responsibility to act in the interest of the relationship above their own individual interest even when there is a perceived chance and incentive for opportunistic behaviour whereas competence trust is the expectation that a party has the expertise/technical ability to perform their role successfully (Das and Teng, 2001). Arriving at such positive expectations can thus be influenced by psychological processes (Colquitt *et al.* 2007), sociological processes (Sztompka, 1999), institutional arrangements e.g. legal framework (Leslie, 2004) and economic incentives (Williamson, 1993).

In construction, research has focussed on how trust develops amongst project teams (e.g. Wong *et al.* 2000; Kadefors, 2007; Khalfan *et al.* 2007; Smyth, 2008; Laan *et al.* 2010) and some barriers to trust development (cf. McDermott *et al.* 2004). Although trust development in construction has been described as a daunting task (Wong *et al.* 2005), the following suggestions have been presented in construction management literature as a means of improving trust across the supply chain:

1. Providing better alignment of incentives through the use of more collaborative procurement approaches can improve calculative forms of trust (Laan *et al.* 2010);
2. Co-location, frequent informal interactions, increased transparency through shared administrative system for recording project events can improve trust from psychological sources (Laan *et al.* 2010);
3. Communicating openly and effectively improves trust (Wong *et al.* 2005);
4. Increased performance by displaying problem-solving ability and competence of work can improve trust (Wong *et al.* 2005);
5. Lower focus on price and authority and the use of informal social control e.g. usage of collaborative tools, self-policing as a means of performance evaluation, joint objectives and profit sharing (Eriksson and Laan, 2007) can promote trust;
6. Use of contracts underpinned by fairness principles e.g. NEC3 contracts where early warning signals are provided to clients in a spirit of mutual trust and cooperation (Gerrard, 2005; Klimas, 2011; Rowlinson, 2011)

INFLUENCE OF MACRO-ECONOMY ON TRUST

Interestingly, previous studies which have sought to investigate how macroeconomic factors influence the development of trust have resulted in ambivalent findings. Khalfan *et al.* (2007) revealed from their case study that interviewees expressed divided opinions regarding macroeconomic influences on trust development. Whilst

some felt trusting relationships should be the basis of collaborative working regardless of the state of the economy, others held a view that the buoyant nature of the economy was the main driver of trust-based approaches. A statement from an interviewee which was presented by Khalfan *et al.* (2007) is particularly striking. The interviewee was quoted as follows:

"I think we are riding on a wave of prosperity at the moment so we can afford the luxury of trust and working together. When it gets down to it if someone [does] a job for £50 and someone else [does it] for £30 the trust will disappear. I think that has happened in the past. At the moment it is reasonable and if you don't get work, no-one will starve".

This is very interesting particularly because the case study investigation by Khalfan *et al.* (2007) was undertaken during the period just before the global financial crisis emerged in 2008. However, does the promotion of trust-based strategies ride on luxury such that during economic downturns, a trust focus becomes a thing of the past? To explore this assertion more carefully, a comparison of trust-based strategies as against traditional transactional approaches is presented in Table 1.

In difficult economic times when construction clients' have heavily constrained budgets, there is less work to be executed and the competition for survival amongst contractors intensifies. Consequently there is a higher tendency for 'cost savings' to become a more dominant criterion during contractor/subcontractor selection. This situation can be illustrated very clearly by taking a look at recent recommendations on procurement put before the UK government by a procurement and client task group which aims to save 20% from cost of public sector projects (CIOB, 2012a). The procurement options which have been proposed in line with achieving such cost savings are cost-led procurement, open-book two-stage tendering and integrated project insurance. Though these recommendations could still be used in the context of a framework or one-off contract, it is the focus on cost that may signal a slight shift from previous trust-based guidelines such as the now defunct "achieving best value" guide. The adoption of Building Information Modelling (BIM) has also gained centre stage in the UK construction industry as a tool to improve efficiency. Although the full potential of BIM has not been realised (Barlish and Sullivan, 2012), research has revealed that BIM can improve efficiency and collaboration through information management, sharing and flow, better co-ordination amongst stakeholders, and alignment of project stakeholder expectations (Aranda-Mena *et al.* 2009).

It is therefore not surprising that Kumaraswamy *et al.* (2010) claimed the recession has re-introduced a cost focus even amongst clients who were major advocates of industry reforms in line with the relational agenda. However, this cost focus is perhaps what has stimulated the need for leaner and more efficient processes across the supply chain. Interestingly, and rather significantly, it has been observed that construction firms in the UK have come to accept the reality of lesser workloads, higher client expectations, lower prices and lesser margins and have adapted to this by working more jointly and efficiently to ensure that they do not further forfeit such low profits (Knutt, 2012). Knutt (2012) revealed that adversarialism is presently less pronounced amongst construction supply chain members given that they have to work together more efficiently to cut out waste and get things right first time. This may suggest that the present economic downturn – with recovery taking longer than initially envisaged – has arguably contributed towards the increase in competence trust amongst supply chain members.

Table 1: Trust-based versus traditional contractual approaches on projects.

Project factors	Trust-based approach	Traditional contractual approach
Main contractor and subcontractor selection	Limited bid invitation where soft-parameters are key	Competitive bidding with much more focus on price
Delivery modality	Partnering, PFI, BOOT	Design-bid-build, design and build
Contract form	NEC 3 and PPC contracts underpinned by fairness principles	JCT and ICE forms of contract
Supervision/management on site	Self-policing for performance evaluation, collaborative tools and promoting openness e.g. joint administrative system	Exercise of authority through strict enforcement of contract conditions e.g. penalties for non-performance.
Payment mechanisms/arrangements	Target cost plus fee (pain share-gain share arrangements) to serve as an incentive for parties	Lump sum or cost reimbursement following re-measurement of quantities
Dispute resolution	Negotiation and adoption of ADR mechanisms e.g. arbitration and mediation.	Dispute resolution through litigation and adjudication.

Note: PFI – Private finance initiative; BOOT – Build, own, operate and transfer; ADR – Alternate dispute resolution; NEC - New engineering contract; PPC – Project partnering contract.

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However, there is still the increased tendency for payment and cashflow problems to become more pronounced across the supply chain during recession periods. This is perhaps fuelled in part by lower profit margins that contractors and other supply chain members have to cope with during recession periods as well as difficulties in accessing credit (Paunov, 2012) due to more stringent requirements by financial institutions. Research has revealed that one in ten large construction firms are reliant on high risk suppliers (CIOB, 2012b) given that such cash flow problems intensify further down the supply chain. It has been claimed that tier 1 contractors have sometimes improved their margins by squeezing their supply chain through prolonged payment periods (Knutt, 2012). Akintola *et al.* (2011) also revealed that claims and disputes in the UK construction industry have been mainly due to poor payment practices – a situation which would only result in loss of trust amongst supply chain members – specifically integrity trust.

It would have been expected that in economic climates pervaded by such payment and cashflow problems, there would be an increase in the number of construction disputes. Rather, fewer disputes have been reported since the recession set in especially because

people are more prepared to negotiate on projects so as to meet the high demands for greater efficiency (Knutt, 2012). Thus the increased need for greater efficiency arising from the recession is arguably improving the extent to which supply chain members collaborate and negotiate on projects when problems arise even under circumstances where the integrity of some supply chain members are questionable. Propositions that trust will disappear across the supply chain during economic downturns have failed to materialise at least for now as it seems the prolonged nature of the current economic downturn has created a stable tendency for higher degrees of competence trust to thrive. Supply chain members have come to appreciate the need for more competence trust so as to cope with the new environment dominated by lower profit margins, higher client expectations and less work. However, working in an environment where firms generally display higher degrees of competence trust and relatively lesser degrees of integrity trust due to financial pressures, there may be the need for more understanding on collaborations that thrive with and/or without integrity trust depending on factors such as the project lifecycle and the nature of collaboration required.

Collaborations with and without integrity trust

The above discussions re-introduce previous arguments by Cox and Thomson, (1997) who went to the extent of questioning the relevance of trust in construction even though others (e.g. Munns, 1995; Kadefors, 2004; Eriksson and Laan, 2007; Laan *et al.* 2010; Smyth *et al.* 2010) have claimed that developing trust across the supply chain is the best strategy for achieving project success. Perhaps, more research is required in construction to explore how the industry can rotate between different governance strategies depending on prevailing project and macro-economic circumstances. This has been evident in the US automobile industry (MacDuffie, 2010). MacDuffie (2010) described how automobile companies in the US became "efficiently fickle" by switching between transactional, relational and intermediate or hybrid patterns of inter-firm governance. A key argument which was raised was that the very fragile nature of trust must be reinforced with the reality that at the inter-organisational level, many factors undermine the possibility of a consistent relationship over time. Factors such as changes in business cycle and the state of the economy were claimed to have resulted in extreme pressures such that even trustworthy automobile companies abandoned long-term suppliers in search of low-cost sources. MacDuffie (2010) cited the dramatic switch in supplier management by Nissan from a relational to a transactional approach after a previous alliance with Renault in the late 1990's. Benefits that ensued from the era of enduring, high trust and socially embedded relationships did not end after this switch and this enabled Nissan to emerge from financial crises back to profitability. This is an example which demonstrates a switch between "collaboration with trust" to "collaboration with less integrity trust" which still resulted in the desired level of output performance.

Hybrid patterns of governance have also been observed in the US context where increasing interdependence of automakers was very high for product design activities that required high levels of interaction and collaboration between automakers and supplier engineers during component development - collaboration with trust (Mudambi and Helper, 1998, Kenworthy *et al.*1996). At the same time, low-trust actions such as pressuring suppliers to provide up-front guarantees of future price reductions and further requesting that those cost savings be passed on to automakers - a manifestation of collaboration without trust – was evident at the production stage (Mudambi and Helper, 1998). This was a kind of intermediate mode of inter-

organisational governance that thrived through cycles of trust and distrust. These hybrid forms of supplier relationships combined collaboration with and without integrity trust – a portfolio of relationships, some transactional and some relational - to achieve the intended performance levels.

POTENTIAL IMPLICATIONS FOR RESEARCH AND PRACTICE

If trust management across the construction supply chain is to an extent influenced by the macro-economic environment as argued in this study, then this clearly has some likely implications for the practice of construction management. Khalfan *et al.* (2007) claimed that if more thought were to be given to trust in construction projects, then this could perhaps impact on procurement strategy. Rahman and Kumaraswamy (2005) also revealed that relational selection based on trust and business ethics related factors are more helpful for collaborative working arrangements. Wandahl *et al.* (2011) have even proposed that trust be applied as a competitive tool in the tendering process by introducing a trust index which would be an addition to existing key performance indicators used to evaluate contractors. However, these efforts could be hampered if price – driven by the macro-economic environment - is gradually re-emerging as a very key criterion for contractor/subcontractor selection.

It can be argued that with the current situation of lower profit margins, less work, and high client expectations, there is a higher tendency for contractors/subcontractors who can operate leaner processes by cutting out the most waste to become more competitive on the market. This could be reflected in the procurement process whereby rather than the integrity of a contractor/subcontractor, their level of competence that ensures that client's needs are achieved with the cheapest and most efficient option, would be mostly desired. Thus, during procurement, it would be prudent for contractors/subcontractors to increase their competitive edge on the market by focussing more resources on how to deliver cost savings to their clients as this would be more attractive to budget restricted clients. Also, there is the need for research on the influence of BIM on trust across the supply chain given its potential to facilitate greater collaboration and co-ordination amongst project stakeholders, as well as improve efficiency by reducing re-work. There is also the need for further empirical investigation on how inter-firm relationships can be switched between transactional, relational and intermediate or hybrid patterns of governance without compromising on project success. This is because the potential influence of macroeconomic situations on integrity trust could sometimes provoke clients to sometimes adopt more transactional strategies especially during recession periods. Thus as part of a larger on-going research on the commercial realities of supply chain management in construction and the dynamics of trust, the influence of the current economic turbulence on the switch between relational, transactional and hybrid modes of inter-firm governance on projects is being researched.

CONCLUSIONS

In this study, a synthesis of literature on trust in construction and other team-based industries has been undertaken to explore the likely influence of the macro-economy on trust development efforts in the UK construction industry. It has been argued that restricted client budgets, lesser profit margins and increased client expectations that have been driven by the current global economic downturn have contributed to increased efficiency across the supply chain. This increase in efficiency is required across the supply chain to ensure that low profit margins are not forfeited altogether. This has arguably contributed to an increase in competence trust across the supply

chain such that firms even have to continuously propose alternative solutions that result in cost savings to clients so as to give them a competitive edge on the market. On the contrary, the economic downturn has arguably exerted a seemingly negative influence on integrity trust due to cashflow and payment problems across the supply chain.

These relatively lower levels of integrity trust during economic downturns are likely to result in the use of more transactional rather than relational approaches for the selection and management of construction supply chains on projects. Revelations from the US automobile industry where relational, transactional and hybrid forms of governance were used to govern inter-firm relationships at different times and for different phases of the production process could therefore stimulate more empirical research on inter-firm governance in construction. Perhaps, it would be more plausible for different governance approaches to be used at both the design stage and construction stage depending on the extent of demand for collaboration with or without integrity trust. It may be more profitable to maintain high levels of project performance by switching between different governance modes underpinned by 'collaborations with integrity trust' and 'collaborations without integrity trust' depending on the project life cycle and macro-economic outlook. The prospects of these need to be further interrogated given that this study is based purely on a synthesis of literature.

This current economic downturn also presents a good opportunity for further research on how the UK construction industry is coping in terms of adherence to relational approaches through trust and/or the existence/emergence of different patterns of inter-firm governance – with or without integrity trust - on projects. This is being undertaken as part of a larger on-going research project. The need for research on the influence of BIM on trust across the supply chain has also been proposed.

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A CONCEPTUAL MODEL FOR CONSTRUCTION SUPPLY CHAIN MANAGEMENT IMPLEMENTATION

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During the last two decades, both researchers and governmental studies revealed an increased interest about Construction Supply Chain Management (CSCM), but up to now practitioners are still facing difficulty to improve business performance through such approach. A call for ad-hoc solutions that foster the effective implementation of SCM practices has clearly risen up. This working paper is part of a wider research project which aims to provide academics and practitioners with a valuable support in this direction. We propose an integrated conceptual model to enhance the implementation of CSCM from a contingent view. The research to date includes an extensive and systematic literature review that assesses the main building elements related to SCM introduction. Such elements include: the antecedents, or prerequisites; the approaches, which involve the interrelation of strategies, structure and practices; the benefits related to an effective SCM adoption; and the contextual and environmental variables. Main implications for academics concern the analysis of extant CSCM literature from an innovative and integrated perspective, in order to highlight actual research gaps and future research agenda. At this research stage, other important goals include the advancement of useful and challenging research questions and hypothesis, with the aim to collect relevant feedback about the suitability of both the model and the research strategy.

Keywords: antecedents, conceptual model, contingent approach, supply chain management.

INTRODUCTION

SCM is a concept that originated in the manufacturing industry as "an integrative philosophy to manage the total flows of the entire business process" (Xue *et al.* 2007). During the last two decades, the debate increasingly involved also the project-oriented contexts such as the Construction sector. Despite the successful expectations surrounding SCM in construction, many organizations in the sector have experienced significant difficulties in achieving the planned business goals (Segersted and Olofsson, 2010). These conditions have caused a number of critics, disputes and questions rise up. The traditional SCM models were in fact developed for a process-centric context and their transposition in the construction sector (and more in general to project-oriented contexts) is not immediate and structured yet (O'Brien *et al.* 2002).

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Aloini, A; Dulmin, R; Mininno, V and Ponticelli, S (2012) A conceptual model for construction supply chain management implementation *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 675-685.

The discontinuity of the information flow and the uniqueness of projects which, for example, jeopardize the management of relationships between the Construction Supply Chain (CSC) members get an undoubted effect on the logic of SCM adoption and the effectiveness of some traditional practices.

Construction sector differs substantially from the stable and continuous supply chains within "goods and service" sectors for a number of specific characteristics, as for example: the high complexity and uncertainty in which the production system operates (Fearne and Fowler, 2006); the transitory site configuration managed by temporary supply chain configuration (Love *et al.* 2002); the high customer influence on the final product (Pesämaa *et al.* 2009); the process fragmentation (Baiden *et al.* 2006); the complex network of stakeholders, which involves multiple organizations and relationships (Xue *et al.* 2007). These peculiarities together with a number of cultural factors (e.g. Love *et al.* 2004) are charged to be the rooting causes of the failure to replicate the positive experiences from other sectors, and the poor results finally achieved. In order to successfully introduce SCM in a project-oriented sector, a context-based approach is essential. This working paper is part of a wider research project which aims to provide academics and practitioners by investigating the building elements that characterize/influence the adoption and implementation of SCM in Construction: antecedents, SCM approaches (strategies, practices and structure), benefits, contextual factors.

From an academic viewpoint, this contribution aims to analyse the state-of-the-art of literature concerning CSCM approaches in order to highlight actual research gaps, and to formalize the conceptual model contributing with useful directions to future research. Nevertheless, the article has also implications for practitioners, providing first insights to support a proper, context-specific SCM implementation, e.g. what are the prerequisites and levers to CSCM adoption (antecedents); what SCM approaches are more suitable (SCM strategy, structure and practices); what target is desirable (SCM related benefits).

RESEARCH DESIGN

Research Strategy and Objectives

The research methodology is showed in Figure 1. It entails two main phases: a literature review and a multiple case analysis. The current status of research can be positioned at the beginning of Step 2: "Design and Preparation".

The literature review allowed uncovering CSCM constructs and variables. Then, case studies will be aimed at exploring and at theory-building patterns or linkages between the proposed constructs and variables. The objective of overall research involves the descriptive and normative study of the CSCM topic, in order to provide explorative and theory-building propositions that regard main SCM elements and their interrelationships. For what concerns the present article, the first research objective consists in reviewing previous research contributions from an integrated perspective, in order to investigate the domain surrounding relevant topics in the construction literature. Such topics concern the main elements that constitute the building blocks of SCM implementation. These include: the antecedents (or prerequisites), the approaches (strategies, practices and structure), the benefits and the contextual factors. The second main objective of the article consists in describing the interactions between such elements through an original conceptual model. We propose a set of Research Questions (RQ) that arises from an extensive literature review. They

represent the basis for future research agenda that we aim to test through empirical investigation.

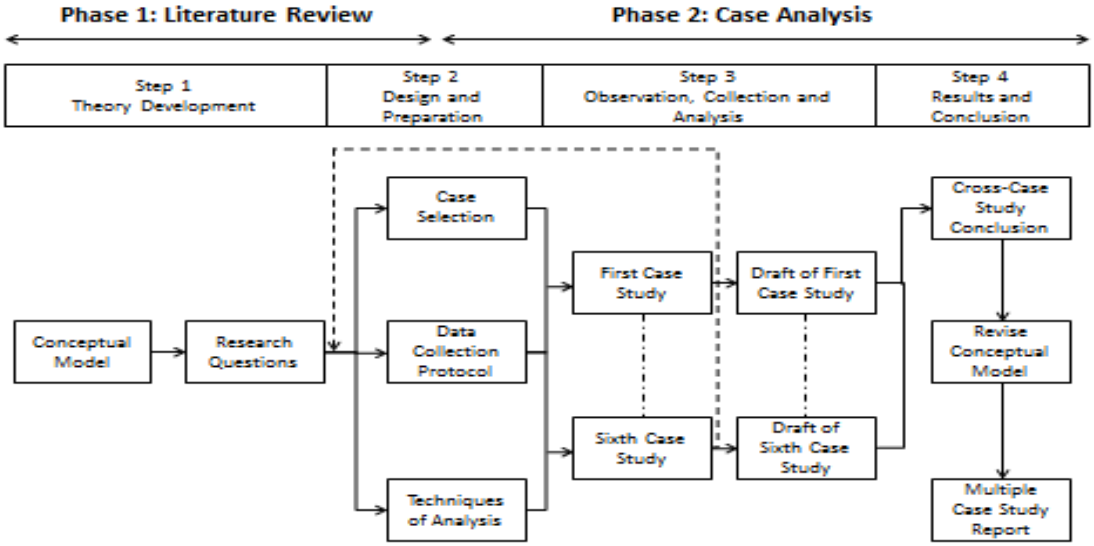

Figure 12 - Main steps of research methodology. Adapted from Yin (1994).

The novel of the proposed framework lies in the different perspective about the elements that characterize CSCM implementation. The rationale of the present research states that a set of antecedents affects SCM adoption/implementation, which in turn affects the achievement of SCM-related benefits. We aim to address several gaps in extant construction literature. In particular, a few building elements have not been introduced yet (e.g. CSCM antecedents), and others require further investigation because at the introductive research level (e.g. CSCM structure and CSCM strategies). At the best of our knowledge, also the relationships between the building elements have not been proposed within the construction literature yet. To analyse such relationships, the contingent approach represents a central tenet of present research. Thus, a set of contextual and environmental variables are included within the framework since they can significantly influence (by mediating or moderating) the relationships and interactions between SCM building elements. Analysing extant CSCM literature, we found a number of useful and valuable contributions. Nevertheless, all these contributions focus on specific aspects of the construction process without addressing an integrated view of the proposed elements that interact in SCM implementation. Without the aim to be exhaustive, we here critically examine some relevant conceptual models. Cox and Ireland (2002), for example, provided a better understanding of how to achieve effective SCM by proposing a model that analyse specific power regimes in buyer/supplier relationships. Love *et al.* (2004) suggested a holistic approach focused on the integration between design and production process following TQM philosophy. Cheng *et al.* (2004) aimed to improve the issue of strategic alliances and examined the purchasing perspective as an organizational change process. Finally, Xue *et al.* (2007) faced the inter-organizational problems in order to enable business process integration and achieve better performance.

Research to date

The Step 1 of research methodology consists in "Theory Development" (see Figure 1). A systematic literature review was performed in order to analyse the issue of CSCM. Main output of this research step consisted in the identification of the building

elements of SCM implementation, which have been included within the conceptual model. The literature review supported also the formulation of the Research Questions for each building element. The review comprehended an initial sample of 176 refereed international articles. This set stem from a search through main scientific electronic databases, namely: Emerald, Scopus, Taylor&Francis, IEEE, JStor. The search contained the combination of the words “supply chain management" and “construction”. Sample selection was limited to papers published in international peer-reviewed journals from 2000 to 2010. This time selection depends on the evolution of procurement approaches in the construction sector (Saad *et al.* 2002), as a perception of a progress in adopting SCM principles was perceptible only in the late 1990s. A selection process was performed in order to exclude book reviews, dissertations, editorials, conference papers, or even articles which key words had different meaning from the chosen one. After the selection process, the final number of papers was 138.

Research proposal

The second phase of research methodology (Step 3 and 4; see Figure 1) is not included within the present article and it will be conducted through a multiple case study analysis. It will be used with the two-fold purpose of exploring and theory-building research propositions and hypothesis related to the proposed model. The case study analysis was considered suitable to obtain in-depth results in a research area that is characterized by limited empirical research as CSCM.

CONCEPTUAL MODEL FOR CSCM

The proposed conceptual framework is showed in Figure 2. It illustrates the relationships between SCM main elements, in order to effectively implement SCM in the construction sector.

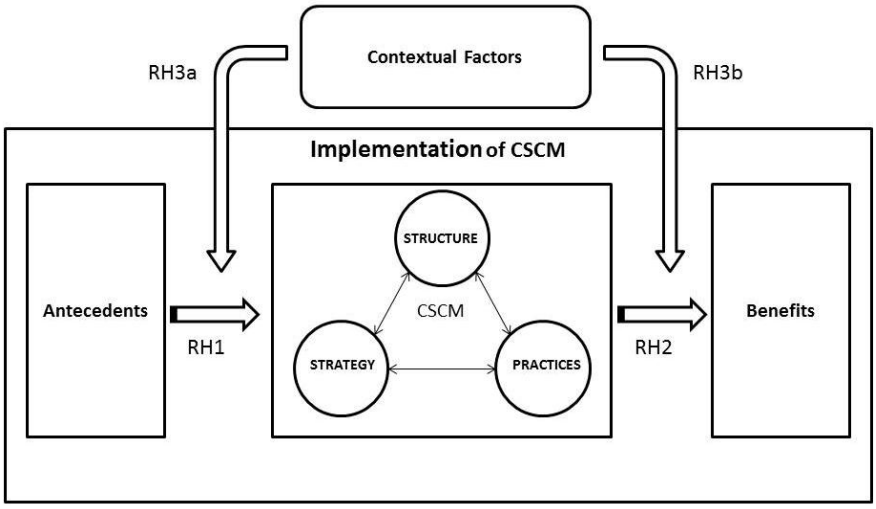

Figure 13 - Conceptual model for CSCM implementation.

The left part of the model includes a number of preconditions. The rationale of present research upholds that a proper understanding of antecedents represents the first pivotal step to properly introduce SCM (Lambert *et al.* 2005). The antecedents are related both to intra- and inter-organizational relationships and their acquisition is required to implement SCM approaches. Such approaches are represented in the middle section of the model. They constitute the core of the SCM concept and show the combination between strategies, structure and practices. They need to be context-specific and to reflect the peculiarities of the construction sector. Hence, the proper deployment of

SCM approaches is unavoidable from a continuous adaptation with a set of contextual factors. Finally, the right side of the model shows the expected SCM-related benefits. Such benefits positively affect the success of final construction projects in both increased efficiency and effectiveness. Also, the identification of SCM-related benefits pull to promote their repartition among SC members, which commitment will be leveraged in turn. All the above-mentioned elements of the framework are further described in the following subsections. Each subsection also proposes a set of Research Questions that will be investigated through the multiple case-study analysis.

CSCM approaches: Strategies, Structure and Practices

CSCM implementation is characterized by the interrelation of strategies, practices and structure. In the proposed conceptual framework, we adapted the core elements of SCM concepts (e.g. Lambert *et al.* 1998), following a project-oriented perspective. Opposing the "one-size-fits-all" paradigm, the present article supports a contingency-based approach for the proper implementation of CSCM. The construction sector requires specific SC solutions (e.g. Cox and Ireland, 2002) and inter-sector differences have to be emphasized in order to catch the peculiar requirements of each supply chain. In the last two decades, many articles contributed to the topic of contingent SCM. They identified a set of strategies, practices and structures that fit the SC characteristics as the context changes. However, these models originally developed within process-centric contexts, where the demand is predictable, volume is high and variability is low (Christopher, 2000). Such contexts face specific criticalities (e.g. high margin of error in forecast) and therefore require specific solutions (e.g. standardization of product components) that may not be translated to the construction sector. A comprehensive definition of ad-hoc SCM approaches is still lacking for the construction sector. Therefore, we analysed both construction and process-centric SCM literature with the objective of investigating how consolidate SCM approaches can be adapted to a project-centric environment. In particular, the following results are showed for each component of SCM approach:

- Strategy. "The concept of project strategy has remained ambiguous in existing studies" (Artto *et al.* 2008). To address this research gap, we selected a number of SCM models from process-centric literature, with the aim to define a strategic profile for the construction sector. The identified models propose different suggestions according to the contingent context of each organization. Such context is described through different contextual variables (e.g. variability, complexity, uniqueness and volume of the final product). The research objective is to investigate the suitability of extant models and the effective applicability of the related strategies among construction companies.
- Structure. As organizations need to adopt new systems to shift to integrated SCM, they inevitably recognized the importance of adopting suitable organizational structures. These vary as the levels of centralization, formalization and hierarchical relationships (Kim, 2007). At this purpose, we identified five different SCM structures through the process-centric SCM literature. The structures are: market oriented (SCM is not recognised as a distinct function and exists as a sub-department of production or marketing); SCM department (SCM department has an equal hierarchical position with existing functional departments); matrix organization (SCM department has an equal hierarchical position with other departments but is focused on coordination and connection); process (SCM department has an higher position than other functional department but plays the role of overall coordinator); and

SCM leadership (SCM department directly controls other functional departments).

- Practice. We identified a set of practices from CSCM literature. They have been divided into three groups in accordance with their impact on the goods flow (e.g. waste reduction, modularity, postponement), the information flow (e.g. co-design, e-procurement, e-collaboration), or the planning and control flow (e.g. supplier scorecarding, time compression, concurrent engineering). The objective of future research is to investigate the modalities and the effective utilization of such practices in the construction sector.

In relation with SCM approaches, the following Research Questions are proposed:
RQ1: What are the suitable strategies, structures and practices to implement CSCM?

RQ2: How construction companies apply the suggested strategies, structure and practices from consolidated models?

Antecedents of CSCM

The importance of preconditions stemmed from traditional SCM literature (Lambert *et al.* 2005, Kotzab *et al.* 2011). In particular, the antecedents are necessary to properly connect the inter-organizational networks (Mentzner *et al.* 2001) in order to enhance the relationship perspective within and among organizations. Extant literature was reviewed to identify the antecedent elements for a successful CSCM implementation. Articles were screened by content (using keywords as "antecedent", "prerequisite", "precondition"), searching for those items that were perceived as relevant to introduce SCM. Results highlighted a total of 20 antecedents to implement SCM in the construction sector. They can be classified in four main groups: management (e.g. suitability of skills, top-management commitment); technology (e.g. IT integration, information sharing); business culture (e.g. trust, sharing of risks and benefits); market (e.g. contractual protection, government regulation). The proposed antecedents shape a heterogeneous set. They impact on different level of SCM implementation, applying to different management areas and requiring different modalities of introduction. We underline that most of identified antecedents are related to the business culture of the Construction sector (8 out of 20). Since the construction has a temporary SC structure, a high and variable number of SC participants, the identification of specific antecedents for this sector assumes considerable importance. The analysis of literature highlighted a major criticality of the elements that are usually easier to implement in more stable contexts as "relational behaviour", "trust" and "focus on the long term". Such difference of focus reflects the late implementation of SCM approaches in the construction sector and requires further research efforts in order to highlight the priorities of intervention that are necessary to adopt CSCM. Most of the antecedents are also related to each other and a certain level of overlap is exhibited. This is a consequence of the heterogeneous usage of definitions surrounding these concepts. However, very scarce information can be found about these mutual relationships and about their priority of introduction. From this viewpoint, the present research represents a first effort to clarify the domain of CSCM elements.

Further research will be addressed to empirically test the following Research Questions:

RQ3: To what extent the identified antecedents are perceived as critical for CSCM implementation?

RQ4: How are antecedents interrelated?

Benefits of CSCM

The measure of project success corresponds to the extent that it satisfies the needs of its intended user. In accordance with Cooke-Davis (2002), the realization of benefits is essential to establish project success. Benefits of effective SCM should be potentially value-enhancing for all the participants within the network. This is especially valid for the construction sector, where the push to implement SCM arises not only from the focal company, as in the process-centric environment, but also from a multitude of participants. Hence, the high recourse to outsourced activities, which count almost 75 per cent of the project value (Gadde and Dubois, 2000), points out a great potential interest for all involved members. The identification of benefits constitutes a first step to leverage the commitment of CSC participants. To identify CSCM benefits, we analysed the selected CSCM literature, searching for the goals and performance improvements related with SCM implementation. Also, we conducted a content analysis for keywords as "benefit", "improvement", "advantage", and "gain". From the literature, we identified a total of 18 benefits that can be related to the implementation of SCM approaches. Such benefits can be represented through a classification between three concentric categories: organizational effectiveness (e.g. coordination among SC members, order cycle times), business performance (e.g. product quality, inventory turnover) and financial performance (e.g. financial liquidity, net profit). Another critical aspect is represented by the different importance that benefits can assume between different supply chain members (Agrawal and Park, 2001), as well as different functional managers (Fawcett *et al.* 2008). The divergence of interests should be minimized, where possible, in the case where it leads to both sub-optimal choices and conflicts.

Our research aims to gain insights about these interesting topics by investigating the following Research Questions:

RQ5: To what extent CSC members perceive as relevant the identified SCM benefits?

RQ6: How CSC members share benefits between each other?

Contextual Factors

In the present article we classified the contextual factors into internal (supply network structure) and external (environmental uncertainty and technical dynamics):

- Supply network structure. Choi and Hong (2002) captured these contextual factors in three main dimensions: formalization of guidelines (rules for enterprises or suppliers that increase work credibility through formalized rules procedures), centralization of decision-making within the supply chain (e.g. the power and size of companies, as the extent to which authority is centralized affects the interaction between enterprises) and complexity of relationships (the product level of complexity, its relevance of speed and its perishability; also it includes the relative importance of linkage costs, the length of the chain and the proximity to final customer).
- Environmental uncertainty. The complex relationships between SC members involve numerous sources of uncertainty. To perform the relationships in an effective manner, a better control of the uncertainty is fundamental and SCM acts as an uncertainty reduction mechanism. Davis (1993) identified three major source of uncertainty: manufacturing (e.g. systems breakdown and human errors); demand (e.g. volatile markets and fluctuating demand); and supply (e.g. natural disaster or shortage of natural resources).

- Technical dynamics. They concern the technological speed of change in relation with the involved materials, as well as the breakthrough in the management of processes and techniques (Hsu and Chen 2004).

Relationships between SCM building elements

The present research also aims to propose a set of Research Hypotheses (RH), in order to investigate how each building element may affect each other. In particular, we aim to gain insights about the following relationships, in accordance with the links represented in Figure 2. The formulation of hypothesis emerged from the result of the literature review and their investigation will be conducted during next research steps.

The first relationship involves the antecedents and the approaches of SCM. The antecedent represents a necessary prerequisite to properly introduce the strategies, the practices and the structure that are best suited to the construction sector. Such relation has been investigated for the process-centric context (see for example Lambert *et al.* 2005; Kotzab *et al.* 2011), but not yet for the construction sector. As emerges from the analysis, scarce information can be found about the impact of the antecedents on CSCM implementation. The peculiarities of the CSC requires further investigation about the relationship between antecedents and SCM approaches in order to determine what antecedents are the most critical to implement specific SCM approaches.

RH1: The acquisition of well-defined antecedents fosters the introduction of SCM approaches (strategies, structure and practices).

The second relationship links the settlement of SCM modalities with the achievement of SCM benefits. Hence, organizations select most suitable strategies, practices and structure in order to achieve such benefits and to strengthen project success. SCM has to be applied consistently among the multitude of companies involved within the construction sector and in a continuous and progressive manner over time. The second research hypothesis aims to investigate what SCM approaches are best suited to achieve different configurations of SCM benefits. The criticality of this relationship is a consequence of the necessary investments required to implement SCM, which represents the most resource-intensive and time-consuming management approach.

RH2: The implementation of proper SCM approaches fosters the achievement of SCM benefits.

The third relationship consists of two sub-hypothesis. Hence, it involves the role of contextual factors, which may affect in turn the settlement of SCM approaches and the achievement of SCM benefits. Firstly, The Research Hypothesis 3a advocates that the settlement of antecedents could not univocally lead to a determined set of SCM approaches. This may be the case when a contextual variable act as a moderator between the antecedent and the approaches of SCM. Hence, in correspondence with the same antecedent configuration, two different companies may require different strategic profiles, or they may need to implement different practices (e.g. the contextual factor "supply uncertainty" may moderate the relationship between the antecedent "relational behaviour" and the practice "e-collaboration"). Another interesting effect that we aim to investigate concerns the mediating role of contextual variables. For example the antecedent "adequate sharing of risks and benefits" may negatively influence the contextual factor "complexity of relationships", which in turn may negatively influence the practice "e-sourcing".

RH3a: Contextual factors affect the relationship between the settlement of antecedents and the implementation of SCM approaches.

Secondly, the Research Hypothesis 3b aims to investigate the moderator/mediator effect of the contextual factors between SCM approaches and SCM benefits. The rationale of this hypothesis assumes that the proper deployment of SCM approaches does not ensure the achievement of full SCM benefits. The success of organizations in achieving SCM benefits depends on the effectiveness of the adaptation with the ever-changing environment (Stonebraker and Afifi, 2004). Thereby contextual factors can limit or foster the amount of each benefit among different SC projects (e.g. "technical dynamics" may act as moderator between the practice "co-design" and the benefit "total cost reduction"). Also, contextual factors can influence the repartition level of benefits between different SC members. In this connection, an interesting example concerns the role of the contextual factor "supply uncertainty" that may moderate the relationship between the "time compression" practice and the benefit "decreased Time-To-Market".

RH3b: Contextual factors affect the relationship between SCM approaches and the achievement of full SCM benefits.

CONCLUSION AND FUTURE DEVELOPMENTS

This paper has to be framed in a wider research project, which aims to provide a support for a more effective, contingency-based implementation of SCM in the construction sector. The objective of this article was to present the results of a CSCM literature review and to propose a conceptual model with the related research agenda. The model was developed from several extant SCM models in the literature, with an intended adaptation for the construction sector in order to enhance its peculiarities. It represents an initial attempt at identifying the various elements to be managed for an effective CSCM implementation. The elements that compose the model have been described and a set of further research questions and hypothesis have been proposed. From an academic perspective, the present article can foster the understanding of CSCM from an innovative perspective. Expected managerial contributions may arise from the further investigation of both the building elements of SCM and their interrelationships (e.g. how antecedents and contextual factors foster SCM implementation, as also, what SCM approaches can lead to higher SCM benefits).

Future developments will be addressed at the empirical investigation of proposed model, through a multiple case analysis.

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COLLABORATIVE SUPPLY CHAIN PRACTICES DURING SEVERE ECONOMIC DOWNTURN IN THE REPUBLIC OF IRELAND

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Construction in the Republic of Ireland held a dominant position in the economy in the decade to 2007, at peak accounting for 24% of GDP. Given the scale of this contribution it is clear that leveraging even modest efficiencies in the supply chain could yield significant benefits. Recent literature in the field of construction supply chain management suggests such collaboration is far more difficult to achieve in times of austerity. Post 2007 the industry suffered a spectacular decline, a collapsing property bubble, exasperated by the world economic downturn in 2008 led to a circa 75% decline in output. A study commenced in 2011 to investigate the extent and nature of supply chain management practices in the industry and to record the impact of the prevailing austerity. A review of relevant literature showed a significant deficit of information pertaining to the Irish industry. As a consequence of this an exploratory questionnaire survey was undertaken to collect data on supply chain management attitudes and practices in the industry to inform and scope future research strands. The results indicate a high degree of understanding of supply chain concepts and strong industry support for collaborative supply chain management approaches. Respondents also have a reasonably clear grasp of the potential of collaborative approaches and the barriers that militate against its wider use. The survey results is compared to previous results from the UK, supporting the general conclusion of an increased focus on 'cost' related supply chain factors in Ireland at present. The generally supportive results of the survey towards collaborative approaches are also compared with evidence that suggests the industry is engaging in widespread opportunistic behaviours such as below cost tendering, claims and late payment that are contrary to collaborative approaches. This prompts the further conclusion that the industry is not practicing what it preaches.

Keywords: austerity, collaboration, Republic of Ireland, supply chain management

INTRODUCTION

Construction related property activity provided a substantial contribution to the recent boom in Ireland. At peak, in 2007 construction activity provided around 24% of GDP output. (DKM 2009) That figure was double the European average and was felt by many leading Irish economists (such as Kelly, McWilliams, Lee etc) to be

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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.

unsustainable. Coupled with the global economic downturn in 2008, the bubble duly burst. In terms of contraction in the construction output (value of production) figures benchmarked at 2005 (100) peaked at 109.7 2006 (Q4) and then commenced a catastrophic decent. Data for 2012(Q1) provided a figure of 25.60 in terms of output the industry has shrunk to around one quarter of its 2006 peak. (CSO 2012a) By comparison, Tennant & Fernie (2010) report UK construction contracted from £110 billion in 2007 to £95 billion in 2010, a 14% contraction, described as '*unprecedented*'.

Employment in the sector decreased rapidly. Definitions of employment categorization for construction are difficult. However taking official labour market definitions, employment peaked at around 269,900 in 2006 before declining to 105,700 by mid 2011 (CSO 2012b) anecdotal evidence suggests a further decline since, albeit at a slower pace.

Smyth (2011) makes a connection between austerity and the degree to which collaborative working practices will take hold. He concludes that during austerity, construction companies' focus on survival rather than collaboration, taking the form of lowering prices to secure turnover. He noted that a minority of companies preserve a collaborative approach, with leads to longer-term competitive advantage. Others support this view of construction in austerity. Green *et al.* (2005) speculated that collaboration would not withstand the next major recession. Ross (2011) confirms anecdotally that this is happening in the UK. Contractors are reverting to competing on lowest price to secure short-term survival.

Tennant and Fernie (2010) writing about frameworks, note that several (mainly private sector) clients have rejected the use of frameworks as the economic downturn enabled them to leverage better deals through traditional routes. They suggest the public sector is also demanding 'more for less' through existing frameworks. They conclude that clients and contractors are returning to 'type' and engaging in opportunistic behaviour in the changed environment.

A useful comparator for Ireland, Savolainen (1999) investigated the Finnish construction industry, after the collapse of the Soviet Union had tipped the Finnish economy into severe recession. Savolainen concluded that the decline resulted in the industry drawing inwards and focusing on survival strategies at the expense of collaboration, which had previously taken hold. Likewise, Lamming (2000) assessed the 1990s recession and austerity in Japan (Still ongoing to some extent) focusing on supply chain relationships. A key finding was a move towards more western open market practices than had previously been the case, moving away from historical collaborative practice.

Recent evidence from Ireland suggests that a similar approach is deeply embedded in construction. A survey by the Society of Chartered Surveyors Ireland (SCSI) (*Sister organisation of RICS*) shows that over half of tenders for construction projects are now below cost bids, a significant increase in such bids was noted over the past two years. (SCSI, 2011) The gap between the economic cost and the lowest bid submitted is -17%. Over half of the quantity surveyor respondents confirmed their experience of projects being delayed or not completed because they were below cost both in the public and private sector. They found that clients knowingly accept such bids on a below cost basis. On an optimistic note Davis Langdon (2011) confirmed the significance of the problem, but suggested that below cost tendering has reached its elastic limit and more sustainable pricing levels are taking hold.

COLLABORATION

A review of literature on collaborative practices generally and for the construction industry was undertaken in 2010. This provided a wealth of contextual information internationally, principally for the United States, United Kingdom, Australia, Asia and some parts of South America. There remains however a significant lack of information in the field of construction management research in Ireland. Chairman of the Construction Industry Council, Kevin C. Kelly noted in 2004 that;

'R&D investment is very low compared to every other industry. There is no investment in research into 'Process' or 'Management Practices'. (Kelly 2004)

This situation is surprising given the prominent position construction attained in the country, that little research was undertaken into a principal engine of the economy. The reasons behind this are outside the scope of this paper, however we may speculate that it has roots in the development of third-level education in Ireland and also in the size of the industry, limiting funding for such research.

Readers of Egan (1998) will note similarities between his description of the UK industry and that of the Irish industry. Aside from the obvious differences in scale, historical arrangements were similar in terms of operating methods and contractual arrangements. The industry is very fragmented, the 'census of building and construction' (CSO 2007) noted that over half of all those employed in construction worked in companies with less than 10 employees and under 17 percent worked for companies with over 50 employee's.

The industry is reliant on a sub-contractor model, where shell main-contractor organisations provide coordination to sub-contractors. Normal contractual arrangements were traditional in nature. Standard forms of contracts for private and public sector were based on models produced by the professions and would be similar to UK Joint Contracts Tribunal (JCT)

The Government is perhaps the only client large enough to drive forward industry wide change. In 2007 they unilaterally introduced new public works contracts with the stated intention of bringing cost, time and quality certainty to public works (Finfacts, 2007a) This action was not well received by the industry (Finfacts, 2007b) who stated that prices would increase to meet the increased risks that contractors felt Government was transferring to them (Taggart, 2008). With the onset of recession (coincidentally) corresponding with the introduction of the new contracts, prices in fact reduced in the face of severe competition. Davis Langdon (2011) reported that the new contracts are leading to a large number of contractual disputes.

Following the economic downturns in the 1980s the industry engaged in a period of introspection, considering the possibilities for a step improvement in the industry as a whole as times improved. Following the Egan Report (1998) in the UK, researchers responded with a range of prescriptions that generally have a core value of collaboration. Suggestions included Supply Chain Management, Lean Construction, Agile Construction, Concurrent Engineering and Partnering to name but a few examples. The theoretical base for these philosophies emanate from manufacturing and was given impetus by Womack *et al.* (1990) which publicised the Toyota Production System, explaining how Toyota continuously sought to collaboratively focus on cost, quality and time in production. Much work in the literature seeks to adopt the core of these philosophies to construction. Some caution that these methods

are however very situational and cannot be applied in every environment. (Cox & Townsend 1998) (Fernie & Thorpe 2007)

In Ireland the Government and Industry initially embraced this change agenda, The Construction Industry Council (CIC) representing the industry, the professions and suppliers. (Finance 2011) and the Government established the forum for the construction industry in 1997. Although focused on the public sector, it was hoped that best practice would percolate through to the private sector. In 2000 the Government published plans to implement eighty-six recommendations made by the forum around the following themes,

- Improve efficiency and productivity in the industry
- Promote a competitive industry at home and abroad
- To secure as far as practicable stable construction demand
- Ensure fair, open and transparent procedures
- Reduce conflict between the parties and reduce resolution costs
- A regulatory environment to promote quality and safety

An analysis of their achievements is outside the scope of this paper, save to say, results have been somewhat mixed. It is however, clearly an agenda for cooperation and collaboration between the parties. In 2004 the Government announced the result of a further review was that issues of cost, time and quality would be addressed via the new public works contracts, which they developed unilaterally and introduced for mandatory use in 2007.

STATUS OF COLLABORATION IN IRELAND SURVEY

To address the lack of Irish literature an exploratory questionnaire study was carried out in 2011 to assess levels of collaboration in the industry. The principal objective was to identify useful future research strands. The study collected 46 usable responses from 114 possible respondents. (Valid return 40.36%) The respondents were industrial partners providing placements to third-level construction students. Respondents were based upon the student placement and random of the researcher. The data was collected by volunteer students and did not form part of their studies. The students posted data back to the researcher for analysis.

Respondents were categorized as: main contractor, sub contractor, supplier, designer or developer. The survey has not been examined for bias or statistical robustness since its objective was exploratory in nature and is not being portrayed as conclusive. The framing of the survey questions borrowed heavily from Akintoye *et al.* (2000) who carried out a much-cited survey of collaboration within UK large construction companies.

INITIAL DISCUSSION OF SURVEY RESULTS

The respondents categorised themselves as: Sub contractors (16 No) Main contractors (15 No) Supplier (10 No) Designer (4 No) and Developer (1 No) the survey document posed 11 questions covering attitudes towards collaboration, the extent of actual collaboration and the motivations and barriers at play. The questions were closed and provided various Likert scales and stated options for respondent selection. A final section allowed an opportunity to make comments.

Question one asked how importantly they rated the need for collaboration? Using a scale of critical, important, limited importance or not important. Thirty-seven

respondents (80.43%) felt that collaborative approaches to management of their supply chains were either Critical (36.96%) or Important (43.47%) to their organisations. Nobody felt it had no importance. This result was similar to the result obtained by Akintoye *et al.* (2000) who obtained a 90% support for important or critical.

Question two asked respondents if they had entered into any formal or informal collaboration or partnerships and if so with whom? The majority (54.35%) stated they had not so engaged, but a sizable minority (45.65%) claimed to have engaged. Some claimed to be in several arrangements. Their partners were; with Main Contractors, (12 No) with Designer (9 No) with Client (6 No) and with Sub Contractors (5 No) a supplementary question asked the length of their arrangements. Many did not address this part of the question, however those that did (11 No) reported that the average duration of collaboration or partnership had been just over 30 months. Akintoye *et al.* (2000) noted 65% of respondents engaged in collaborations. However their study solely looked at main contractors. If the main contractors, here is isolated only 40% claim to be engaged in collaborations, suggesting a lesser appetite in Ireland, for such arrangements, by main contractors than in the UK.

Question three highlighted a claim from literature that there is more desire for collaboration with clients than with suppliers. This hypothesis was supported to some extent by the results, showing that a slight majority, (22 No) respondents did indeed value client collaboration more highly than collaboration with suppliers. However nearly the same number (21) said both options would be equally valued. Mining down into the responses however shows that main contractors generally favoured client collaborations more (60%), whilst sub contractors (50%) and suppliers (20%) tended to value all collaborations more widely. Literature suggests that organisations align their strategies to maximise competitive advantage and the results here may reflect the wider needs of the latter organisations. A range of further questions was presented seeking attitudes and motivations for the respondent's organisation as to why they would potentially (if they had not already done so) or why they did in fact enter into collaborations and / or partnerships.

Question four looks at internal factors and arrangements within the organisation, the most important factors (using a five point scale from very important to not important) supporting collaboration were felt to be, Purchasing (80.04%) very important / important and the production planning (69.56%) very important / important, again chiming with Akintoye *et al.* (2000) who found strong support for these two functions. Other factors rated on very important / important responses, included transportation (63%), Stock / inventory (56.52%) and Storage (47.83%). Mining down into the data suggests that main contractors tended to rate their production planning and purchasing sections as being central to collaboration, whilst other respondent types tended to have broader views, seeing transportation, stock holding / inventory and storage being relatively more important than main contractors did. This is possibly a reflection of their relative position / needs in the supply chain.

Question five surveyed motivations for collaborating with suppliers / sub-contractors from an answer selection of better service levels, cost benefits, simplify the project process and simplify the order / bid process. Responses indicated strong support for cost benefits (91.30%) very important / important and, better service levels (80.13%) with lesser support for simplification of the project process (67%) and simplification of the order / bid process (63.04%) for very important / important responses. Isolating

the main contractor responses found universal support for cost benefits (100%) being either very important or important. Akintoye *et al.* (2000) found similar support orders, however, for Ireland, the two leading responses have changed places with a greater focus on cost benefits, whereas the UK survey found service levels to be the highest rated factor. This may reflect the severe economic conditions prevailing at this time.

In regard to collaboration with clients, Question six, the respondents still felt that the possible cost benefits (95.65%) very important or important, were the most attractive motivational factor to collaborate, however there was more regard to the potential to improve the construction process (78.26%) and simplify tendering procedures (71.73%). Simplification of the design process (58.69%) also received significant support suggesting that early involvement by all stakeholders could improve that process. The order and scale of responses was relatively well aligned with the previous results by Akintoye *et al.* (2000)

Question seven, sought responses for collaborating with main contractors, again cost benefits was highest response (80.43%) very important or important, Simplify the project process (60.86%) Simplify the tender process (65.21%) Simplify the design process (52.17%) and create a standard process (47.83%) (All responses shown are for very important / important.) The results generally suggest lesser potential support for possible benefits when compared to collaboration with clients as question seven.

Question eight addressed collaboration with designers. Again cost benefits was the highest factor (84.78%) but was closely followed by simplification of the construction process (78.26%) simplify the design process (69.56%) Simplify the design / build interface process (82.61%) and create a standard process (60.87%) All responses shown as rated very important or important. Although cost is predominant, the relative closeness of ‘process’ related factors suggests respondents feel there is some potential to address the disconnection between design and build elements found in the literature. Love *et al.* (2004) and Egan (1998) for example.

Question nine sought views on the general benefits of collaboration from a palette consisting of reduced supply chains, Improved quality, supplier benefits, increased competitiveness, reduced costs, increased profits, reduced bureaucracy, improved customer service and client benefits. In terms of very important responses, the leading responses were increased profits (67%) Reduced costs (52%) and Increased competitiveness (52%) The three leading responses obtained by Akintoye *et al.* (2000) were client benefits, improved customer service and reduced bureaucracy. This shows more support for ‘cost’ related matters in this study, as compared with ‘process’ type factors in the earlier UK survey. Again this may reflect the economic context of the Irish results.

Question ten canvassed opinions as to the factors that help build effective supply chain relationships, relationship enhancement being an area that has exercised many in the literature. (Meng, 2009) (Love *et al.* 2004) From a range of possible options, respondents were asked to select what was very important. The most favoured response was reliability of supplies (57%) Secondly come three factors receiving similar support levels, again all heavily discussed in the literature. These were the support of senior management (37%), free flow of information (37%) and the degree of 'trust' present. (35%) Other responses were, more meetings (7%) training / development (19%) integrated IT systems (15%) link supply & demand (15%) Joint business planning (24%) and mutual interests (19%) ‘Trust’ in various forms is often

cited in the literature as being a prevailing relationship factor and received highest ranking in Akintoye *et al.* (2000) In this survey trust level was ranked fourth, a considerable distance behind reliability of supply.

The final question (Q11) assessed opinions on the barriers, preventing closer supply chain collaboration; again this is a particular area that has been heavily investigated in literature from many jurisdictions. (Spekman 1998) (Boddy 1998) (Dainty *et al.* 2001) The most favoured responses (for very important) were lack of understanding of the concepts involved (37%) poor organisational structures (30%) lack of top management support (28%) Other responses included lack of integrated IT systems (8%), lack of understanding of what the potential benefits are (15%) general lack of commitment (17%) Generally these responses chimed with Akintoye *et al.* (2000) in terms of the leading three opinions,

Finally several respondents made useful contributions in the open, other comments section. These included: *(Negative comments far outweighed the positive as reflected in the selection below)*

- 'The Irish industry is too small to support supply chain collaboration'
- 'Collaborating with suppliers / sub-cons will not work as it will cause a lack of competitiveness'
- 'Below cost bidding is making competition very fierce, If you bid using fair collaborative prices you will not win any work'
- 'The new Government contracts are causing serious problems, costs are extending and you cannot claim them back, contractors are taking all the risks'
- 'Lowest cost is still the main factor in contract award on vast majority of contracts'
- 'We have worked on a new framework with the Health Service and won a lot of contracts from it'

CONCLUSIONS

Initial evidence for Ireland from this early research and indeed many cases from other places recorded in the available literature points towards a contradiction in what practitioners say about collaborative supply chain methods and concepts and what they subsequently go onto do in practice. The results of the exploratory survey reported here show strong support for collaborative approaches and indicate subtle and detailed understanding of the general concepts involved. On the other hand contemporary reports of empirical practice from SCSI and Davis Langdon amongst others, suggests large scale opportunistic behaviour is taking place in the industry and that collaboration is being ignored.

This contradiction may at first seem odd, but upon reflection has logical foundations to it. The concept of 'collaboration' between parties in a supply chain is a very seductive argument. Most people would instinctively feel that 'collaborating' would yield better results than being ‘hands-off’ or indeed further along the scale to ‘adversarial’. Much of the published literature tends to support this, reporting positive perceptions of collaboration, suggesting that the industry feels that such collaboration is desirable and in its best interest. Available literature discussing empirical field studies also tends to acknowledge the difficulties involved with transforming these aspirations into reality, several suggesting this is a particular difficulty in construction situations. As Womack *et al.* (1990) suggested *'They know the words to the new song, but could not hold the tune'*

Many barriers to implementation have been identified, for example, scale of change needed and ill-defined benefits. (Boddy *et al.* 1998). Project based product, many small players and a wide geographical spread. (Briscoe & Dainty, 2005) Unrealistic programmes, late payments, poor contractual terms, poor site managers (Dainty *et al.* 2001) Economic environment, (Savolainen, 1999) (Lamming, 2000) the latter potentially having significant implications for Ireland and its embattled economy.

The analysis presented in this preliminary investigation in the Republic of Ireland gave rise to two questions, which are currently under further study:

Q1 Is there a significant difference between the views espoused by participants in the construction industry in regard to supply chain collaboration and the subsequent supply chain practices they engage in.

Q2 To what degree of influence has the current severe economic downturn impacted the construction industry with regard to the existing use and potential for supply chain collaboration in the sector.

Currently more detailed investigations are underway, using a construction project in the West of Ireland. Semi-structured interviews are being undertaken to assess, in more depth, attitudes and practices to SCM and the impact of recession upon those attitudes and practices.

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TRUST, CONTROL AND KNOWLEDGE INTEGRATION IN A ROCK TUNNEL PROJECT

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Rock tunnel projects that experience geological uncertainties tend to be both lengthier and more costly than planned. Traditional contract arrangements have proved to be less suitable when uncertainty is high; problem-solving being further hampered by contract-related distrust, communication failures and disputes. To efficiently respond to uncertainty and control risks of time and cost overruns, the knowledge of specialists in different firms needs to be mobilized. Findings from a case study of a railway tunnel project in Sweden aim to describe knowledge integration, communication and decision making related to geological conditions, comprising both formal and informal aspects. Findings show that formal and informal aspects are often complementary, also when they are contradictory, but that knowledge integration may suffer from a more formalized communication. Further, it is also important to consider relationships within the main actors' organizations as well as relationships and structures extending beyond the individual project.

Keywords: communication, control, knowledge management, relational contracting

INTRODUCTION

Urbanization increases the demand for land in central city locations and many public and private interests are competing for urban space. Underground facilities for transportation, then, are more expensive but cause less harm to other city functions. New interregional rail transportation to shorten commuter time and reduce climate impact also contributes to a likely increase in future underground construction.

Past experiences show that underground projects tend to encounter problems in terms of contracting and cost control. Risk is often considerable since geological conditions are never fully known until actual construction starts. A worldwide survey showed that at least 30% and probably more than 50% of underground projects experienced significant cost and schedule overruns (Reilly and Brown 2004). In a study of major European infrastructure projects by Hertogh *et al.* (2008), it was mainly tunnelling projects encountering unforeseen geological conditions and projects depending on the

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Eriksson, T and Kadefors, A (2012) Trust, control and knowledge integration in a rock tunnel project *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 697-706.

development of new technology that experienced cost increases and delays during the construction phase.

In Sweden, many underground projects involve rock construction. In the past, several Swedish rock tunnel projects have experienced high cost overruns and expensive litigation, partly associated with tighter environmental restrictions regarding leakage. At the backdrop of a particularly large lawsuit in the Southern Link project in the Stockholm area, a general industry initiative "Renewal in the Civil Engineering Industry" to improve relationships in the civil works sector was started in 2003. One subprogram specifically focused on relationships in rock construction.

Following from the dissatisfaction in the Swedish rock construction sector with current ways of managing and contracting for rock tunnel projects, a research project has been started with the aim of studying decision-making and communication in rock construction more in depth. This paper reports the findings of a pilot study of a rock tunnel project, aiming at identifying focus and issues for further research. The main question is: In the light of the past experiences of highly conflict-ridden projects, how do formal and informal aspects of control interact in shaping decision-making and knowledge integration regarding rock construction?

Contracting for rock construction

Specific contracting models have been developed and are regularly used to handle variations in geological conditions (ITA 1996; van Staveren 2006). These are based on classification of rock (or soil) categories, each associated with a technical design and a price list. As construction proceeds, rock quality is regularly assessed and the appropriate design, for example the level of grouting for reinforcement and sealing, is chosen. To make necessary adjustments and negotiate monetary compensations, continuous communication between the client organization and the contractor organization is required, thus, specialist technical functions are regularly involved in decisions affecting contracts and project costs.

However, assessments of rock quality are not unambiguous and actual construction costs do not always correspond to the prices of quantities defined in the contract. Reinforcement and sealing at the tunnel front is especially problematic and costly. This is because tunnel excavation progresses in one direction only and is dependent on heavy and expensive equipment, which means that standstills quickly lead to high cost increases. Further, the temporary reinforcement needed during tunnel construction is the responsibility of the contractor, while the permanent design - under a traditional contracting scheme - is the client's responsibility (ITA 1996). All these aspects contribute to disagreements and disputes when geological conditions depart much from what is predicted (van Staveren 2006).

Research on inter-organizational relationships in the construction area, both generally and specifically in tunnel construction, has most often been related to the relationship between the client and main contractor (Reilly 2000; Kadefors 2004). However, the client is not represented by one person or even by a homogenous group of client employees. Instead, the client project management organization in Swedish infrastructure project often consists to an important part of consultants. On the contractor side, several companies are generally engaged as subcontractors to a main contractor. Engineering consultancy firms contracted to make designs also use sub-consultants when needed. Hence, a great number of specialized organizations are involved in decision-making.

Formal and informal relationships

The relationship between formal and informal aspects of an organization has gained much attention in research on inter-organizational relations. Trust research has shown that the relationship between trust, collaboration and contracts is ambiguous and potentially contradictory (Biljsma-Frankema and Costa 2005). As noted by Argyres *et al.* (2006), the tendency in management research has been to view detailed formal contracts as unnecessary or even harmful to trust and collaboration (Macaulay 1963). More recently, however, researchers have increasingly considered effects related to sensemaking and learning (Vlaar *et al.* 2006; Poppo and Zenger 2002). Ring and Van de Ven (1994) describe the development of collaborative relations as a cycle, where informal trust building and formal commitments are two dimensions that interact to reinforce the relationship over time. Thus, relational and contractual governance in combination, not only separately, affect the relationship between a client and a supplier (Vandaele *et al.* 2007).

These aspects may interact in different ways; the informal and the formal organization may supplement and reinforce each other, or the two systems may be only partly aligned and emphasize different aspects. As argued by Gulati and Puranam (2009), the informal organization is the more persistent of the two, and the formal organization often focuses on behaviours that are not adequately supported by the informal organization. Thus, Gulati and Puranam (2009) suggest that by having formal and informal organizations that push in different directions, organizations may pursue desirable but organizationally incompatible goals (such as simultaneous exploration and exploitation). However, the system for producing informal understandings is less obvious, and is based on relational interaction that may take place in formalized meetings as well as on purely informal occasions. This implies that the informal system is also harder to control, so that important underlying cultural elements may be unintentionally lost over time.

In a study of Swedish rock construction, Styhre (2009) stresses that managing knowledge is about managing social relations and that everyday practices in the specific context therefore need to be considered. He emphasizes the role of oral and informal communication for knowledge sharing in the production phase, and claims that such communication is often expected to occur spontaneously, without explicit managerial initiatives. In effect, it is often dependent of the existence of physical shared arenas where actors can meet. Styhre expresses similar concerns as Gulati and Puranam (2009) that relying too much on informal channels may be both inefficient and risky. Thus, informal relationships are important and often needed to complement formal relationships, but also risk being under-managed.

METHODOLOGY AND DATA COLLECTION

The qualitative case study approach was chosen to get an in-depth understanding (Yin 2008) of the communication channels that might not be revealed by studying contracts and formal documents alone. Data was collected through five site visits over one year's time including eight semi-structured interviews. Interviewees were two project managers, two rock construction managers, an engineering geologist, an environmental coordinator and an assistant contract engineer in the client and contractors' organizations. Additionally, one client rock construction manager was observed during three of these days, including attendance at two different construction site meetings. Two interviews with engineering consultants were also performed at the premises of their firm.

The initial, client, interviews were not recorded to keep discussions more relaxed and informal. These were summarized, and if anything was unclear the file was sent to the interviewee who had the opportunity to correct and elaborate if needed. The later interviews with contractors and engineering consultants were recorded and summarized into text documents. All collected data were analysed to detect communication patterns and decision routes, as presented below.

THE PROJECT ORGANIZATION

The case study concerns a rural project including a two kilometres rock tunnel within a larger infrastructure development program. The tunnel, excavated with the drill and blast technique, was considered to be relatively uncomplicated by the client organization, although there were minor so called GK3-areas of more difficult rock conditions. It was a traditional contract, meaning that design was specified in detail and the client retained design responsibility through employing an engineering consultancy firm. However, there existed a partnering-like add-on called Increased Cooperation (IC) to the contract between the client and main contractor. What could be considered special within the project was that there were around-the-clock excavations with a client rock construction manager on duty, due to a tight deadline.

Client organization

Of the seventeen members in the on-site client project management team, only the project manager was an employee of the client organization. The other members were a mix of consultants from several consultancy firms. In addition, some in-house client support functions were active in several projects and not located on-site. These included PR and technical managers, such as a rock specialist.

Among the consultants, the three rock construction managers had the most central role for tunnel progress, making necessary everyday decisions and performing inspections to see that construction corresponded to specifications. Often the decisions were made in collaboration with, or based on information from, an engineering geologist who was responsible for inspecting the rock's characteristics and ordering the permanent reinforcements. The ground/bridge manager handled all contact with the engineering consultant firm, including tunnel related issues.

Several of the consultants in the on-site organization had been involved in one or two other tunnel projects in the overall program prior to this project and knew each other quite well. Among these were the assistant site manager, two of the rock construction managers and the engineering geologist.

Engineering consultant organization

When creating the designs more than 40 people, including sub-consultants, were usually engaged simultaneously in the engineering consultant's team. In the construction phase the engineering consultant provided construction support and the official organisation was reduced to a handful of people. A construction support manager, who previously had had another role in the project, was appointed to act as the engineering consultants' contact towards the client.

Contractor organizations

The main contractor was active in three road and rail projects within the program, making this rock tunnel project only part of their everyday concern. In this project the main contractor was responsible for informing the client on construction progress and handled all the formal contacts, but did not perform any actual tunnel excavation

activities. Instead, a tunnel subcontractor was engaged to execute the drill and blast procedure, in turn employing two second-tier subcontractors to perform mechanical tunnel cleaning after blasting and to remove loose rock and gravel.

At the time of the contractor interviews, the personnel in the main contractor site organization had worked together within the program for three or four years. However, this was the first time that the main contractor worked with this specific client team. As for the subcontractor, who entered the project later, this project was the first time to work with both the main contractor and the client organization teams.

Within the subcontractor organization, all roles obviously were related to the tunnel works. The project manager and the assistant project manager handled administrative tasks such as cost estimates. The site manager directed the works supervisors, with work environment and budget responsibility. Works supervisors were responsible for the performance at the tunnel front.

COMMUNICATION CHANNELS

Even though most decisions, including tunnel related ones, were formalized there existed both formal and informal settings were the project activities were discussed.

Formal communication

For formal communication, a document procedure was implemented in the preceding rock tunnel railway project in the program. It was introduced by the client's assistant site manager, who had come across it in a previous project. This specific document format had then spread to all other projects in the program.

The system organized the communication, so that if for example a subcontractor encountered a problem or wanted to make a suggestion they filled in a form that was sent to the client via the main contractor. The assistant site manager in the client organisation investigated the issue, consulting relevant expertise in the client organization, and formulated a response. If needed, the ground/bridge manager communicated issues to the engineering consultant's support manager via weekly meetings, emails or telephone. Responses were then sent back to the contractors the same way. Many tunnel-related issues had a technical character, such as requests for using another specific component than that stated in the documentation. The client's response could be requests for justifications that, in turn, were answered and finally approved or not. This meant that the procedure could be repeated in several iterations until an issue was resolved.

There were also a number of formal meetings connected to the system. All actors had their own weekly internal production-related meetings to discuss project progress as well as the upcoming week's goals. Issues were usually brought up then, prior to putting them into text. The contractor additionally had subcontractor meetings where tunnel excavations were discussed together with other subcontractor issues. These meetings usually took place before a weekly, joint client and contractor meeting at the client's site office. The tunnel subcontractor was in fact allowed to participate during the first part of these client-contractor meetings since that part concerned the tunnel progress. Main and subcontractor participants were usually six to seven members of top or middle management. From the client organization most of the personnel participated. More overall issues such as budget changes were dealt with in other monthly meetings between the client's and main contractors' top management.

Another rock-related dialogue that affected the production was of a more irregular character. When the excavation reached a more complicated area, according to predefined specifications, an external so called GK3 expert was called upon. This specialist, who had also reviewed the designs, would confirm or reject the temporary and permanent reinforcement solutions proposed by the onsite personnel. Either the expert would visit the site personally or the rock construction manager and the engineering geologist would call and brief the expert after inspecting the tunnel, who then gave a final decision. The GK3 expert was employed by the same consultancy firm as one of the rock construction managers and the engineering geologist.

The client was satisfied with the main contractor as a single contact point for all issues regarding contractor issues. Similarly, the consultant's construction support appreciated not having any direct contact with the contractors, since the consultancy firm did not have the mandate to make decisions on the client's behalf. The rock subcontractor, on the other hand, would have preferred to have more opportunities for a direct, formal dialogue with the client. It was mentioned that it could be difficult to gain approval on certain suggestions, especially when there was no obvious gain in the client budget, and even if the reason for a rejection probably was acceptable it was seldom explained.

The subcontractor's project manager also missed the possibility to communicate directly with the engineering consultant; he would have found this reassuring and also time-saving, since the consultant then could start to investigate the question before it formally arrived. Neither did the rock construction managers have any direct contact with the engineering consultant. They considered this to be the ground/bridge manager's job, but still commented during the interviews upon aspects in the design documents that they were not satisfied with. Some issues, they said, had not been changed although they had been pointed out during design document reviews.

A client rock construction manager stated that without documentation, referring to the formal document procedure, it would be difficult to know what had already been decided by the client organization, since the rock construction managers worked shifts around the clock. Also at the subcontractor the time issue was mentioned: since construction employees worked in shifts while the administrative staff did not, there could be difficulties informing everyone of updates in the weekly meetings.

Informal communication

Although the formal communication route generally was followed, there was also communication at the tunnel front, primarily between the subcontractor’s works supervisors and the client’s rock construction manager and engineering geologist. The communicated decisions were formally the rock construction managers’ but informally often made jointly with the engineering geologist. Informal decisions or agreements at the tunnel front were often formalised ex-post in the formal procedure.

In these discussions, it was important for the rock construction managers not to interfere with contractors responsibilities. When an experienced rock construction manager saw that the contractor was doing something that he thought could be done better, he was careful to formulate his opinion as advice: “In that situation I would have used Z to accomplish Q”. This way the rock construction manager could share knowledge without issuing orders and thereby assume responsibility for worker safety that justly belonged to the contractors. If formulating it as an order, an invoice for a change order would probably appear as well.

To reduce meeting time and not overwhelm the other disciplines, there also existed informal tunnel related meetings between the client, the main contractor and the subcontractor. Usually, the purpose was to go into depth of something specific in production, possibly before bringing it up on the weekly meeting, but the meetings could also be used to simply check that all parties were on the same page.

Relations and collaboration

The project manager did not have any former experience of rock works or tunnels and relied on the rock construction managers' expertise, trusting their opinions and decisions. All client interviewees claimed that the working climate was very open within the client organization. Client-contractor relations were also good, and one rock construction manager said that "you should be able to have a big disagreement and then take a coffee break together", implying that this was the case in the project. The contractor and subcontractor as well agreed that there was a good climate in the project. That client and contractors' site offices were located within walking distance from each other was considered helpful to the positive atmosphere.

The contractors were located in the same building and had daily interactions. There was a trust in each other's expertise and neither party interfered in the other's responsibility. The organizations supplemented each other in some ways, i.e. since the main contractor had an experienced environmental coordinator the subcontractor could employ a less experienced one. It was suggested that this could be taken one step further, e.g. by giving the client's environmental coordinator mandate to make decisions in all three organizations instead of each actor having their own specialist.

Several of the client's consultants, as well as the subcontractor's project manager, mentioned that the rock works industry is small in Sweden. Most of them had come across each other over the years in other projects and then often in other roles, both in client and contractor organizations. Lessons were also learned from own former projects or from projects that had become public knowledge. The conflict-ridden Southern Link project, mentioned initially in this paper, was brought up spontaneously by several interviewees as an example of practices and relationships they wished to avoid.

As a consequence of the IC element, the client and contractor employees participated in workshops twice a year to discuss collaboration. Opinions on these exercises differed, the main contractor interviewee and the client's project manager were positive, even though some possible improvements were mentioned. The subcontractor's project manager participated in the workshops but did not feel involved in IC apart from this. Some client members saw the workshops as somewhat unnecessary and had given them a slightly condescending nickname, "hugs-and-kisses-meetings". The engineering consultant was not involved in IC at all.

DISCUSSION AND CONCLUSIONS

Clearly, formal communication in writing, formal meetings and informal, everyday communication were of central importance in the project. There is a tradition in construction that client representatives communicate decisions in oral discussions on site, but formal systems are increasingly used to regulate such communication and reduce the risk of confusing informal communication and change orders (Kadefors 2005). The formal system in this project was relatively new to the participants and generally well received. It was not perceived as a control mechanism or sign of distrust. Rather, the parties welcomed the reduced ambiguity and documentation of

decisions, which was useful also for internal communication purposes (Vlaar *et al.* 2006). In many cases, the formal system was complemented by informal communication fora, and then functioned to confirm decisions already discussed in face-to-face interactions in explicitly informal technical meetings or at the tunnel front (cf. Ring and Van de Ven 1994; Styhre 2009). Table 1 shows identified interactions between actors, which was most extensive both formally and informally between individuals on site.

Table 3 Actors formal (top of cells) and informal (bottom of cells) means for communicating or controlling tunnel related issues. The top row indicates what actor that uses what means to interact with the actors listed in the left-hand column.

	Client	Main contractor	Subcontractor	Engineering consultant
Client	GK3 expert Documentation Internal meetings	Joint meetings Documentation	-	Document-ation Meetings e-mail
	Everyday interaction	Informal meetings	Informal meetings Queries in tunnel	Telephone contact
Main contractor	Inspections Documentation Joint meetings	-	Sub-con meetings	-
	Informal meetings	-	Informal meetings	-
Sub-contractor	Joint meetings	Meetings Documentation Colocation	Internal meetings	-
	Informal meetings Advice in tunnel	Informal meetings	Everyday interaction	-
Engineering consultant	Meetings Documentation e-mail contact	-	-	Internal experts Email
	Telephone contact	-	-	Everyday interaction

However, there were some trade-offs and drawbacks in the area of knowledge integration. One aspect was that information exchange at the tunnel front was hampered somewhat by the client's concerns to avoid additional costs and responsibilities. Another aspect concerned processing of suggestions and requests from subcontractors. The formal system followed the contractual hierarchy, and less centrally placed parties suffered from longer communication channels. In the rock area, expertise was found in the client organization (one central expert, the on-site rock managers and engineering geologist), the engineering design consultancy firm, the tunnel subcontractor firm and the GK3 expert. There were few opportunities to process suggestions from the tunnel subcontractor informally with knowledgeable expertise on a higher management level.

In line with the findings of Gulati and Puranam (2009), the formal system was introduced to come to terms with inadequacies of the informal system, which risked producing unclear responsibilities and disagreements about costs. However, the formal system also relied upon a complementary informal system, compensating for the lengthy formal processes, in which communication was restricted to writing and passed several functions which lacked rock construction expertise. Between some actors, semi-formal meetings were held, and communication was also enabled by co-location or physical meetings on-site (Styhre 2009). Subcontractors then could partly compensate for their formally peripheral position by their central position on site. The main contractor had a formally strong position, but informally it was weaker. The engineering consultant had a weak position formally as well as informally, which impacted negatively on opportunities to share knowledge within the project regarding rock-related issues. Interestingly, only the rock subcontractor saw this as a problem, but the lack of integration still indicates a potential relational weakness that may be a breeding ground for conflicts in the case of more important technical problems.

Another important issue concerned internal relationships within each major actor. Clearly, the client project manager showed a substantial level of trust towards the consultants acting as client representatives, especially those in the field of rock construction where she had little knowledge. The rock construction manager and the other client project management consultants together acted on behalf of the client in many decisions affecting cost and quality. Formal control mechanisms in these relationships existed primarily in the purely technical area: the independent GK3 expert checked construction in difficult rock areas, and the client's internal rock expert also checked technical solutions.

Further, it was clear that relational control could not be understood without considering also relationships beyond the individual project. It was stated by several interviewees that relationships developed in previous projects within the same program helped to create the friendly atmosphere and smooth communication in the organization, for example between the engineering geologist and the rock construction manager. Also client-contractor relations extended beyond the project, and that the subcontractor was new to the program probably contributed to their perceptions of being less involved. Further, the Swedish rock works industry is quite small. Information and knowledge is shared between individuals who acquire common frames of reference. Reputation regarding the competence and attitudes of individuals on both sides spread efficiently, functioning as informal behavioural control systems.

Thus, the opportunities of an ambidextrous strategy, formally emphasizing one set of values and behaviours while strongly relying on behaviours produced within a partly contradictory informal system (Gulati and Puranam 2009), is sustained by interaction taking place within long term relationships between individuals who meet in different projects and in different roles.

FUTURE RESEARCH

We conclude that to understand knowledge integration in rock construction it is necessary to examine formal and informal relationships in interaction. Since rock-related expertise is often less centrally placed in organizations, mechanisms enabling lateral communication bypassing the formal system are important, as well as norms and understandings produced in longer term relationships.

Further, the issue of internal client relationships is a neglected area: To what extent is knowledge sharing, for the purpose of reducing construction costs, environmental impacts or client management costs, supported by formal and informal systems? And when client functions are increasingly outsourced, how does the more long term informal control system develop in interaction with contract-based project governance systems?

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IMPROVING SUPPLIER RELATIONSHIP MANAGEMENT WITHIN THE AEC SECTOR

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Due to changes in many facets of projects and organisations, relationships between firms in the delivery of construction projects have consequently become more critical for the success of the project. Whether it is a transactional exchange or series of transactions spread over a period of time, relationships need to be managed. However, the concept of managing supply chains and relationships between firms has been relatively new to construction industry. Early pioneers of the concept, primarily automotive, aerospace and manufacturing industries, have greatly benefitted from non-adversarial, long-term and collaborative relationships. Although contextual factors within those industries largely shape each industry's approach to SCM (Supply Chain Management), it is application within the AEC industry is slowly beginning to appear in a distinct shape and form. Through a comprehensive review of literature on construction-specific SCM (cSCM), the study has identified that partnering, collaboration and trust are the three most prominent variables within the cSCM literature. Partnering and collaboration are considered to be relationship management tools, whereas trust is identified as the most significant relationship facilitator. In spite of its significance on relationship development, there is very limited research carried out on the trust aspect of relationships. By understanding how trust is built and maintained, and what the conditions that result in mistrust are, firms can better manage their supply chains and their relationships with firms in the supply chains, manage factors that result in mistrust and mitigate potential conflicts arising from mistrust. Consequently this will facilitate better collaboration, result in high-level of commitment, improve project teambuilding, and avoid conflict and adversarial relationships. Drawing on organisational relationship management literature, we argue that trust must be approached from five dimensions; economic, social, psychological, inter-personal and organisational. These dimensions are unidirectional and they must be accounted conjointly as they are interrelated and interdependent.

Keywords: supply chain management, relationships, trust, partnering, collaboration.

INTRODUCTION

Management of supply chains within the AEC industry is beginning to attract more interest from academia and industry. Early pioneers of the concept, primarily automotive, aerospace and manufacturing industries, have greatly benefitted from non-adversarial, long-term and collaborative relationships. Although the concept of managing supply chains has been adopted and adapted to the construction industry from these industries there is still large amount of work to be done to improve the AEC organisations' supply chain management

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Pala M; Edum-Fotwe F ; Ruikar K; Peters C and Doughty N (2012) Improving supplier relationship management within the aec sector *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 707-716.

operations. One of the most prominent variables suggested in the literature for an effective and efficient supply chain management strategy is 'trust'. The purpose of this study stems from the fact that although trust has been suggested as the most important relationship attribute it is not considerably studied within the construction specific supply chain management literature (cSCM).

Importance of supply chains in achieving industry wide improvement plans, enterprise level business strategies and project level operational objectives is significant for all the actors involved in a construction supply chain. Most firms have realised that by managing their supply chains effectively potential cost-savings can be achieved on projects as well as throughout their relationship; for example, through better supplier management practices and long-term relationships with key strategic suppliers/subcontractors (Matthews *et al.* 2000). Consequences of unmanaged supply chain relationships are 'arm's-length', opportunistic and adversarial relationships which further results in disputes and inefficiencies in construction processes and increased cost and waste (Briscoe and Dainty, 2005).

To add to the problem further, both the research and the practice had an hindsight approach where majority of attention has been given to firms who are at the upstream level (Akintoye *et al.* 2000; and, Briscoe *et al.* 2004) ignoring the downstream supply chains (Saad *et al.* 2002) where up to 90-95% of contractual relationships occur in a project (London, 2004). As reinforced by Briscoe and Dainty (2005) every relationship requires a different approach to its management which makes the management of supply chain relationships a complex process. In addition to this, it has been highly advocated that firms must re-evaluate their approach to engage with both clients and suppliers. It must be noted here that attention should not be solely directed on certain relationships which are only 'dyadic' (i.e.: partnering) but consider the extended network of relationships between buyers and suppliers where the aim should reflect a total relationship management approach.

The aim of this study is to explore the 'trust' attribute in construction supply chain relationships by conducting a desk study on relationships in construction supply chains. Although there are a few conceptual ideas beginning to form (McDermott *et al.* 2005; Khalfan *et al.* 2007; Lau and Rowlinson, 2010; and, Laan *et al.* 2011) the discussion seems to be fuzzy and disconnected from one another. The conceptual base of 'trust' in construction supply chain relationships is not adequately developed for it to be empirically tested in the industry. It is repeatedly preached that supply chain firms should trust one another during a transaction/interaction however there seems to be limited study on how to execute a trust-based relationship. This study argues that a multi-dimensional perspective on trust is needed for comprehensive coverage of the concept in empirical studies.

Trust in Construction Supply Chain Relationships

Generally, relationships are characterized as having a multi-dimensional relationship structure where many elements (both human and firm) shape a relationship's type, form, duration and intensity (Håkansson and Ford, 2002). Hence there could be many multiple, dynamic, and context specific relationship layers within construction supply chains (Pryke, 2006). Trust is placed at the core of these layers, however within the AEC industry lack of trust undermines majority of interactions within supply chains (Briscoe *et al.* 2001b; Lau and Rowlinson, 2009; and, Laan *et al.* 2011). Trust can have a direct or indirect consequence on almost every element of supply chain interactions. There is a unanimous agreement within the literature reviewed that trust is one of the most important constituents of long-term, collaborative and non-adversarial construction supply chain relationships.

In terms of its main function, trust has three primary roles in organisational relationships. Accordingly, it's a (i) 'social mechanism' that works outside formal arrangements (Möllering

et al. 2004); (ii) 'lubricant' that enables smoother flow of information, products and services (McDermott *et al.* 2005); (iii) 'glue' that holds people and organisations together and creates synergy (Noteboom, 2002). For instance Spekman (1998) claimed that trust is the foundation of supplier relationship management. Eriksson and Laan (2007: 389) stated that "*to obtain advantages and synergies of cooperative relationships, establishment of trust is vital*". Latham (1994: 87) noted that "*disputes will continue as long as people fail to trust one another*." Frödell (2011) argued that trust is the most critical factor and most important relationship enabler between strategic partners.

Despite its significance in supply chain relationships there appears rather limited research concentrating on this vital attribute specific to cSCM. The research carried out on trust aspect of relationships is primarily descriptive and lacks empirically tested studies. More specifically, there appears very limited research which explains how trust is built and maintained, and what are the conditions that result in distrust in construction supply chains. Anecdotal research generally focuses on impact of trust on partnering arrangements (for example Eriksson and Laan, 2007; Lau and Rowlinson, 2009; and, Laan *et al.* 2011) and does not consider the various dimensions of trust embedded in construction supply chain relationships. By understanding and establishing high level of trust within and between firms and individuals; supply chain firms can manage their relationships with fewer resources, understand the consequences of their decisions, increase and maintain trust to the highest level and then reap the benefits of trust-based relationships. This is illustrated in Figure 1.

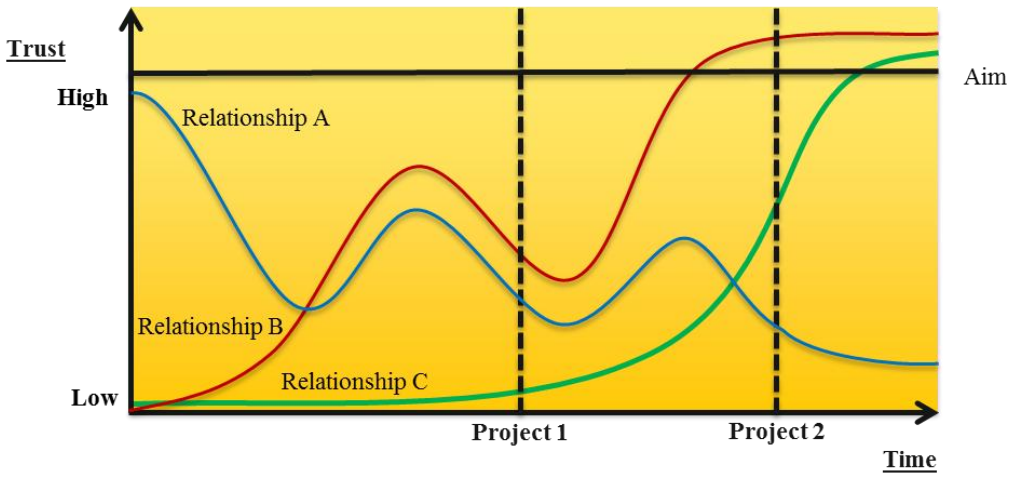

Figure 1: Development of trust in project relationships

DISCUSSION

Within this study 40 articles published in various peer-reviewed journals were selected to identify the most common themes for effective and efficient supply chain relationships (See Appendix 1). Majority of these articles are empirical studies which are based on cSCM. Analysis of the articles was carried out using coding where each specific relationship attribute mentioned in the article was mapped in a matrix.

An effective and efficient supply chain is usually judged on social, economic, organisational, interpersonal and technological dimensions of interaction. Therefore the key relationship attributes were categorised into these five areas on the vertical axis where each specific attribute for effective and efficient cSCM were identified and then marked with a sign to indicate its agreement, disagreement or contextual arguments in relation to that variable.

Appendix 1 shows there is more emphasis on improving the organisational aspects of supply chains. According to this matrix partnering, trust and collaboration are the top three relationship attributes associated with effective and efficient supply chains. Partnering and collaboration can be considered as the relationship management tools which give rise to the physical interaction between supply chain firms. The trust attribute can be described as the facilitator of the interaction which enables a relationship to form, develop and function.

DEVELOPMENT OF TRUST IN CSRM

The effectiveness, efficiency and other resource qualities of a collaborative supply chain can only be as good as the weakest link in the chain. The primary reason for this is the knock-on effect which is triggered by the weakest firm in the supply chain which is further cascaded upstream or downstream in the chain. In addition to this, the transient, independent and multi-organisational characteristics of construction projects require development and alignment of *relationships* in a much faster way. Management and control of these relationships are crucially important to ensure that system works smoothly without any obstructions. Therefore the role of trust within these contexts can have a considerable impact on many facets of projects and organisations. In spite of its significance in relationships, 'trust' has been studied from a parochial view within cSCM literature where all of the constructs of trust have not been adequately discussed. Available literature on construction supply chain trust (for example McDermott *et al.* 2005; Smyth, 2006; Khalfan *et al.* 2007; and, Lau and Rowlinson, 2009) only studies the relationships from interpersonal or organisational perspective.

Trust is a multi-perspective and multi-dimensional construct which can be categorised into five broad dimensions: economic, social, psychological, inter-personal and organisational (referred to as 'ESPIO' dimensions of trust, see *Figure 2*). When studying the impact of trust on relationships the ESPIO dimensions of trust must be accounted conjointly as they are interrelated and interdependent. For example, organisational trust can be shaped by the individuals within that organisation and individual trust in turn, can be shaped by psychological or social trust vice versa.

The literature on trust is very diverse and covers a variety of levels within the scope of these dimensions. Some of the forms of trust identified within the literature are presented in the box opposite to the dimensions of trust in *Figure 2*. However, it must be noted that there could be many overlaps or cross-disciplinary dimensions of trust, hence a form of trust (i.e.: the label which addresses trust within that dimension) can be used interchangeably within different dimensions (*Figure 2*). An example of this is macro-level trust within a socio-organisational dimension.

In relation to the sources of trust; that is the attributes of the trustee, there are wide range of sources (objects, traits and characteristics) identified and grouped according to its relative dimension. Contributing factors are considered to be the antecedents, in other words factors that facilitate development of trust. Several studies have revealed some construction specific factors within different project environments (for example Khalfan *et al.* 2007), but the list mainly consists of inter-personal and organisational attributes that contribute to the development of trust and lacks economic, social and psychological dimensions of trust.

In most of the studies on trust, the trust construct is primarily regarded as a concept made up of several abstract entities which give rise to its existence. This is termed as '*sine qua non*' of trust (Laan *et al.* 2011) which is the conditions of trust, without which trust would not exist. For example, Rousseau (1998: pg.395) argued that trust is "*a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another*". This implies that trustor has to be vulnerable to the actions of trustee

under the conditions of risk, uncertainty, vulnerability, opportunity, dependence and unpredictability.

Two arguments are noted with regards to the control and trust in relationships (Noteboom, 2002). On one side, it has been argued that more control on above elements will result in less trust and vice versa, and on the other side, it has been argued that trust and control are complementary in counteracting these elements (Schoorman *et al.* 2007). In relation to the first point, for example the use of governing mechanisms to monitor a subcontractor's activities and/or create reward structures that reinforce the contractor's desired activities may not necessarily facilitate the development of trust (Noteboom, 2002). Therefore actions of the trustee may be attributed to the existence of these incentives or governance mechanisms rather than to the trustee.

With regards to the second point contracts can be regarded as sources of trust where existence of these control mechanisms eliminates the need for trust. However, no contract is complete in its scope for covering every possible factor that may affect the relationship. Therefore, conditional trust is adopted by the trustee until a relational trust is built between the trustee and trustor. For Smyth (2006) the development of trust requires a 'socially orientated' approach to build trust-based long-term relationships between supply chain actors.

In view of the above, two arguments can be made in relation to developing trust-based relationships in the AEC industry: formal and informal. Formal tools which are mainly applied from 'transaction cost economics' practices are not favoured for developing long term relationships and informal mechanisms such as social and cultural-structural dynamics embedded in supply firms are highly advocated for development of trust. In addition to this, there are many 'soft' tools such as high-level and individual commitment; effective information sharing and communication; team-working; openness of relationships; organisational culture; individuals attitude, behaviour and culture; honesty and reliability which have been mentioned within the matrix. For example Briscoe *et al.* (2004) identified

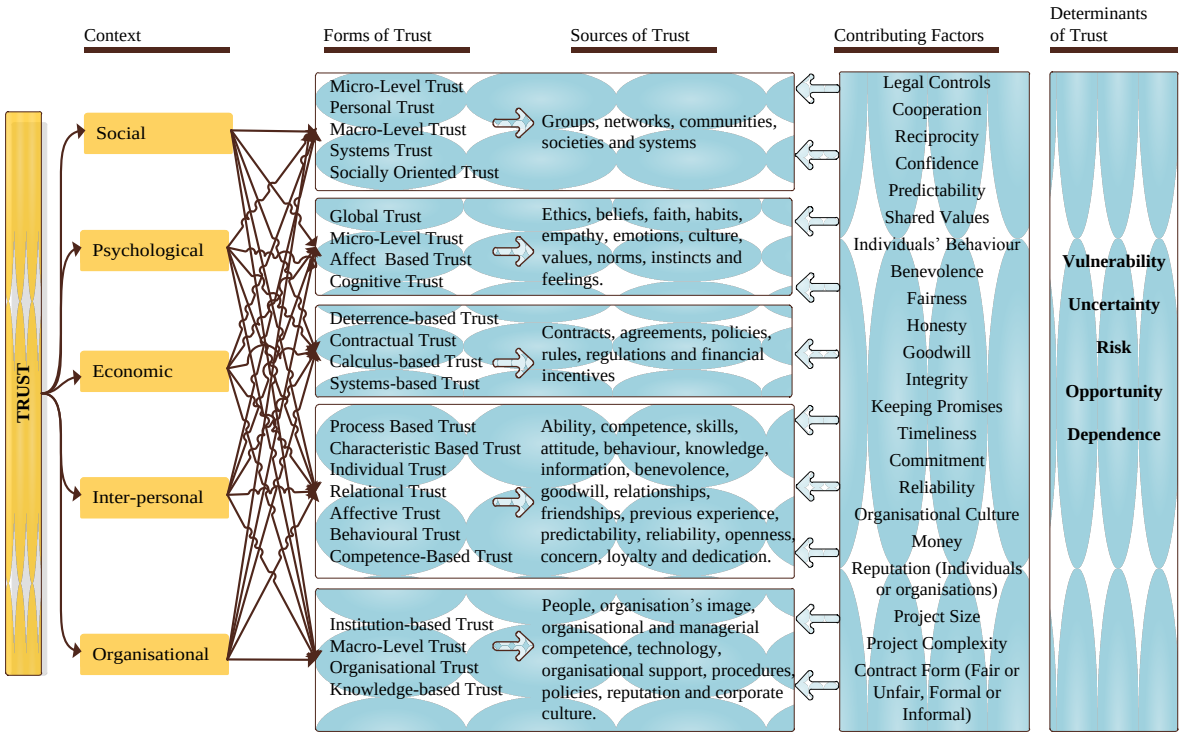

Figure 2: ESPIO dimensions of trust

that collaborative relationships evolve more effectively when not constrained by the formal aspects of contractually defined relationships.

Furthermore, there appears two opportunities for further investigation. Measurement of different dimensions of trust may not be the same therefore how different dimensions of trust develop within and between supply chain firms must be studied in order to measure the inter-firm trust between supply chain firms. Secondly, in relation to social dynamics of relationships social capital should be considered in understanding how trust develops within socio-organisational dimension of relationships.

CONCLUSIONS

Responses to the challenges that plague the construction supply chains have predominantly discussed partnering, collaboration and trust between supply chain firms. This was also confirmed from the review of 40 articles in construction specific supply chain management literature. Partnering and collaboration are two important practices for relationships to function whereas trust is the single most quoted facilitator of that mechanism which has a multiple role between the supplier buyer interfaces. The importance of managing supply chain relationships should never be underestimated. Management of the various interfaces that a firm has with other supply chain actors could have an impact on the project network where many buyers and suppliers contribute to the development of a project. If mistrust between the parties overshadows the collaborative environment it can result in adverse relationships between supply chain actors but if the opposite is the case than benefits gained from trust-based relationships must be persistent and further developed for subsequent interactions.

cSCM must be a high-priority at the project level and enterprise level for long-term, non-adversarial, mutually beneficial and synergistic inter-firm relationships. In order to develop better relationships between supply chain firms 'trust' must be deeply embedded into these relationships so that benefits of the high-trust relationships can be fully reaped. The literature discussing trust in construction relationships is inadequate and falls short of covering various dimensions of the trust construct. This paper introduced the argument that trust as a construct comprise of economic, social, psychological, inter-personal and organisational dimensions which are intertwined and enmeshed in a complex web of interactions between individuals and organisations. A conceptual base for developing trust is what is needed so that further research can focus on each element in more detail.

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APPENDIX I

Key:	
Paper supports SCM & SRM, and discusses this variable	●
Paper mentions this variable but does not discuss it	○
Context and Relation Dependent variable	Δ
Paper is counter argumentative	Red

		Core Themes																																														
		Partnering																SCM									SRM								Trust					Power	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
		Briscoe *et al.*, 2001	Matthews *et al.*, 2000	Dainty et al., 2001a	Black *et al.*, 2000	Bresnen and Marshall, 2000a	Bresnen and Marshall, 2000b	Humphreys *et al.*, 2003	Naoum, 2003	Beach *et al.*, 2005	Wood and Ellis, 2005	Hartman and Bresnen, 2011	Mason, 2007	Larson, 1997	Eriksson, 2010b	Eriksson *et al.*, 2009	Gadde and Dubois, 2010	Akintoye *et al.*, 2000	Vrijhoef & Koskela, 2000	Eriksson, 2010a	Briscoe *et al.*, 2004	Briscoe and Dainty, 2005	Green *et al.*, 2005	Eriksson and Pesamaa, 2007	Saad *et al.*, 2002	Power, 2005	Fridell, 2011	Smyth and Edkins, 2007	Haksever *et al.*, 2001	Dubois and Gadde, 2000	Eriksson and Laan, 2007	Eriksson *et al.*, 2007	Rahman and Kumaraswamy, 2004	Kumaraswamy and Matthews, 2000	Khalfan *et al.*, 2007	McDermott *et al.*, 2005	Meng *et al.*, 2011	Laan *et al.*, 2011	Lau and Rowlinson, 2009	Cox and Ireland, 2002	Ireland, 2004	*Total '●'*
	Google Scholar Citation Index	90	47	115	166	260	147	47	96	53	40	1	11	103	4	2	2	166	245	2	74	40	34	26	99	139	1	42	9	116	19	16	38	66	25	11	1	3	6	62	16	
Generic Attributes	Specific attributes of effective and efficient supply chains																																														
Social	Honesty	●	●	●							●		●																					●	●	●		●	●			**10**
	Trust (Universal)	●	●	●	●	Δ		●	●	●	●	○	●		●	●		●	●		●	●	●	●	●	●	●	●	●		●		●	●	●	●	●	●	●	Δ		**30**
Economic	Open book accounting	●		○									Δ		●						●															●	●	●	●				**7**
	Joint conflict resolution					Δ	Δ		●	●				●	●						●			●	●		●			●	●	●	●	●		●	●	●				**16**
	Best value approach		●	●	●	Δ	Δ		●	●							○	●			●	●		○	○	○	●							●			●					**11**
	Profitability and repeat business					Δ											●	○					●				●				●				●				●	Δ	●	**7**
	Logistics and operations management																			●						●				●												**3**
	Alternative forms of procurement and sourcing		●	●	○	Δ		●	●			●			●	●	●		●	●	●		●	●	●					●	●	●	●		●	●	●	●				**22**
	Sharing of risks and rewards			○	●				●	●			●	●	●	●			○	●					●	●		●			●	●	●				●	●				**16**
	Transparency	●	●	●							●								○		●				●						●			●		●	●	●		Δ		**11**
Organisational	Power					Δ																Δ					●									○				Δ	Δ	**1**
	Partnering	●	●	●	●	Δ	Δ	●	●	●	●	●	●	●	●	●	●	●	●	●		●		●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	Δ	○	**33**
	Reliability and interdependence									●			●				●	●	●				●		●		●		●	●					●	●	●	●	●	Δ	●	**16**
	Previous experience						Δ						●	●							●			●					●		●				●	○						**7**
	Common purpose-mutual Interest	●	●			Δ			●			●	●		●	●	●	●	●				●		●		●			●	●	●	●	●	●	●	●	●			Δ	**23**
	Project teambuilding						Δ	●							●									●								●			●			●					**6**
	Structural alignments for strategic interactions		●		●				○			●					●	●	●				●	●		●				●						●		●					**12**
	Organisational trust			●	●			●	●																			●					●	●	●	●	●	●	●				**12**
	Relationship Management												●				●	●		●	●				●		●	●		●			●			○	●			Δ		**11**
	High level commitment				●	Δ	Δ	●		●				●			●	●			●	●			●	●			●						●	●			●			**14**
	Organisational culture	●			○	Δ	Δ		●	●													Δ		●		●							●	●	●	●					**9**
	Cooperation	●	●	○		Δ	Δ		●		●		○		●	●	●	●	●	●	●	●		●	●	●	●					●	●				○	●	●	Δ		**20**
	Project Culture		●																														●	●								**3**
	Early involvement		●	●	●		●	●		●					●	●				●	●	●		●		●					○	●		●								**15**
	Continous Improvement		●	○		Δ			●	●				●	●	●				●												●	●				●					**10**
	Long-term focus					Δ	Δ		●				●		●	●				●	●		○	●			●		●	○	○	●		●			●				○	**12**
Individual	Alignments for operational interactions				●	Δ	Δ					●					●	●	●	●	●	●				●												●	●			**11**
	Individuals' trust in and between organisations			●																●														●	●			●	●			**6**
	Individual commitment				●					●						●									●										●	●		●				**7**
	Training and skills	●	●	●	○			●		●				●	●	●		●														●						●				**12**
	Individuals' attitude, behaviour and culture	●	●	○	●	●	●	●				●				●							Δ		●										●	●		●	●			**13**
Technological	Collaboration			●		Δ	Δ			●	●	●	●	●	●	●	●	●	○	●	●	●	●		●	●	●	●	●	●	●	●	●	●			●	●	●	Δ	●	**28**
	Lean Construction Principles	●	●																	●										○										Δ	●	**4**
	Integrated ICT infrastructure/Virtual Organisations	●		○											●	●				●	●	●		●		●	●			●		●		●				●				**13**
	Communication/Information Exchange	●		○	●			●	●	●			●		●					●	●	●	○	●	●	●	●		○			●	●	●	●	●	●	●	●	Δ	●	**23**

PRE-SELECTION OF CONSTRUCTION CONSULTANTS BASED ON ATTRIBUTES OF TRUST

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A review of construction consultants' selection identified weaknesses in the process that focused on cost and technical abilities alone. This paper presents a construction consultant pre-selection factor model based on attributes of trust, which attempts to improve consultant selection processes. A review of related literature shows that trust was found to enhance the decision making process. However, there is a knowledge gap in construction management literature as regards what constitute the attributes of trust which can be of benefit to the construction client or its agent in selecting appropriate consultants. In total 37 consultant selection trust attributes thought to potentially influence consultant pre-selection were identified from literature. Based on these attributes, a structured questionnaire survey was designed using a Likert-type scale and administered online to 189 willing construction clients. Survey responses were analysed using principal component analysis. This led to the development of an 8-factor model of consultant pre selection, namely, (1) service quality,(2) collaborative relationships, (3) qualification, (4) organisational trust, (5) personal qualities, (6) ability, (7) experience and (8) respect. The research provides the construction industry clients with a practical 8-factor pre selection model that can be effectively used by the construction clients to improve the consultant selection process.

Keywords: consultant selection, pre-selection, principal component analysis, trust.

INTRODUCTION

Clients in the UK appoint construction professionals to design, manage and control the construction process. The construction professionals according to CIB (1996) must provide 'design, cost, management and other advisory services'. Construction professionals include 'architects, engineers, project managers and surveyors' (Temple 2006). Evidence from a review of related literature shows that clients require improved performance from construction consultants (Bohn, 2004). Project performance can be enhanced by the 'recruitment, selection and training of project personnel… in so far as clients wish to appoint those who can enhance team performance and compatibility', (Rowlinson and McDermott 1999). OGC (2003) concurs, claiming that the quality of these services has a direct impact on the

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McClements S; Odeyinka H and Eadie R (2012) Pre-selection of construction consultants based on attributes of trust *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 717-726.

remaining 98% of the whole life cost of the construction project. A review of consultant selection methods showed weaknesses in consultant selection systems and that offered this research the opportunity to advance knowledge on improving consultant selection processes. Weaknesses in selection methods could result in clients employing "incompetent consultants which may lead to problems in design, planning, cost control and supervision, which could in turn affect the time, cost, quality and risk levels of a project' (Cooley, 1994). Although lack of trust was not mentioned as an inherent weakness in consultant selection systems, Price *et al.* (2005) identified low levels of trust that can result in problems such as low motivation, commitment and a lack of confidence in the organisation, and have resulted in the 'breakdown of relationships' (McDermott *et al.* 2004). This research aims to synthesis consultant services with attributes of trust to construct a consultant pre-selection factor model. The objective of this paper is to identify selection attributes based on trust and to understand the critical attributes associated with consultant pre-selection. It is anticipated that this study could enhance advance the rigour of the consultant selection process.

LITERATURE REVIEW

Pre-Selection

In selecting a team of construction consultants Leung (1995) found that many public and quasi-governmental clients have adopted a two stage or a 'two-tier' process for evaluating consultants in an attempt to improve the rigour and reliability of consultant selection decisions. The first stage, namely pre-selection can take many forms but the overarching aim, according to Ng and Chow (2004) is to formulate a list of equally suitable and capable consultants upon which invitations for submitting a bid for a consultancy assignment can be founded. Fundamentally this requires carefully identification of selection attributes.

Trust

Clients, according to Sharma and Patterson (1999) are in a vulnerable position which requires them to trust in the competencies and abilities of their consultants. Client vulnerability is a key element of trust in client consultant relationships. Trust can enhance cooperation between parties, improve reputations and provide the basis for the best mutual outcome. Ultimately the best outcomes of project success are achieved when there is 'a true professional relationship of absolute trust between the client and consultant', FIDIC (2003). Sahay (2003) found that trust can be used as a prediction process; therefore a selection method based on attributes of trust could enhance the client's ability to select a trustworthy consultant. Whilst previous research efforts have identified 'trust' as a key element in consultant selection, there still remains a gap in knowledge as regards the attributes of trust which helps the construction client in an objective way to make consultant selection based on trust. This research therefore explores the view that pre-selection based on attributes of trust could enhance consultant selection methods and improve client satisfaction and furthermore identifies salient pre selection attributes based on trust.

Identification of Attributes

By conducting a systematic review of trust and consultant selection, 37 pre-selection attributes based on trust were identified. The attributes and descriptions are presented in Table 1. The attributes were gathered into a quantitative analysis to determine salient pre-selection attributes based on trust.

RESEARCH METHODS

The research method adopted in this study is the questionnaire survey. In total 37 consultant selection attributes based on trust were identified from literature. Based on these attributes, a structured questionnaire was designed using a Likert-type scale in order to evaluate salient pre selection attributes based on trust. A purposive sample of the client population in the UK construction industry was identified in the 'Top 100 UK Construction Industry Clients', (2004 – 2009), as published in Building Magazine. In total 189 clients agreed to take part in the survey. The survey was issued using LimeSurveyTM 1.9. Table 2 identifies the actual number of clients who completed the survey, and the demographic information about the clients surveyed.

The literature review showed that 30-40% of UK construction industry clients are, and historically have been, public sector clients (ONS, 2008). The survey results show that 14% of the clients who participated in this survey were private sector. Table 3 identifies the combined spend of the clients used in this survey represents 60% of the UK construction total spend, 2004-2009, and therefore the sample is representative of UK construction clients.

Data from the client survey was analysed and found that all 37 attributes were considered important in consultant pre-selection. The focus of this paper is on the application and identification of Principal Components of consultant pre-selection.

Attribute	Description
Character	Character is a requirement for trust, the 'can- do', with the 'will-do'.
Benevolence	The extent to which a trustee is believed to want to do good for the trustor.
Acting with integrity	Integrity is the extent to which a trustee is believed to adhere to sound moral and ethical principles.
Honourable	Honour is an attribute of mutual trust, requiring the consultant to protect the rights of the client throughout the construction process
Cooperation	Cooperation requires a willingness to share risks.
Commitment	In terms of a construction project, individuals are expected to commit to the shared goals and values of the project and the teams.
Confidence	Confidence has been identified as a key attribute of trust, as confidence in another's actions/ words.
Effective Communication	Effective communication requires the 'the accurate passing of information'.
Professionalism	Professionalism if the utilisation and quality of knowledge rather than the acquisition of knowledge
Membership of a Professional organisation	Initially trust consultants on the basis of the consultant's membership of a professional institution and its perceived level of trustworthiness.
Expert Knowledge	Clients require construction consultant to have expert knowledge, knowledge which is deemed competent
Education	The attainment of expert knowledge derived from education
Experience	Clients out of necessity require construction consultants to apply their expertise to the successful delivery of a project. This expertise is a culmination of the consultants education, experience and professional training, that furthermore is required to be applied competently
Professional Training	Professionalism has been defined as the attainment of expert knowledge derived from education, experience and professional training
Skills	The ability of a trustee as having specific domain of group of skills
Qualifications – academic Qualification - Professional	Qualification refers to both an academic qualification and a professional qualification and is the crucial threshold in the career progression
Ethically motivated	The degree of trustworthiness and integrity with which companies and individuals conduct their business
Specific Competence	A key area in which competency based trust can be assessed.
Quality of Technical Service	Technical quality (the core service or "what" is delivered).
Quality of Functional Service	Functional quality, is concerned with how" the core or technical service is delivered.
Interpersonal Competence	Interpersonal competence is based on a person's ability to engage with others effectively

Business Sense	Business sense is based on an individual's experience, wisdom, and common sense.
Wisdom	Wisdom is a core attribute of competence based trust
Common Sense	Common sense is
Business Experience	Trust that depends on past experience has been described as 'dispositional trust' and 'trust propensity'.
Reputation	To have a good reputation requires individuals to be accountable and responsible for their actions and to accept and manage the risk and vulnerability of placing another's requirements before their own
Achieving Results	Trust cannot develop unless consistently positive results are produced
Value Added Services	Value added services have derived partly from the increase in client knowledge and expectation and also due to the increase in alternative types of supplier.
Reliability	Professionals must demonstrate high levels of reliability so that the client can transfer risk to the consultant
Predictability	Predictability is a measure of cognitive trust, and is based on assumptions for future behavior
Perceived Capabilities	This requires clients to make an assessment of consultant's capabilities at the selection stage, which results in the achievement of project targets.
Leadership with Organisations	Trust can be enhanced be setting an example in the workplace
Personal Motives of Managers	The personal motives of managers within organisation are one base upon which trust in a manager can be placed
Supportive Leadership	Supportive leadership was indicative of trust in a manager
Emphasizing a collective identity	Emphasizing a collective identity is indicative of trust in the leader and thus the level of trust expected by the client.
Levels of Managerial trust	Levels of trust placed in managers by their employers was found to be significant indicator of levels of trust a client could expect from the organisation.

Table 2 Client survey demographics

Client Sector	Number of clients who completed survey
Central Government	10
Private	14
Local Government	61
Housing	8
Universities	7
Total number of responses	100 (53% response rate)

Table 3 UK Construction Client Total Construction Spend

Client	Total Spend (£M) 2004-2009	Percentage of UK Construction Client by Spend %
Client Sample	131,843.37	60%
Client Population	219,746.81*	100%

APPLICATION OF PCA

Lingard and Rowlinson (2011) define Principal Component Analysis (PCA) as a 'statistical technique which is used to replace a large set of variables by a smaller set of variables which is the best representation of the larger set. The application of Principal Component Analysis was required to reduce the 37 pre selection attributes into few more meaningful principal components. The first step in conducting principal component analysis was to determine the adequacy of the survey data. In relation to sample size for PCA the most common measure of sample size is the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1974). The KMO measure calculates variables by identifying the squared correlation between variables to the squared partial correlation between variables. Kaiser (1974) recommended accepting sampling scores between 0.8 and 0.9 as great. Based on these guidelines the KMO value for the attributes was 0.84 and therefore falls into the range of being good. In addition, the Bartlett's test of sphericity was used to indicate if there is sufficient correlation between the variables to facilitate PCA. Bartlett (1954) suggested that significance should be less than 0.05. The Bartlett test was highly significant ($p <.000$) for the attributes, therefore indicating that application of PCA was appropriate for this data.

Components Extraction

Following the recommendation of Norusis (2006) on the process of PCA, a correlation matrix for all variables R = {R[Rmm]}, was identified. The extraction of components was done using SPSS version 17 software package. The results of the PCA identified 8 individual components representing 69.998% of variance, each with eigenvalues greater than 1, and satisfied the recommendations of Kaiser (1974). The components were rotated using the orthologonal method of rotation utilising the Varimax solution, which are applied to components that are considered independent. Rotation maximises the loading of each variables on one of the extracted components whilst minimising the loading on all other components. Attributes with loadings greater than 0.45 were identified by the SPSS programme, thus ensuring that component loadings were of sufficient strength.

The process of naming the 8 principal components involved structured interviews with industry experts. Clients were identified from the four UK regions (England, Northern Ireland, Scotland and Wales). Three expert interviews were conducted (England, Northern Ireland and Scotland). A number of unsuccessful attempts were made to secure an interview with a client representative in Wales. Consensual agreement was achieved, between the industry experts, on the naming of the 8 principal components, and is presented in Table 4.

Table 4 Pre selection principal components

Principal Component	Attributes and Component loadings	Base of Trust	% of Total Variance
1 Service Quality	Quality of technical service (0.84), Quality of functional service (0.79), Specific competence (0.79), Skills (0.62), Expert knowledge (0.61), Experience (0.57) and Professionalism (0.47)	Competence	31.79%
2 Collaborative Relationships	Cooperation (0.84), Achieving results (0.72), Commitment (0.68), Effective communication (0.62), Value added service (0.61) and Confidence (0.45).	Mutual and Competence	10.00%
3 Qualifications	Academic qualification (0.84), Professional qualification (0.82), Membership of a professional body (0.75), Professional training (0.69) and Education (0.67).	Competence	7.00%
4 Organisational Trust	Emphasizing a collective identity (0.73), Levels of trust placed in managers by employee's (0.73), Supportive leadership (0.70), Leadership within organisations (0.70) and Personal motives of managers within organisations (0.67).	Affective	5.20%
5 Personal Qualities	Honourable (0.72) and Acting with integrity (0.68)	Mutual	4.73%
6 Ability	Reliability (0.71), perceived capabilities (0.68) and Reputation (0.54)	Cognitive and Competence	4.19%
7 Experience	Business experience (0.73), Wisdom (0.61), Common sense (0.61) and Business sense (0.53)	Competence	4.00%
8 Respect	Benevolence (0.76), Character (0.69) and Ethically motivated (0.57).	Mutual and Competence	3.01%

RESULTS AND DISCUSSION ON THE PRINCIPAL COMPONENT ANALYSIS.

The results of the PCA identified an 8-factor pre-selection model for consultant pre-selection based on attributes of trust. The first principal component is service quality, representing 31.79% of the variance with the pre selection component matrix and represented 4.55% of the variance within the selection matrix component. This research has shown that clients can effectively predict consultants' quality of service through the application of trust in the selection process.

The second principal component was collaborative relationships, representing 9.998% of the variance within the pre selection component matrix. This research has shown that commitment underpins collaborative relationships, thereby enhancing the

relationship and promoting the chances of a successful relationship. Consequently without trust there is no commitment to the relationship. Collaborative relationships require a commitment to sustain long-term cooperation, together with a willingness share risks (Sahay, 2003). Commitment also requires the effective communication between the client and consultant that can increase the effectiveness of the relationship. Furthermore commitment can lead to the development of trust by increasing the certainty of the outcome. This research found that certainty of outcome could be measured as achieving results was essential in the development of trust on client consultant relationships and in turn increases confidence in the consultants' ability to deliver a high quality service.

The third principal component, qualification, represented 6.998% of the total variance within the pre selection component matrix and 10.393% of the total variance within the selection component matrix. Qualification refers to both academic qualification and professional training. Professional qualification is the crucial threshold of construction consultants in order to gain professional recognition and membership of a professional organisation. This research has shown that consultant's qualification should be considered in consultant selection processes, whilst Bohn (2004) further adds that qualification should drive the selection process.

The fourth principal component, organisational trust, represented 5.199% of the total variance within the pre selection components matrix and 6.441% of the total variance within the selection components matrix. Shamir et. al. (1998) research concluded that supportive leadership was indicative of trust in a manager, that the levels of trust placed in managers by their employers was a significant indicator of levels of trust a client could expect from the organisation; while Rogers (1995) concluded that unethical leadership behaviour eroded trust placed in an organisation

The fifth principal component, ethics, represented 4.731% of the total variance within the pre selection components matrix and 3.348% of the total variance within the selection components matrix. Specifically this research found that consultant's character insofar as the consultant is required to be benevolent, and is honourable are indicative of trust in the client consultant relationship.

The sixth principal component, ability, represented 4.185% of the total variance within the pre selection components matrix. This research has shown that selection processed focus on the consultant's professional ability. Furthermore ability is often expressed as credentials and merits of an individual, thus the reputation of the consultant's ability can enhance trust in the client consultant relationship. According to Price et. al. (2005) without a reputation for trustworthiness, possible partners are unlikely to enter into the first steps of a partnership. Furthermore reputation can be obtained by personal experience or by previous experience.

The seventh principal component, experience, represented 3.996% of the total variance within the pre selection components matrix and 4.002% of the total variance within the selection components matrix. This research has shown that fundamentally clients appoint construction consultant for their expert knowledge, knowledge which is deemed competent and can only be derived from education and experience. Successive iterations or experience was identified by Bohn (2004) who adds that experience is essential in providing realising client satisfaction. In addition positive experiences promote positive perceptions and client ability to predict the quality of service delivered by a consultant. The eighth principal component, respect, represented 3.009% of the total variance within the pre selection components matrix.

Respect requires consultants to be benevolent and behave ethically towards the client and supply team members. Character, benevolence and ethically motivated are attributes of mutual trust. Jaggar et. al. (2001) writes that mutual trust is a to requirement for stimulating the transfer of information between organisations in the construction procurement process, which is essential to the success of a construction project.

LIMITATIONS

Whilst the findings of this research are significant this research is not without limitations. The survey responses were predominately local authority clients and did not include other members of the supply chain who may be involved in consultant selection.

CONCLUSIONS

The literature review identified 37 consultant selection attributes based on trust and through the application of a quantitative methodological design using a questionnaire survey and the application of principal component analysis, and has led to the development of an 8-factor model of consultant pre selection and provide the construction client with a tool to aid consultant selection decision making.

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ROLE CONFLICT AND ROLE AMBIGUITY IN CONSTRUCTION PROJECTS

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Role conflict happens when a person faces different and incompatible expectations regarding a particular social status which they occupy. The literature on role conflict is reviewed for a better understanding of project dynamics in construction teams. The discussion focuses on issues surrounding the miscommunication of role expectations and tensions owing to differences in expectations of the same role. This ongoing doctoral study involves a qualitative research design, based on interviews with practicing professionals. Analysis will focus on the relation between formal expectations, as evidenced in contracts and other types of written communication, and informal expectations as observed from the interviews. Insights from the literature review suggest: 1. that the differences between formal and informal expectations is a major sources of role conflict in construction teams and 2. that this effect is exacerbated by the failure of team members to recognise it and take it into account.

Keywords: contract, organizational behaviour, project dynamics, role conflict.

INTRODUCTION

Teams in construction projects are dynamic in different aspects. Phenomena like team motivation, integration, coordination and individuals' happiness and satisfaction at work have been the object of much research, in construction and beyond. However, some issues have not yet been studied closely, particularly in construction projects. One of these is incompatible role expectations. These may arise from differences in formal and informal sources. They are seen to cause strain and dissatisfaction for participants (Kahn *et al.* 1964). In some cases the pressure is so high that a participant may resign and leave the team (Jackson and Schuler 1985), which, in turn, may jeopardize a whole project (Chapman 2002).

The aim of this study is to investigate the effects of incompatible and/or unclear role expectations (role conflict and role ambiguity) in construction design teams. In construction, even on relatively small projects, hundreds people may be involved in decisions before the project reaches construction stage (Hughes 1989). However, a core group of organizational members, such as the architect, engineer and client, are

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Kabiri S; Hughes W and Schweber L (2012) Role conflict and role ambiguity in construction projects *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 727-736.

present for significant portions of the process. This study focuses on these core members.

The causes of role conflict and role ambiguity may be formal or informal. While research attests to contradictions from formal sources, such as contracts and codes of practice (Hughes and Murdoch 2001), little is known about the consequences of these tensions. As for informal sources, research highlights ambiguities associated with the introduction of new roles which clash with customary project practice (Georg and Tryggestad 2009, Gluch 2009). However, researchers have yet to examine more established roles. As Wells (2007) argues, more theory-based research in emerging informality is needed.

This investigation explores the extent to which role conflict and role ambiguity exist among the major roles in construction design teams, the situations that are characterized by a high degree of role conflict and role ambiguity and the consequences that these phenomena have on the individual and the team. In order to do that, formal and informal sources of role expectations and their contradictions will be studied using a "role theory" lens. A secondary aim is to develop role theory further as it does not yet deal with evolving changes to roles during a project, with the dynamic interaction between roles or with the effect of role conflict and role ambiguity on project team dynamics.

LITERATURE REVIEW

The procurement of construction projects is a prime example of complex inter-organizational workplace situations. A central characteristic of workplace roles is their dual specification by formal and informal sources. In studying the misalignment of role expectations it is important to consider both types.

Formal and informal sources of role expectations in construction projects

The expectations for different roles in construction teams and the notion of "who does what" have been discussed in the academic literature and government reports for many years. For example, some textbooks provide general descriptions of roles in the construction industry (Murdoch and Hughes 2008, Ndekugri and Rycroft 2000) but they do not discuss how roles relate to each other. Research in this area mainly concentrates on one specific role. For example, Kagan and Leary (1986) investigated the potential conflict and risks arising from the difference between the "perceived responsibilities" and the "actual responsibilities" of the design engineer. They identified a potential role for a specialist in quality control. In a more recent work, Georg and Tryggestad (2009) studied the role of project manager and how it changes during a project. They criticized the commonly held view that: "*Roles are presumed to be relatively stable and dictated by contracts and/or cultural relations"* (p 969).

Their case was a skyscraper project studied through interviews, observations and document-based studies. They concluded that the role of project manager involves not only managing the project, but also negotiating roles in construction. In some cases he/she may act as a mediator for the project and have a qualitative effect on it, whereas in some other cases a PM merely transfers different points of view. Georg and Tryggestad (2009) highlighted that roles are not necessarily stable during a project and they considered both the formal documents and informal relationships in the project. However, they did not explore differences in contractual and cultural definitions of task specific roles.

A related line of inquiry examines roles within contracts and plans of work. For example, Hughes and Murdoch (2001) analysed responsibilities in construction sector plans of work. They found extensive variation in terms, not only between published works but also, in some cases, within the work. The term "client" is not used in contracts, even though it is used in different plans of work. There are differences in the titles used for some roles as well as some stages of the work. This research builds on their work by examining the consequences of these contradictions. It extends it by examining the interaction between formal and informal role expectations.

A related point concerns project team members' ignorance as to the formal specifications of their role. Gray and Flanagan (1989) showed that the pressure on sub-contractors to estimate and price does not leave them enough time to read the whole contract. So, although the contracts are assumed to clarify the rights and expectations, many participants do not read them properly. These issues have also been central in many government actions and reports. The Association of Consulting Engineers, the Institution of Civil Engineers as well as the Office of Government Commerce have expended significant resources to develop standardized contracts and guidelines, partly in order to clarify legal expectations and to provide guidelines for construction participants to work more coherently (Latham 1994, Egan 1988, Office of Government Commerce 2007, Institution of Civil Engineers 2009). These documents are usually intended to cover all project participants, across all phases of a project. This proliferation of reports has not yet displaced the widespread characterization of problems in the industry. Moreover, none of it deals with the problems stemming from the misalignment of role expectations. One reason why the issue of incompatible role expectations has not been resolved is that expectations do not originate solely from formal documents. Informal communications also have a big impact on role expectations.

Over the last decade, the importance of informal practices has become highlighted in construction management research (e.g. Chan and Räisänen 2009). Informality is an issue that is best viewed in relation to formality, and not as a problem that could be made to disappear by more systemized and formal approaches.

Gluch (2009) examined how environmental professionals form their roles and identities in relation to project practice. The research considered both formal and informal aspects of the work. The research showed how different communication cultures and different world-views, along with the perception that environmental management is "bureaucratic nit-picking", created tensions between environmental work and project practice. In order to deal with this tension environmental engineers adopted a formal role in line with their job description and an informal role which is more suitable for that special project. This need to conform to the formal and informal expectations separately and in different ways puts extra pressure and stress on environmental professionals. Gluch concluded that "contradictory practices prevent environmental professionals from fulfilling their expected role and function." (p. 959). Gluch's work raises the question of whether this problem exists only among newly created roles such as environmental professional or whether it is more widespread.

Other studies of informal roles highlight the importance of group interaction and stereotypes in creating role expectations. Nicolini (2002: 167) used the term "project chemistry" to "embrace how and how well people interact, perceive each other and work together in the project". In his investigations, practitioners highlighted their training as one of the most important reasons for resisting calls to work as a team.

Loosemore and Tan (2000) studied occupational stereotyping within the construction industry by interviewing various construction professionals. They showed that stereotyping is stronger in some groups than in others. However, neither the origin of this stereotyping, nor its consequences on the individuals, the team and the project were studied. Feeling constrained by professional and organizational expectations was also highlighted by some participants in projects led by award-winning construction managers (Baiden *et al.* 2006).

This literature draws attention to variations in the origins of expectations which one team member may have of another. It does not, however, systematically examine variations in the source of expectations or their effect. Of all of the above mentioned studies, Gluch's work comes closest to examining the effect of contradictory expectations on team members. This research draws on role theory to examine role expectations in more established roles.

Role theory

Role theory concerns one of the most important characteristics of social behaviour—*the idea that human beings behave in ways that are different and predictable depends on their respective social identities and the particulars of the specific situation* (Biddle, 1986: 68). Biddle (1986) categorizes different perspectives on role theory into five major groups: functional, symbolic interactionist, structural, organizational and cognitive role theory. Organizational role theory is the one that will be used in this research. This focuses on roles in formal organizations. In this perspective, roles are associated with identified social positions; normative expectations generate roles but norms may vary among individuals and can reflect the official demands of the organization or the influence and force of the informal groups.

Kahn *et al.* (1964) analysed organizations as an open and dynamic system that delineates a continuing process of input, transformation and output. This model can be used to study construction work. Construction projects bring together different disciplines working on different parts of the project at different times in different places for a limited period of time. This "temporary multi-organization" (Cherns and Bryant 1984) is the kind of organization at the focus of this study.

There are a number of confusions and disagreements in role theory, some of which stem from differences in definition of role (Biddle, 1986). Turner (1956) defined 'role' as "*a collection of patterns of behaviour which are thought to constitute a meaningful unit and deemed appropriate to a person occupying a particular status in society (e.g. doctor or father), occupying an informally-defined position in interpersonal relations (e.g. leader or compromiser), or identified with a particular value in society (e.g. honest man or patriot)*." In Turner's view, one may enact a role but cannot occupy a role. This definition is useful as it draws attention to the potential tension between formal and informal expectations.

A number of core concepts from role theory help to define 'role conflict' and 'role ambiguity'. 'Role set' refers to the set of (role) expectations which a person is subject to by virtue of occupying a particular social status (Merton, 1957, p.110). That person is referred to as the 'focal person'. 'Role senders' refers to the members of the focal person's role set. For the purposes of this study, it will include formal sources like contracts and plans of work, as well as other team members. 'Received roles' are the focal person's perceptions and cognitions of what was sent, while what was sent is called a 'sent role' (Katz and Kahn, 1978). Finally, 'role behaviour' refers to

behaviour performed by the focal person in the enactment of their role. It may or may not conform to role expectations (Katz and Kahn, 1978).

Role conflict and role ambiguity

The concept of social role draws attention to the fact that different members of the role set may not hold compatible expectations for the focal person and this may lead to role conflict. Role conflict can happen when one member of the role set requests the focal person to behave in two incompatible ways. It can also happen when pressure sent by one of the role senders to the focal person opposes the pressure sent by another role sender (Katz and Kahn 1978).

Role ambiguity simply means the focal person doesn't know what he/she is supposed to do. A certain amount of information is required for adequate role performance. First, the focal person needs to know his/her role set and their different expectations; his/her rights, duties and responsibilities. Second, he/she should know what kinds of activities would fulfil those responsibilities. Third the focal person should know the possible consequences of role performance or non-performance for himself/herself as well as for his/her role set. On top of that the person needs to know the kind of behaviours which are satisfying or frustrating for his/her personal needs and values.

The concepts of role conflict and role ambiguity were introduced by Kahn *et al.* (1964) to investigate the mental health of individuals in organizations due to rapid changes in technology and the slow process of users' adaptability. In a nationwide study of male wage and salary workers, they discovered that almost half of them were facing noticeable role conflict. Since then, research on role conflict and role ambiguity tends to be on roles for which some polarizations of differences among role senders seemed likely. Roles like the role of industrial foreman, salesperson, teacher and manager have been studied and role conflicts have been found to contribute to distress. These effects were associated with lower levels of job satisfaction, decreased commitment as well as increased tension and a higher likelihood of leaving the organization (Jackson and Schuler, 1985). In a more recent study, Floyd and Lane (2000) investigated the inconsistent expectations that managers face in the renewal process of their organizations, based on the need to deploy the existing competences and to create new ones. In another study, Tang and Chang (2010) studied the effects of role conflict and role ambiguity on employee creativity. With survey data from 202 employees of Taiwanese companies, they concluded that role conflict has a negative effect while role ambiguity can have a positive effect on creativity. As this description suggests, research tends to focus on the effect of role conflict and ambiguity on the focal person, rather than on members of the role set, or in this case, of the team. This is particularly relevant for construction projects where each team member has a very specific skill that is not easily replaced, should they decide to leave.

Another issue with the literature is that professional roles are usually considered as fixed and permanent. According to Lynch (2007), role theory is not very concerned with the process of how each individual "*learns, adapts to, and affects a role performance over time*". Its basic concept is more in the direction of behaviour. The result of the ongoing investigation will be used to develop role theory further in this direction.

As mentioned earlier, Gluch (2009) highlighted the issue of the mismatches between formality and informality for environmental engineers and how that led to role conflict. This research uses role theory to extend her approach to other roles in the construction design team. Furthermore, most studies, especially in psychology and

organizational behaviour, examine role sets from the perspective of a single focal person, without considering the dynamic interaction between focal persons with overlapping role sets. The originality of this research lies in the application of these constructs to construction projects as a particular type of organization and in the development of role theory by studying the way that individuals learn and sharpen professional roles over time. The research is organized around a model which Katz and Kahn (1978: 196) developed to study role conflict and role ambiguity.

MODEL OF FACTORS INVOLVED IN ROLE CONFLICT AND ROLE AMBIGUITY

Figure 1 shows the model that Katz and Kahn (1978) developed to study role conflict and role ambiguity elements. While not all the elements in their model are the main concern of this study, they help to explain the approach.

In the model, the "role senders' box" involves motivations, cognitions and behaviour of the members of the role set. The "focal person's box" reflects motivations, cognitions and behaviour of the focal person. Arrow 1 represents a causality direction which is the effect of role expectations on role behaviour. Arrow 2 is about the feedback loop. It shows the degree to which the focal person conforms to the expectations of the role set at one point in time and it will influence the expectations at the next moment. If the focal person conforms to expectations then she will have a different reaction compared to the situation in which the focal person's response is a counterattack. In sum, this process of role sending and feedback is a cyclic and ongoing process. This cyclic process, however, cannot be studied in isolation. Organizational factors, attributes of the person and the interpersonal factors between the focal person and her role set also influence this process.

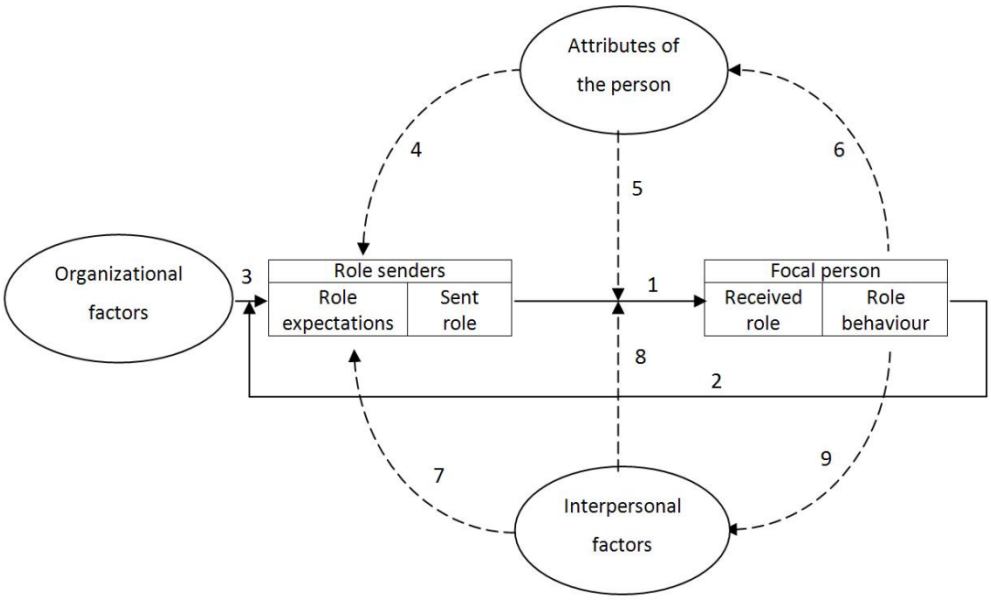

Figure 1: Model of factors in role conflict and role ambiguity (Katz and Kahn, 1978)

Katz and Kahn consider the technology of the organization, the structure of its subsystems, its formal policies and its rewards and penalties as organizational factors that are sent to the focal person through her role senders. Attributes of a person involve her motives, values, sensitivities, defence preferences and fears and will affect the sent roles (Arrow 5), the response to the sent role (arrow 4), and can be affected by the focal person's role behaviour (Arrow 6). In addition, interpersonal factors also

play a similar role. The way that the sent role is received by the focal person depends on her interpersonal relationships with her role set (Arrow 8); these relationships can also influence the person's role set (Arrow 7) and will be changed by the role behaviour of the focal person (Arrow 9).

This model also shows that the focal person's role behaviour will change from one point in time to the next as a result of role sending and feedback process. In the long run, this phenomenon will influence and even alter the focal person's perception of himself or his role senders. It is in this type of process that people learn and adapt to changes. However, as mentioned earlier, these changes have been studied in relation to behaviour rather than to role definitions.

Based on Katz and Kahn's model, a model was developed to study role conflict and role ambiguity in construction projects (Figure 2). Studying these two constructs can best be done by studying formal and informal role senders; these sources, even within themselves, might communicate incompatible role expectations to the focal person to the extent that compliance with one would exclude the other one.

In this model the elements of organizational factors, interpersonal factors, attributes of the person, and box of role senders were substituted by the two new terms of "*formal role senders"* and *"informal role senders"*. As indicated above, formal role senders within the project include contracts, plans of work and the like for each focal role. Informal role senders include all the interpersonal factors as long as they are involved in the role sending and feedback process for each focal person.

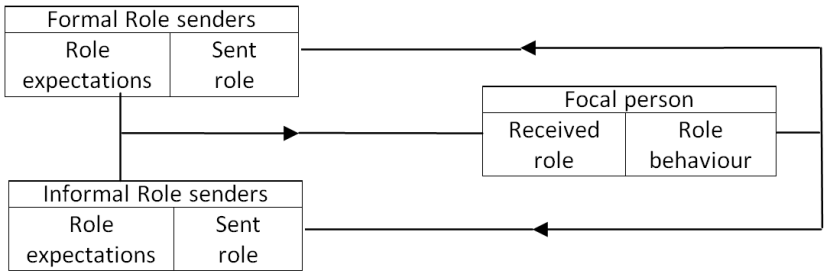

Figure 2: Model of factors involved in role conflict and role ambiguity introducing formal and informal role senders (based on Katz and Kahn, 1978)

The crucial message of this model is that the role expectations of role senders should be studied separately from the role behaviour of the focal person. In this study the focal roles are assumed to be the architect, client, structural engineer and the quantity surveyor (the selection of the focal roles will be discussed further below). The discussion so far helps to construct the following research questions:

1. Who/what are the formal and informal role senders for the architect, structural engineer, client and quantity surveyor in the design phase of construction projects?
2. How familiar are the architect, structural engineer, client and quantity surveyor with their contracts?
3. For each focal role examined, what are their expectations? Does the person in the focal role experience role conflict or ambiguity? If so, around what issues?
4. What types of role conflict and role ambiguity appear to have the most serious effects on the individual, the team and the project as a whole?
5. Does the process of role sending and feedback affect the performance of the role over time? If yes, how does it take place?
6. How can role conflict and role ambiguity be managed, negotiated, or resolved for the individual and within the team?

Thus, the research will enhance awareness of academic researchers as well as practitioners about role conflict and role ambiguity in construction design teams. In addition to that, analysis of changes of role performances will contribute to role theory as this is something that role theory has not dealt with in the past.

RESEARCH METHOD

This study will investigate the effects of role conflict and role ambiguity on some of the more established roles in the construction design team. Most research into role conflict and role ambiguity relies on survey data. However, this is a qualitative study, oriented around providing an understanding of human behaviour. In other words, the subjective meaning of social action will be grasped by the researcher, in line with an interpretivist approach (Bryman, 2004). The research adopts a case study method as best suited to explore the interaction between focal persons within a single team and the impact of role conflict on team dynamics. Research will be carried out for two cases during the design phase. The cases will be similar in terms of size but different in terms of the people involved so that the results can be compared. The following three options within the design phase will be left open: the outline design, detail design and client's signoff points before tendering.

Selection of the focal roles: Research focuses on a number of roles in project teams, including: the client, architect, structural engineer, and quantity surveyor. The reason for choosing these roles is that they are fundamental and well-established. . This focus on well established roles contrasts with Gluch's work (2009). She discussed the challenges of environmental professionals, whose role, in her point of view, "*has meaning but has yet to develop a professional identity, visibility and an authoritative position in project based organizations* (p 967)". In contrast, roles discussed in this research are well established. As such, one would expect roles and role expectations to be well understood/highly consensual and problems stemming from role ambiguity and role conflict go unexamined. The quantity surveyor may not be quite as traditional as the other three roles, but it is still well-established; the cost advisor is an essential part of each project and the issue of cost is extremely important for the design. Thus, the total number of focal roles in this study is four.

Selection of role senders: The selection of the role senders is limited to those members of the team with the most impact on the focal person. Given this study's interest in the interaction between role sets, special attention will be paid to the sent roles coming from the three other roles as well as from the supervisor/boss of the specialist firm. While the above participants are assumed to be the core role set of the focal person, within the interview, the focal person will be asked about the major roles affecting his/her tasks. To the extent that other roles are identified as important, these role senders will also be interviewed. As for formal role senders, contracts and codes of practice are considered to be the most important ones. They will be read and analysed carefully and the level of the focal person's awareness about them will be examined in the interview

Data collection: Data collection will be carried out in two ways of document review and semi-structured interviews. The aim of the research design is to explore the impact of role conflict and role ambiguity on the team. In doing so, a focus for the analysis of the focal person's role behaviour is required. This study sets tasks as this dimension; the tasks that the focal role has to accomplish in order to meet the expectations of his/her role senders. Contracts and codes of practice for every focal role will be reviewed to obtain his/her list of tasks. By doing so, formal role senders

will be studied. In addition to formal role senders, informal role senders may also influence the tasks that each person does and they will be obtained from interviewing each role as well as their core role set. Interviews are the best method to explore the focal roles' perceptions and understandings of their own role as well as other focal roles (as role senders). The focal person will be interviewed to obtain information regarding their perception of their own tasks, their major role senders and their relationship to each of them. In order to investigate any adaption and changes in the roles, the first interview will be followed by another two interviews over a period of four months. Role senders will be interviewed so that the intensity and the direction of the pressure that they pose to the focal role can be measured, and the effects of any role conflict and role ambiguity of the focal role on them can be investigated. The list of tasks that was produced based on the focal roles' contract and the interview with the focal person will be discussed with them. The role senders' interview will also be followed by another two interviews in the course of four months.

CONCLUSIONS

Provisional findings suggest that differences in formal and informal sources of expectations lead to some degree of role conflict in construction design teams. Research also suggests that most participants are unaware of role conflict and its effects on themselves or their fellow team members. When it comes to contracts, most team members do not read their contracts carefully, while ambiguity in the contract documents gets in the way of the clear identification of tasks. In other words, contracts do not play an effective role in clarifying tasks for design team participants.

RECOMMENDATIONS

Research in role ambiguity may have some other interesting implications like management of risk or role ambiguity due to the emergence of new technologies such as BIM. These implications could also produce very interesting research works.

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