THIRTY-FIFTH ANNUAL CONFERENCE 2019
September 2-4
Leeds
Working Papers
Foreword

Welcome from the Chair of ARCOM 2019

Professor Chris Gorse, Leeds Beckett University

Leeds Beckett University extends a warm welcome to the construction management research community and invites all to enjoy the great County of Yorkshire. Yorkshire is the largest and, some would argue, the friendliest County in England. Leeds and the surrounding areas are steeped in history, so during the ARCOM conference, we will be offering a little Northern nostalgia as we spend time at Headingly Campus, holding the social event at Salts Mill World Heritage Site and engage in our local engineering legacy. We will learn from those that shape the world and build knowledge in the ‘here and now’ as we focus on transformation and a new era of digital innovation.

We have an exceptional conference lined up with leaders and scholars primed to share their experience. Professor Jacqui Glass of the University College London will provide a visionary perspective on a new era for our research as we transform construction. Chair of Operations and Supply Chain Management, Professor Jan Godsell of the University of Warwick, offers insight into the central issue of integration. On our second day, we challenge the systems and digital innovation in construction with Professor Jennifer Whyte of Imperial College London, while the Director of Innovation in Construction Dr Wei Pan from the University of Hong Kong, shares his insight of a move from blocks to modules.

We have a distinguished panel helping to push forward the boundaries of the discussion. Joining us will be Professor Charles Egbu President of the CIOB, Dr Chrissi McCarthy Managing Director of Constructing Equality, Joanne Jamieson Managing Director of United Living, Eddie Tuttle CIOB Director of Policy, Research and Public Affairs, Dr Colin Harrop Partner of Sanderson Weatherall, Jonathan Wilson Development Director for CITU and Stuart Norris President of Insulation Manufacturers and Portakabin’s Senior Product Development Engineer.

The conference theme this year addresses productivity and performance. The issues of transformation and change are at home in Yorkshire, a County steeped in an ability to harness energy, delivering quality products and services that extend around the globe. Yorkshire’s industrial heritage would not have been so influential if it wasn’t for the visionary leaders of ‘time’ that stepped outside of their traditional boundaries with technical and social innovation. Travel and the distribution goods were once extended to the world, by a Yorkshire carpenter, through the invention of John Harrison’s timepiece. Without accurately measuring ‘time’, we would not have been able to safely navigate the seas. Interestingly, time followed a similar path to ARCOM, the concept of the atomic clocks that we use today was first suggested by Lord Kelvin in 1879. Kelvin was born in Belfast with much of his mathematical analysis taking place in Glasgow. As ARCOM moves from Belfast, though Leeds to Glasgow, we are wise to reflect that ‘time’ is just the interval between events.

Events, such as those of the industrial revolution, shaped the world. Sir Titus Salts of Leeds, still considered a thought leader in modern day manufacture, historically challenged management convention with social and cultural advancement, creating environments to deliver products of exceptional quality form the largest factory in the world at that time. The impact on the local area and community, through the Salt’s ethos, was beneficial to the workers’ health, education and wellbeing. The Saltaire buildings and artefacts, which were awarded UNESCO World heritage status, show
how important the site is, but the social significance of Salt’s vision, possibly has had a much greater influence on working practices today than we are able to truly understand. Social impact, like time, is difficult to measure, but without doubt both are significant in our quest for production and performance. It is a pleasure that the ARCOM community will join us at Leeds Beckett University, to experience Yorkshire, its community and to embrace the experience.

Welcome to ARCOM and Leeds Beckett University.

Chris Gorse

Chris Gorse
Conference Chair, ARCOM 2019
**ARCOM Committee for 2018/2019**

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The success of the Annual ARCOM Conference depends on the voluntary efforts of the Scientific Committee. We are indebted to the members of the Scientific Committee who, together with the ARCOM Committee members, provided rigour and constructive feedback in the peer-review process.

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PROBLEMATISING BUILDING PERFORMANCE
COPING WITH STONE: A SHORT-TERM ETHNOGRAPHY OF SKILLED WORK IN UK HOUSEBUILDING

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Speculative housebuilding in the UK is frequently criticised for the poor quality of its outputs and low productivity. Reliance on traditional and overtly manual methods of building are seen as contributors to these problems and this mode of production is unlikely to significantly change in the near future. Individual performances of skilled manual work in housebuilding are investigated using short-term ethnography, which includes traditional techniques of observation and interview as well as the collection of audio-visual data. A theoretical ideal type of ‘pure craft’ is developed which is then taken into the field and used to analyse the execution of skilled manual work and attendant judgements about the completion of that work. The results of the fieldwork firstly reveal an absence of codified forms of knowledge that cannot be fully explained by the alternative concepts of tacit knowledge. Secondly, the fieldwork validates the potential of short-term ethnography to reveal unforeseen or taken for granted behaviours that play out beyond the usual focus of construction management research.

Keywords: craft, ethics, housing, quality, ethnography

INTRODUCTION

UK speculative housebuilding is subject to much criticism about both the quality and quantity of its outputs (Bryde 2008; Auchterlounie 2009; Craig et al., 2010; Hopkin et al., 2016). Partly this is a structural problem inherent to the labour model of the industry, which is reliant upon subcontracting skilled but scarce manual labour. The government-backed Farmer Review calls for a transformative switch to pre-manufacture and re-skilling of the construction labour workforce as a solution (Farmer 2016). While momentum is growing for the widespread adoption of MMC in housebuilding (NHBC 2018), the adoption of new approaches, especially in housebuilding, remains slow (Lang et al., 2016) and the overwhelming proportion of new houses in the UK are built using traditional, labour intensive methods; between 2008 and 2015 traditional masonry construction consistently represented approximately 70% of houses built by NHBC members surveyed (NHBC 2016). This method predominantly refers to cavity wall construction (e.g. brick and block skins), timber floors, partitions and roof trusses, tiled roof coverings and plaster or drylined internal finishes. Mechanisation on these sites beyond the level of personal power tools is generally low, with perhaps a crane being the only significant technological equipment in use (Clarke and Wall 2000). These traditional methods give housebuilders flexibility to manage outputs and productivity in the most profitable,
although not necessarily speediest, manner as familiar building methods using generic components available ‘off the shelf’ provide programme flexibility to cope with unpredictable demand compared to the long lead times and necessary design freeze of offsite manufacture (Ball 2010; Lu and Liska 2008). Research in this field has tended to adopt, perhaps unsurprisingly, a construction management paradigm including, for example, a quality systems perspective (Forcada et al., 2016), defect impacts and costs (Mills et al., 2009), stakeholder perspectives (Hopkin et al., 2017) and analysis of causes of construction defects (Jingmond and Agren 2015).

There is less in the literature where researchers are engaging at the very point at which the building work is actualised. A defining characteristic of the traditional form of construction is its reliance on human-scale production and energies. Given the criticisms of its performance, and the evidence suggesting this traditional form of construction will remain dominant, or at least significant, for many years to come, this research explores what happens at that human level of making on site with regards to judgements about building work taken by those that are performing it: The site operatives. Theoretical understandings of craftsmanship that draw on sociology, anthropology and philosophy consider the process of making from the subjective, individual perspective rather than from a management perspective. This research draws on theories of craftsmanship to explore speculative housebuilding at the “sharp end”, that place “beneath the progress plans and design drawings” (Orstavik 2018) and does so by deploying a short-term ethnography methodology on a speculative housebuilding site. Short-term ethnography is an evolving form of ethnography particularly suited to research in the workplace where the emphasis is on intense collection of multiple forms of data in specific areas of practice. This paper presents the intensity and depth of findings that can be found by a researcher using ethnographic approaches.

CRAFTSMANSHIP: UNDERSTANDING A FORM OF WORK

To understand the making of judgements by building workers, the research draws from a range of literature to identify traits of craftsmanship. These traits are used as reifications of a 'pure craft' concept- a way of working that is the apogee of manual work. In this concept, the craftsman is the judge of his own work, his products have more value compared to machinofacture (Conty 2013) and craft output is inherently productive. Most importantly, as the craftsman is the sole judge, he doesn’t need external approval and in fact “abhors articulation and specification” (Ingold 2013: 110). The traits of pure craft are:

- Autonomous working and problem solving.
- A hand-tool-material relationship where machinery may assist but doesn’t dominate.
- Work is a negotiation with materials rather than a dominance.
- Outputs are not geometrically straight.
- Work activity is haptic, physical and dextrous.
- Judgements of completion are tacit, lack codification and based on the values of the craftsman.
- Work practice is based on a long period of training and the worker is within a field of established norms of behaviour. There is practiced expertise.
- There is creativity and uncertainty of outcomes until the end, i.e. non-hylomorphic.
SHORT-TERM ETHNOGRAPHY AS A WAY OF UNDERSTANDING CRAFT

The research deploys an ethnographic methodology to capture the personal experiences of participants and allows their subjective experiences of the world to emerge (Wadick 2010). The traits of pure craft identified above are then used as a theoretical lens by which to analyse the actions and judgements of building workers. Ethnography is “describing a culture and understanding a way of life from the point of view of the participants” (Mackenzie et al., 1999). It develops in practice, especially for a novice ethnographer as is the case here, involving a combination of techniques as well as reflection on the role of the researcher (Gibb and Dainty 2013). Applying the social scientific ethnographic method to construction provides an understanding of construction work (Pink et al., 2010) by providing access for the researcher to tacit understandings. Much has been said about the place of tacit knowledge in the construction field (Styhre 2009), especially with respect to workers actions, and it is an enormously important part of understanding craftsmanship. Ethnography is the method that allows the researcher to observe, hear, watch and speak with the participants, so providing the means to approach this tacit realm (Marrewijk et al., 2014).

Traditional anthropological ethnography requires a long period of immersion by the researcher and extensive involvement with participants (Pink and Morgan, 2013; Pink et al., 2010; Phelps and Horman, 2010). Ethnography appears within the body of construction management research, having “an important part to play in illuminating construction management phenomena”, but it remains “under-represented” (Bresnen and Harty 2010). For others the approach is “emerging” (Gibb and Dainty 2013) and “an innovative, highly immersed approach to exploring lived experiences” (Shipton et al., 2014).

It has been used where researchers are seeking access to the otherwise undocumented perspectives of working lives, for example in conveying the embodied labour of building workers in refurbishment (Lyon 2013), changes in collaboration over a long period of time, (Marrewijk et al., 2014), safety behaviours among workers on large construction sites (Oswald et al., 2018), and the personal experience of being a construction site labourer (Löwstedt 2015).

Lengthy periods of ethnographic immersion on a construction site may be unsuitable because of the very contingent nature of construction activity. Delays, weather, and setbacks create “shifting temporal and spatial patterns” that may hinder the researcher (Löwstedt 2015). Frequent turnover of labour means a prolonged stay by the researcher would reveal nothing of the participants’ ethos and attitude (Sykes 1969). A more intense ethnography in short episodes is a response to the environment being studied. A pragmatic adaptation such as this is typical of the way ethnography is practiced (Atkinson and Hammersley 2007).

The intensity is achieved by shifting away from more traditional recording techniques and making extensive use of video and audio recording. By not being encumbered by the need to collect detailed field notes (the audio and video can do this) the researcher is more mobile and able to be more engaged with the participant. Secondly, and more importantly, the data is available for later analysis. Visual ethnography techniques can be planned in advance, but the way the use of video unfolds during the fieldwork is unpredictable (Pink 2007: 47). Typically, ethnography focusses on repetitive
behaviours. Closure is achieved when, after repeated observations, nothing “new about its cultural significance can be learned” (Mackenzie et al., 1999).

THREE ETHNOGRAPHIC EPISODES

The following provides details of three brief episodes that occurred while ethnographic research was being undertaken during a speculative housebuilding project. The site, located in East Anglia, was for the construction of two large, high specification new houses with extensive traditional detailing required by the planning authority due to the immediate site context. The speculative housebuilder constructs approximately 100 houses a year, sometimes acting as main contractor to housing associations or developers. They have no directly employed labour, relying on subcontractors for all phases of construction. The site managers and project manager are employed by the contractor. The architect was employed by the developer. In this example, the contractor was building the homes for the speculative development division of their parent business. The houses were estimated to be sold for £650-700k each. At the time of this fieldwork, marketing of the properties had not begun.

One of the design details required was to build brick gables with parapets capped with reconstituted stone copings. In the following episodes the researcher is following the bricklaying gang as they attempt to finish the tops of the brick gables with coping stones laid up the pitch of the gable. The episodes are only a small part of a considerable amount of data collected but serve to illustrate the mobilisation of short-term ethnography as an “intense route to knowing”, and how, for the researcher, it brought practice and theory together both onsite and in subsequent analysis. Pink and Morgan (2013) present three qualities of short-term ethnography: The intensity of the research encounter, a focus on the detail and the ethnographic-theoretical dialogue. These qualities are borrowed as the sub-headings for the episodes below.

Episode 1- Intensity of the research encounter

The brickwork gables have been built by the bricklaying gang, and now they need to cap the gables with stone copings, laid to a pitch of 45 degrees with a shoulder stone at the bottom and a top stone at the apex. The bricklayers lay the first stone at the bottom of the gable and very quickly appraise it visually, and then with a cursory measure of the projection using a tape. I am struck by how quickly they move onto laying the muck for the next stone and take this as unspoken confirmation within the gang that the first stone was complete. I ask the question, “you are very quick at deciding that something is right or wrong, aren’t you?” The gang leader responds, “if it looks right, it is right… nothings ever going to be spot on is it? Nothing”. After a pause, he offers some elaboration as if to suggest the first response was a little too simplistic. “if you level the bottom then in theory, they should be alright”. After a little less than an hour, when the copings to one side of the gable have all been laid, the bricklayers are more effusive with their judgements. They say the copings “can’t be too far out” and are “relatively in line”. The final concluding remark comes in the form of a rhetorical question from one of the senior bricklayers, “Look, that looks the bollocks doesn’t it?”

The intensity of the encounter (Pink and Morgan 2013) comes from the researcher positioning themselves at the heart of the action. The building site is a noisy, busy place and, with the scaffold only 1m wide, simply being near the action puts the researcher slightly awkwardly in the way, with workers brushing past, but the proximity brings contact, and inevitable conversation. But the intensity also comes from the baggage of theory that the researcher is carrying, and the irresistible need to deploy this in search of an explanation.
The overwhelmingly dominant method of judgement by the bricklayers was a continual visual checking that happened unceasingly, but was not supported by any explicit deployment of knowledge of what the visual checking was against, leaving the researcher to conclude that it could only be a check against the bricklayers own concept of what the gable should look like because there was no reference to plans, specification, method statement, installation instructions or any other form of codified knowledge. The bricklayer cannot produce perfection- this is impossible- but produces his version of Platonism's ideal type, at the second order removed, always with "his eye on the appropriate form" (The Republic: 596-597). It was as if the bricklayers were saying to the researcher “this is good because we say it is good; and we are bricklayers”.

**Episode 2- A focus on the detail**

The coping stones were not made to measure for the length of the gable, and nor were the brickwork projections for the stone kneelers all the same size, although they were supposed to be according to the elevation drawings. This meant the stones needed to be cut by the bricklayers. In this instance the cutting was done by the boss of the firm. While on the scaffold he stands the unstable coping on end, somewhat stabilises it with his right foot, and then, slightly wobbling himself on his remaining standing left leg, uses a petrol disc cutter to cut the coping amid a cloud of dust with the cutting disc passing within a couple of inches of his toes. Immediately coming to my mind observing this is the overwhelming odds against the stone being cut as accurately as the bricklayer would really wish. Having finished the cut he comments to me that the need to cut materials on site should be “engineered out”, but “it’s the same on every site”. The labourer expresses his approval of the cut when the stone is offered up, “that’s awesome”, he says to his boss.

After the gable copings were finished, the site manager walked past and made only one remark; “it’s a shame about that little cut at the top. I would have done it differently”. He was referring to a small slip of coping stone, approx. 100mm wide, next to the topstone. His preference was for the top two inclined copings to both be cut and so avoid having a very small infill piece.

Throughout the fieldwork the role played by tools in the activities of the workers was a constant theme for analysis prompted by the craft literature. Technology breaks the intimate connection between work and human agency that is so imperative to the concept of pure craft because techne, the skill of the craftsman, is “inseparable from the experience of particular subjects in the shaping of particular things (Ingold 2013: 315). The disc cutter episode brings to the fore the tension between getting the job done and appropriate levels of quality. While not detracting from any skill on behalf of the bricklayer in using the disc cutter, as a powered machine it lacks discretion (the roofers used the same tool for cutting GRP valleys) and removes the connection between sensory perception and the actions of the hands, which is the skilled constraint of the craftsman. While some ethnographies have uncovered work practices where workers are dissuaded from using power tools when they want to because of a philosophical attachment to craft methods (See Yarrow and Jones 2014), on the speculative site the use of power tools to speed the process is unquestioned. The workers want to save themselves from the laborious and tiring aspects of the work, as they always have done (Rose 1937: 5). In comparison with the carpenters that were observed on this site, the bricklayers were very low-tech and low-cost in the use of power tools. While the carpenters claimed to have perhaps £10k worth of tools in their van the bricklayers were keen to point out their most expensive tool was a £100 spirit level.
Even with the site manager's mild admonishment at the end, there was never any suggestion the work would be done in any way other than that which the bricklayers chose. Pye recognises two dimensions to making. One is the “workmanship of risk” where the quality of the work is not predetermined but “the quality of the result is continually at risk during the process of making”. This is the emergent process of making. The other dimension is “the workmanship of certainty” where the “quality of the result is exactly predetermined” (Pye 1995). Many of the comments from the site management team and the architects about the bricklayer's work were that it was “good” in comparison to what other gangs might produce. The outcome of the brickwork is anticipated but unknown (Stein 2011).

Pink and Morgan (2013) suggest that focussing on details is appropriate in short-term ethnography as a solution to a context where in other forms of ethnography the researcher would be apprenticed into the subject of study. The cutting of the coping stones is an example where the background of the researcher enables him to seek out the details. The researcher already knows some of the copings will need to be cut and the cutting task will enable plentiful reflection on the presence or otherwise of the craft traits already identified in the literature. The ethnographic place, the realm inhabited by the researcher, cannot preclude the life experiences of that researcher. After all, it is those experiences that have led, through an unfolding life, to this fieldwork. And it is the "personal knowledge" (Polanyi 1958: vii) gained that lead to the researcher sensing that, of all the activities happening on site that Friday lunchtime, the cutting of the coping stones was the one to watch.

**Episode 3- ethnographic-theoretical dialogue**

The first morning of installing the coping stones immediately struck problems when the bricklayers laid the kneeler stone and the first inclined coping stone and realised that without mechanical fixings the copings could be displaced from the gable and fall to the ground in the future, as well as being difficult to lay now. Much debate ensued between the bricklayers and the site manager. The bricklayers talk of leaving the job until a solution is found. The site manager needs to keep the bricklayers on site and eventually comes up with a mechanical fixing solution of his own. He sources the necessary fixings and the work of laying the copings begins.

I was struck again, as I had been at other times during this fieldwork, of how little the decisions and judgements of the workers referred to any formal information, perhaps regulations or codes of practice, that might inform their decision making. Every problem was approached on its own merits, almost as if it was the first time such a problem had been faced because it seemed to me that the solution was developed from first principles, not from previous experiences of how these problems might have been overcome on other jobs.

In short-term ethnography, data collection and analysis are intertwined (Pink and Morgan, 2013) because a sharper focus is necessary. The lack of reference to plans, specifications, regulations, product information and the almost complete reliance on in-situ, instantaneous development of ad hoc solutions has some of the traits of craftsmanship. In this sense the theory had pre-empted the ethnographic experience. The craft theory from literature posited the presence of tacit knowledge as a trait of craftsmanship. But many of the episodes on site, including one in the example above, prompted the researcher to consider if the oft-repeated phrase, “we can know more than we can tell” (Polanyi 1966: 4) was an inadequate explanation of the lack of presence of codified forms of knowledge. It wasn’t a case of knowing more than could be told, but more a case of just not knowing. The aura of the craftsman as master of his domain (Roper 1982) was not there, nor any confident display of “expert
performance” (Ericsson et al., 1993). The theory that had been advanced in anticipation of the fieldwork was about the action, dexterity, physicality and materiality of the craft practice allied with an exercise of tacit knowledge in making judgements. In practice the first characteristics were somewhat there, but the tacit knowledge of making judgements was not wholly convincing in the field because there were repeated episodes where building workers were in an instantaneous, emergent situation where they made judgements as individuals but the idea that they were deploying solutions mined from a deep repository of knowledge was not the observation of the researcher. It was only the project manager who carried a sense of this mastery in the way he tackled problems and was self-aware enough to reflect that “I have been on building sites since I was fifteen. I forget just how much I know.”

**The ethnographic place and abductive research**

Some observation is done in the field, but by far the greater part of the ethnographic analysis takes place away from the field by watching recordings (Pink and Morgan 2013). The use of video cameras had considerable practical benefits for the researcher. But, in respect to Pink and Morgan’s emphasis of how audio-visual allows “ongoing reengagement”, the audio visual has served to extend the fieldwork into the researcher’s own workplace where the analysis of the video footage occurs. As the fieldwork finishes, analysis shifts away from the site which the researcher will never visit the again, but the video files provide the ability to instantly reconnect with the place, people and activities that were observed. The video footage provides for triangulation. Conversations can be listened to again. The sequence of works, the actions of workers, including very detailed footage of repetitive acts can be viewed over again to corroborate or contrast with field notes. The links between the ethnographic fieldwork and the ethnographic analysis are therefore not consecutive but concurrent. In this way, the ethnographic place is not the building site but the “entanglements through which ethnographic knowing emerges” which is not location specific, but where researcher, data and analysis takes place.

**CONCLUSION**

Short-term ethnography places the researcher at the heart of the action, literally in among the workers and their workplace. In being able to watch, listen, question and simply think about what is happening as the bricklayers go about their everyday tasks the researcher is in a continual negotiation with theory and practice, trying to understand what is actually happening by using theory as a tool for explanation. The anticipation ahead of the fieldwork was to use the concept of pure craft as a mirror, enabling reflection on what the workers were doing. However, the data obtained during the fieldwork, when analysed at the time and later away from the site, showed an absence in the way workers formed judgements. The task now is to explain not so much what they were doing, but to account for what they were not doing. This requires a renewed engagement with theory and with the fieldwork data that is typical of an abductive and iterative approach to ethnography that searches for patterns and reads signs (O'Reilly 2009: 107; Blaikie 2007: 90). Surprise, and an openness to new concepts during the conduct of the fieldwork (Agar 2006) occurred here for the researcher. Based on the observations made, the researcher reflected shortly after the end of the fieldwork that it seemed for many of the building workers "Things are entirely what they appear to be and behind them… there is nothing" (Sartre 1965: 140). The freedom, action and responsibility of these workers is the surprise revealed (Sartre: 1956). This ongoing entanglement with the fieldwork is possible because of
the possession of large quantities of data, provided by the adoption of a short-term ethnographic approach that can be continuously re-analysed.

REFERENCES


FINDING THE MICRO IN THE MEGA: A MULTI-ETHNOGRAPHER STUDY INTO THE MICRODYNAMICS IN A MEGA CONSTRUCTION PROJECT

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Studies of megaproject management have often analysed the causes of time and cost overruns. Such scholarship could be distinguished between those who see overruns as an inevitable consequence of scope creep and changes from inception to completion, and those who consider overruns as a result of strategic misrepresentation or optimism bias. What both groups have in common is the assumption that more accurate and honest planning in the front-end would lead to a greater chance of success. In this article, we question this assumption by drawing on a short-term, intense, rapid ethnographic study of the construction of a 361-hectare liquefied natural gas (LNG) processing plant in North Australia. By following a group of scaffolders, we observed and analysed how what is intended (policies, plans and procedures) is put to work. Through a vignette on weathering work, we found that deviations to the plan were far from duplicitous; rather, these resulted from ongoing workers’ efforts to stick to plan while navigating through the paradoxes that emerged from the changing physical, material, and climatic conditions on-site. There is therefore a need for deeper understanding of how the microdynamics of practices on site can better inform the planning of megaprojects.

Keywords: heat stress, infrastructure, megaprojects, practices, rapid ethnography

INTRODUCTION

Megaprojects have in recent times come under the spotlight of policy-makers, industry commentators and academic researchers. As Flyvbjerg (2014) pointed out, megaprojects have become a fascinating context to examine as a subset in the field of project studies in part because of their magnitude in costs, duration and scale, as well as the consistent pattern of failure in terms of time and cost overruns in these projects. To better understand the causes of these problems, scholarship has largely developed in two main tracks; on the one hand, there are evolutionists who recognise that overruns are a result of scope creep where changes are an inevitable consequence of gaining more information and certainty in the project life cycle (see e.g. Love and Ahiaga-Dagbui, 2018), and on the other hand there are psycho-strategists who take the view that overruns are a consequence of a more systemic problem in megaproject management of deliberate deception and misrepresentation or planning optimism (see e.g. Flyvbjerg et al., 2018).

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A common thread that ties together both streams of scholarship on megaproject management is the supposition that accurate (and honest) planning especially in the front-end phase is important to ensure projects can be completed on time and to the budget. This assumption is, for instance, evident in Pollack’s et al. (2018) recent review of classics in megaproject management, in which they revisited Morris and Hough’s (1987) *The Anatomy of Major Projects*; Flyvbjerg, Bruzelius and Rothengatter’s (2003) *Megaprojects and Risk: An Anatomy of Ambition*, and; Merrow’s (2011) *Industrial Megaprojects*. The failures of megaprojects are, according to these classics, attributable to a lack of strategic clarity on the part of the project sponsor, underinvestment in the earlier phases of the project, premature authorisation of a project before the strategic case is made fully clear, and estimates of duration and costs tampered by political agenda and/or optimism bias.

The front-end has long been recognised as a critical but undervalued phase of projects. For instance, Tzortzopoulos et al. (2006) reiterated the importance of a good requirements capture process and argued that this is especially vital for novice construction clients as they muddle through the fuzzy front-end phase of projects. Williams and Samset (2010) emphasised the significance of strategic alignment at the front-end of projects so that the relevance and impact of a proposed project are analysed before such projects are authorised. Williams and Samset also noted that such analysis is often either not undertaken or undermined due to political drive to push through projects. They also observed how there is often a tendency to use the temporary and bespoke nature of (mega)projects to avoid the use of data and learning from past projects (see also Flyvbjerg, 2014; Flyvbjerg et al., 2018). In the same vein, Edkins et al. (2013) stressed the importance of the project sponsor and identified gaps in front-end management of projects in relation to building competences and tools for developing more sensible estimates of costs and benefits of projects.

Unsurprisingly, much research effort on megaproject management has focussed on developing tools and methods for planning and optimising outcomes in terms of managing risks, costs and benefits of complex projects, often drawing on thinking from the field of engineering system management (see a recent bibliometric analysis by Li et al., 2018). Notwithstanding these contributions, prevailing scholarship that promotes rationalistic approaches to managing megaprojects is problematic. The inherent complexity and plurality of stakeholders involved in and affected by megaprojects suggest that there are limits to taking a unitarist and monocentric organisational approach. For instance, in a recent reflection of megaproject organising, Gil and Pinto (2018) argued that the problems of time and cost overruns in these contexts is not simply due to scope creep of deliberate misrepresentation or optimism bias; rather, the difficulties are an indication of a need to pay careful attention to what they called polycentric forms of organisation where decision-making is often found dispersed across different organisational units and where ongoing negotiation is required to achieve local consensus on how these megaprojects are managed. Thus, “[t]he complexity and ambiguity of megaprojects can make the maintenance of these rationality facades much more difficult” (Pollack et al., 2018: 382). It is, as Biesenthal et al. (2018) noted, important to deepen our understanding of the institutional context of everyday practices of managing megaprojects.

One approach of getting closer to the everyday practices of managing megaprojects is through qualitative research methods such as ethnography. For example, van Marrewijk et al. (2016) undertook a year-long ethnographic study into collaborative practices in the Panama Canal Expansion Program megaproject to find multiple
realities of how collaboration is perceived and practised that goes beyond the ceremonial rhetoric of ‘trust’ and ‘marriage’ in establishing collaborative governance principles. What van Marrewijk and colleagues also found was that collaboration entailed shifting power relations as the authority of who took the lead shifted between the sponsor (Autoridad del Canal de Panamá) to the agent (CH2M Hill). Through such rich examples of qualitative research, the realities of how megaprojects are managed beyond the principles, tools and methods espoused in the literature can be made accessible. It is in this tradition that this present study of the microdynamics of managing megaprojects is framed.

In this article, we report on a short-term, rapid ethnographic study of an energy plant construction in North Australia. Our entry into the field was initially motivated by the question of how heat stress was regarded and managed. By following a team of scaffolders during a week-long multi-ethnographer study, we became quickly concerned as to how project policies, plans and procedures were put to work. In so doing our observations suggest that, contrary to claims of duplicitous behaviour, the workers we followed expended much effort in trying to make plans work. What we see, nevertheless, is an ongoing and never-ending push of various envelopes of planning, physical constraints and climatic conditions by constantly negotiating the paradoxes of everyday life in the megaproject. In what follows, we first explain the ethnographic context, data sources and analytical approach. Through a vignette of how the scaffolders navigate through everyday paradoxes in weather-ing work, our contribution lies in questioning the limits of front-end planning in ensuring the success of megaproject delivery and the role everyday work practices can play in informing that planning.

METHODS

Ethnographic Context, Data and Analysis

Although the construction management research field has long been dominated by positivistic studies, there has over the past two decades a growing interest in developing more interpretive insights through e.g. ethnographic research (see e.g. Phelps and Horman, 2009; Pink et al., 2010). In the context of studying megaprojects, Pollack et al. (2018) also expressed a need to look beyond the numbers to study, more qualitatively, the practices and institutions that shape what goes on in doing megaprojects. Ethnography as a methodological approach offers researchers access into what actually happens in the observational research setting, and a reality that may not be found simply by talking to people about what they do (Watson, 2011). To paraphrase Barley and Kunda (2001), ethnography allows management and organisational scholars to bring work back into our studies.

The construction context offers an interesting work setting for ethnographic research. Pink et al. (2010) noted that whereas ethnographies have more recently focussed on pre- and post-construction work, there is a need for more ethnographic studies that examine work during construction. They argued that ethnography enables researchers to gain access to knowledge embodied in the practices that are situated as the workers move around the workplace (see also Gherardi et al., 2013). For Pink et al. (2010: 653), however, what constitutes the construction workplace is often not fixed as “the concept of a locality is itself difficult to apply to the realities of construction sites […] It thus involves interacting in a recognizable environment that might be reconstituted in rather different configurations for different jobs, rather than in a determined locality”. As Marshall and Bresnen (2012) aptly ask, ‘Where is the action?’ as they
noted how the ethnographer cannot be everywhere at the same time. Indeed, in Thiel’s (2012) exposition of what being a construction worker means in terms of such social divisions as class, gender and ethnicity, he spent a proportion of time in his 51-week ethnographic study of Topbuild working with labourers, office workers, and latterly painters.

The Context

In this study, we join this growing line of ethnographic scholarship that distinguishes between what happens in principle (body of knowledge) and what happens as work happens around the site (embodied knowledge). While ethnographic studies on construction safety have been illuminating in terms of creative power of workers particularly when things do not go to plan, ethnographic studies in a megaproject context remain rare. An opportunity arose to follow a team of scaffolders working for ScaffoldCo on the construction of a liquefied natural gas (LNG) plant in North Australia. According to the publicity brochure of the lead consortium, this was one of the world’s largest and most advanced LNG processing facility found off the coast of Western Australia. The megaproject was really three megaprojects in one, comprising an offshore central processing facility, the construction of one of the world's longest subsea gas export pipeline spanning 890 kilometres, and an onshore processing facility on a 361-hectare site. The focus of our ethnographic study centres on the work of ScaffoldCo on the site of the onshore processing facility.

The mega construction project was authorised to begin in 2012. By the time approval was given for the project to go ahead, the initial estimated cost had already risen to USD$32 billion. At its completion in 2018, over a year after it was scheduled to be operational, the total cost had escalated to around USD$45 billion. The delay to the schedule and cost overrun therefore makes this mega construction project a classic case study for investigation. The site was projected to produce 8.4 million tonnes of LNG per year for a duration of 40 years.

Conventionally, ethnography demanded long periods of participant observations typically lasting over a few months or even years. There have, nevertheless, been recent calls for considering shorter, more rapid forms of ethnography (see e.g. Pink and Morgan, 2013). The site itself was subject to much controversy and political struggle between various interest groups. A lot has been said in the public relations campaign to promote the projected economic benefits of the LNG plant with estimates of contributing nearly a fifth of the regional GDP and injecting around USD$3.5 billion to the local economy per year. Yet, the site also attracted a lot of (at times, heated) discussion on the impacts of the megaproject on the local community. With a peak workforce of over 8,000 workers, largely drawn from an itinerant workforce known as FIFOs (Fly-In-Fly-Outs), debates ensued as to whether the costs to the local environment, local and indigenous culture and local community outweighed what was perceived by some to be the economic benefits derived from a temporary boom.

Given negative publicity from some segments of the media, the site was not amenable to allowing access to long periods of observational research. Thus, the research team was granted access to the site over a one-week period in January 2017. This access was negotiated with a senior project manager working for ScaffoldCo, who had a prior working relationship with the co-author of this article and who granted this author an earlier week-long period of observational research in 2015. Thus, this short-term, rapid ethnographic study could be regarded as one of what Pink and Morgan (2013) called “intensive excursions into their lives” (352).
Data Collection and Analysis

Ethnographic research requires the researcher to become engaged in the setting, often as a participant observer rather than a disinterested (or distanced) party. The site in Northern Australia was in a geographic location where the climate was warm and humid all year round, with temperatures ranging between 25°C and 32°C and relative humidity levels often over 80%. Exposure to heat stress is therefore a major concern for ScaffoldCo, and so the co-author was introduced to the project team in 2015 as an expert in occupational health and safety with a focus on heat stress. During the observational period in 2017, the first author of this article joined in the study and was introduced as a colleague of the co-author.

As mentioned earlier, the workforce on site was largely itinerant, comprising of two distinct groups of workers. Blue-collar workers tended to work six days a week continuously for four weeks at a time before they are granted a week off work. Managers would work six days a week continuously for six weeks at a time before they were granted two weeks off work. Because the geographic region in which the LNG plant was situated was one of the least-populated parts of Australia, workers would fly into the nearest airport from other major cities in Australia, the Asia-Pacific region, and even from the UK. Every morning, a convoy of buses would pick the workers up from the purpose-built accommodation village situated around 30 kilometres from the site. We were also picked up every morning at 5:30am so that we could reach the site by 6am. The day was then spent walking around the site, speaking with workers during their break times, collecting information about climatic conditions, and writing up fieldnotes in the site office before leaving the site at around 6pm. Where possible, we tried to be as inconspicuous and un-obstructive. That said, because the high-visibility safety jackets used on site were colour-coded, it was easily identifiable as to who came from the client or contractor organisations and who were visitors. Thus, we did not have the luxury that Löwstedt (2016: 408) had in blending in with the apprentices. Nevertheless, because the client was led by a consortium based in Japan some workers had thought that we, being visitors and Asian, were representing the client organisation.

Due to the sensitive nature of the site both in terms of its (scale of) construction and of its eventual use, photographs and audio recordings were not permitted. While this posed some difficulty in capturing conversations verbatim, we attempted to write extensive notes that describe what we saw as we moved around, with the workers, on the site. As the site measuring 361 hectares is extensive, the advantage of having two ethnographers was that we were able to some extent remedy the problem raised by Marshall and Bresnen (2012) of not being everywhere at the same time. At times, one of us was able to stay in the air-conditioned administrative office while the other was out in the field where the scaffolders were operating. Being able to walk around the site enabled us to fully appreciate the size of the area, as well as the heat and relative humidity that characterised the working conditions on-site.

Where interesting conversations with the managers and workers surrounding occupational health, safety and wellbeing took place, and when issues were raised about heat stress, we attempted to reconstruct these conversations in our fieldnotes. Herein lies another advantage of having more than one ethnographic researcher on-site at the same time. There were moments, particularly when one or both of us thought an interesting occurrence, observation or conversation took place, when we were able to discuss our perceptions and perspectives of that event or incident. We
would, for instance, adjourn to the office pantry or to an available training/meeting room to discuss the relevance and significance of what we saw, experienced or heard. This constituted what Goffman (1959) would call the ‘back stage’ of our ethnographic research where we would move away from those we were engaging with on-site.

Conventionally, ethnography from the anthropological tradition tended to be done by a sole researcher; yet, as Barley (1996) noted, the benefit of having more than one ethnographer on-site can be liberating since each of us could observe freely emically (as an insider) and interpret together etically (as an outsider). We would add that, given the short-term, rapid character of our ethnographic study, working as a pair intensified our experiences and analysis (see Pink and Morgan, 2013). That is not to say there were no disadvantages. As the ethnographer cannot fully divorce herself or himself from theory (Pink et al., 2010), this means that each of us were also burdened by our theoretical perspectives - one of us is more inclined to draw on institutional perspectives of practice that emphasises the collective, whereas the other focuses more on the microdynamics of practices that highlights the individual. The tyranny of multiple theoretical perspectives, as Barley (2016) puts it, has resulted in differences of interpretation which is beyond the scope of this article. For the purpose of this article, we focus on the points of agreement in relation to how what is intended (policies, plans and procedures) are put into practice (intended or unintended). Our observations are supplemented by further, quite intensive analysis of secondary materials - press releases, news reports, other scholarly analysis - about the project, which continued until the end of 2017. The rich array of secondary information provided us with another opportunity of what Hopkins described as ‘armchair ethnography’ where we were able to ‘re-live’ the experience of the atmosphere on-site without stepping again on its premises. In the next section, we present our analysis of two interesting vignettes to illustrate the microdynamics of putting plans into action.

**A Vignette: Weather Work in Watching the Paint Dry**

In this section, we present a vignette that highlights how (and why) what is intended by means of policies, plans and procedures are not always put to work (or workable). A major aspect of any LNG processing plant is the installation of pipework. On this onshore processing plant, the pipework stretches to 8 kilometres in length. Any changes to the pipework therefore have severe implications for the duration and cost of this megaproject. To prolong the lifespan of the pipes and to prevent these from corrosion, it is important that protective coats of paint are applied. It is this process of painting the pipes that has created one of the major delays and cost overruns on this project.

According to Bahadori (2015), painting the pipes in the oil, gas and petrochemical industries had to be done under very specific conditions. These constraints include painting cannot be conducted “when the temperature of the surface is less than 3°C above the dew point of the surrounding air, or the relative humidity is higher than 80% […] when the surface temperature is higher than 35°C, when there is the likelihood of an unfavourable change in weather conditions within 2 h after coating, when there is a deposition of moisture in the form of rain, condensation, frost, and other moisture on the surface.” (158) In order to ensure that the paint was applied appropriately and adequately, the plan was to prefabricate the painted pipes in a controlled, manufacturing environment in Thailand. Despite this, when the pipes were installed in-situ, the project team found that the paint was not adequately applied especially in the welded joints. To resolve this major hiccup, there was a need to strip off the paint
and repaint to the quality specifications. At the time of our observations in 2017, ScaffoldCo had been employed to undertake the preparation for this additional work.

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Figure 1. Extract of climatic conditions on the LNG site over two days in January 2017.

Away from near clean room conditions in a manufacturing environment, the scaffolders had to erect the temporary structure for the painters to undertake their work in-situ. ScaffoldCo was also responsible for monitoring the climatic conditions on-site. Figure 1 above provides a snapshot of the climatic conditions over two days, and it is clear that these do not meet the constraints as identified by Bahadori (2015). In fact, despite normal weather conditions on-site, these weather conditions were not conducive to the stringent requirements for painting the pipes. For more than half the working days in January 2017, the painters were unable to find the optimal temperature, relative humidity and dew point levels that would facilitate the painting job. To exacerbate matters, ScaffoldCo attempted to reproduce ‘clean room’ conditions by erecting temporary enclosures to contain the painting task to protect the work from rains in the wet season. As a consequence, however, these temporary enclosures actually worsened the climatic conditions by raising the temperature and relative humidity levels, especially during the process of stripping the existing paint that failed the quality test. Could the team have had a better plan for the optimal climatic conditions? The short answer is no.

Daily meteorological reports did indeed form part of the information used by the project team to plan their daily tasks. We took part in briefings every morning in which weather conditions for periods of the working day were summarised. These were also then posted on news boards around the administrative office. However, because of the spatial scale of the site, the average temperature and relative humidity levels provided by the meteorological reports rarely reflected the fine-grained realities of fluctuations on site. A painter could start painting at one end of a pipe only to find that the temperature has changed by a degree or two by the time he or she gets to the other end.

Within the confines of the ‘clean room’ that ScaffoldCo temporarily constructed to facilitate the process of stripping the existing paint and repainting the pipes, controlling the temperature and relative humidity conditions was observed to be a constant battle. Even when the temperature and relative humidity levels fell within
Finding the Micro in the Mega

the narrow margins of what was acceptable, these levels could change dramatically during the acts of stripping existing paint and repainting. Using high-pressure water to strip existing paint in the ‘clean room’ in the tropical climate meant that the ‘clean room’ effectively became a ‘steam room’. Workers had to constantly measure temperature and humidity levels to ensure that the temperature and relative humidity levels stayed within what was permissible especially for the precise activity of repainting the pipes, otherwise the coatings will not adhere adequately to the pipes, which would in turn result in further rework.

Thus, what we observed was a moment-by-moment negotiation with the weather as the workers had to maximise work within the narrow material and climatic margins of the technical constraints of painting. During our observations, the weather often won in preventing the workers from making the much-needed progress to bring the project back to the ‘plan’. Oppermann et al. (2018) who have also studied heat stress in the same geographic region argued that we should move away from thinking about heat as a quantitative (absolute) measure of high temperatures and shift our thinking towards how workers weather work and work the weather. Our observations have shown that the workers in ScaffoldCo and the painters were constantly weathering work and working the weather to try stick to the plan, a plan that was often shifting.

DISCUSSION AND CONCLUSIONS

In addressing the problems of time and cost overruns in megaproject delivery, Flyvbjerg and colleagues have pointed to the issues of strategic misrepresentation or optimism bias as sources of concern. They have also developed a strong argument for the need for reference class forecasting in creating more accurate estimates of project duration and budget (Flyvbjerg, 2014; Flyvbjerg et al., 2018). While these proposals have focussed on the quantitative analysis of megaproject management, others have started to call for more qualitative analyses of the practices of delivering megaprojects (van Marrewijk et al., 2016; Biesenthal et al., 2018). We have therefore answered this call for more qualitative studies through our ethnographic study of ScaffoldCo and their responses to rework as a result of poor prefabrication of painted pipes.

In some sense, what Flyvbjerg (2014) noted in his overview of megaproject management holds true in our case. For instance, the senior project manager in ScaffoldCo was indeed delighted that there was additional work due to the emergence of rework. However, this was not a consequence of strategic misrepresentation or optimism bias. Our qualitative observations have shown to some degree the limits of quantitative forecasting at the front-end of the megaproject. At least in this example of painting pipes, the requirements were pre-empted early on (Tzortzopoulos et al., 2006; Edkins et al., 2013) by outsourcing the prefabrication of pipework to a manufacturer who could produce these in a controlled environment. But this still failed. Thus, the improvisational responses of ScaffoldCo underscores the importance of the need to appreciate polycentric ways of organising in managing megaprojects (2018).

It is also not the case that weather conditions were not anticipated, but there are also limits as to how useful meteorological forecasts were in identifying the precise temperature and relative humidity conditions at the specific locus of work. This was exacerbated by the expansive geographic scale of the site, and the precision required in stripping out the existing paint and repainting the pipes in a make-shift ‘clean room’. And in any case, while Flyvbjerg (2014) argued that issues of bad weather can be statistically predicted, what we witnessed here was not ‘bad weather’ per se, but
‘normal weather’ known to the project team. Yet, this ‘normal weather’ was almost always exceptional since this was just not conducive to meet the technical complexities of painting the pipes.

While the megaproject in this case was delayed by over a year and saw its cost more than double its original estimate, our observations suggest that the workers were constantly battling with the physical, material and climatic conditions on the site to stick to an evolving plan. This is not to say that calls to improve the forecasting of durations and budgets should be ignored, but it is also important to sense-check any statistical forecast with consideration of the microdynamics of everyday practices, and that more could be done to integrate rich qualitative analysis with quantitative forecasting. Just as Pollack et al. (2018) argued that much that is written about megaprojects can also apply to small projects, we would argue it is vital to also find the micro in the mega.

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CIRCULARITY CHALLENGES AND SOLUTIONS IN DESIGN PROJECTS: AN ACTION RESEARCH APPROACH

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Design professionals need to fundamentally rethink their design practices in light of a transition to a circular built environment. Traditional design approaches result in static buildings that poorly adapt to changing user needs and leave conventional demolition as the only viable end-of-life option, which results in significant amounts of waste. A 'circular' model of production is currently worldwide promoted as an alternative, but little is known about how circularity thinking may be implemented in design projects. This research therefore aims to explore how circularity challenges can be better understood while attempting to solve them in an actual project. An action research approach was adopted to study a pioneering renovation of a primary school building in the Netherlands. Circularity challenges were observed during 17 design meetings with different design disciplines and client representatives over a six-month period. A Circular Project Model was consequently developed to provide an overview of linear and circular material flows. The use of this model during a workshop with 22 designers showed that the practitioners could identify and exemplify key circularity challenges in design, such as building code compliance, complexity of buildings and ease of demolition. It also helped them in finding solutions for some of the challenges, including assessing reuse potentials of materials in existing buildings, designing with future disassembly and reuse in mind and promoting commitment among clients and other stakeholders. This action research study hence offers new opportunities for researchers and practitioners to understand and solve circularity challenges in design projects.

Keywords: action research, circular economy, design management, renovation

INTRODUCTION

As part of an emergent transition towards a circular economy, design professionals need to fundamentally rethink their design practices. The construction industry is recognized as one of the most resource intensive and polluting industries (Cheshire, 2016). One of the root causes of the significant amounts of construction and demolition waste associated with the industry is the designers’ traditional view of their creations being permanent (Durmisevic, 2006). As a result, most buildings can poorly adapt to changing user needs. New usages do happen though and they “persistently retire or reshape buildings” (Brand, 1994). The designs then typically leave conventional demolition, in which a building is converted into mixed waste, as the only viable end-of-life option. To allow building transformations and recovery practices, researchers have proposed a “circular” model of production that is restorative or regenerative by design (Ellen MacArthur Foundation, 2013; Pomponi

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and Moncaster, 2017). Design professionals, however, lack systematic methodologies to help them implement circularity thinking and documented examples of real-world circular design practices are still scarce.

Construction management research has overlooked possibilities to cope with circularity challenges. While issues around energy flows are widely explored, the idea of a circular economy is relatively new in construction (Leising, Quist, and Bocken, 2018). The concept is often simply "depicted as a combination of reduce, reuse and recycle activities" (Kirchherr, Reike, and Hekkert, 2017), but its implications for design appear to be fundamental. One branch of design studies focuses on designing buildings with components extracted from an old building. Gorgolewski (2008), for example, found that designers need additional information to design effectively with recovered components and must be aware of the associated risks, economics and implications to the project. Other design studies focus on designing new buildings so that components can be disassembled and reused in the future (Durmisevic, 2006). Both design approaches pose significant challenges for the project teams, such as the complexity of buildings, low value of materials at end-of-life and a lack of awareness across supply chain parties (Adams, Osmani, Thorpe, and Thornback, 2017). How to deal with such challenges is still poorly understood, which limits the construction industry's eminent transition from the use of new and disposable materials towards reuse.

This paper therefore tries to provide new opportunities to better understand and deal with circularity challenges in design. The next section presents an action research approach to explore the topic. Using data from an actual - pioneering - design project collected over a six-month period, the authors then present a Circular Project Model and reflect on its implementation during a workshop. The paper concludes with insights into possibilities to understand and solve challenges that designers face when trying to implement circularity thinking in their projects.

**ACTION RESEARCH DESIGN**

This research aims to explore how circularity challenges can be better understood while attempting to solve them in an actual design project. Since implementing circularity thinking in projects represents a complex problem with technical and organizational challenges, a research approach based on engaged scholarship was selected. Engaged scholarship is a form of research that advances both science and practice through engagement of scholars with practice (Van de Ven, 2013; Voordijk and Adriaanse, 2016). The researchers here engaged with practitioners who sought to change 'something' in an actual design project so as to enhance circularity. This study was thus designed as action research, an engaged scholarship type of research that aims at building and testing theory in a real-world problem-solving context. Action research consists of five interrelated steps that researchers perform in collaboration with practitioners (Azhar, Ahmad, and Sein, 2009): I - Diagnosing (identifying research problems); II - Action planning (developing an intervention); III - Action taking (implementing the intervention); IV - Evaluating (assessing the outcomes); and V - Specifying learning (abstracting different types of knowledge).

The action research approach was adopted within the context of an architectural and engineering design project. The project concerns the renovation of a primary school building (which houses two schools) located in the eastern part of the Netherlands. The building has two building layers and a gross floor area of approximately 3,750 m². Originally constructed in 1978, it does no longer meet the requirements of its...
users. Cost calculations had shown that replacing the building (through demolition and new-build) grossly exceeded the available budget. It was therefore decided to renovate the current building instead. Together with this planned renovation, ownership of the building would transfer from the local municipality to two separate primary school associations. The researchers decided to collaborate with the architectural and engineering design professionals involved in this project, because the scope concerned a 'circular and sustainable renovation'. Since there are still very few documented examples of actual projects in which circularity thinking has been implemented, this project qualifies for a "unique" (Yin, 2009) case.

In line with the tenets of action research, data was collected during all five research steps. The first mentioned researcher collaborated with several design professionals over the course of the project. He observed 17 design meetings over a six-month period and received minutes of these and 6 other design meetings. About half of the meetings were meant to review a design-in-progress together with the clients; half of the other meetings were meant to discuss design issues between designers, in particular between the architectural and the Mechanical, Electrical and Plumbing (MEP) disciplines. The researcher also collected project data, such as design files, schedules and detailed cost estimations, and he visited the school building twice, photographing building characteristics with a focus on materialization. To plan for 'action', he then developed a Circular Project Model. The first two authors implemented this model in the project through organizing an interactive workshop with design professionals. This workshop was audio-recorded, and the relevant discussions were transcribed verbatim afterwards. The first researcher also discussed and evaluated the action together with the leading design professionals on the day after the workshop. Data analysis consisted of marking, coding and organizing the meeting minutes, transcription and other project documents. All three authors regularly convened to reflect and discuss the different types of knowledge generated during the study. This (one-off) action research cycle ultimately resulted in detailed insights about the design for a planned circular and sustainable renovation.

'CIRCULAR AND SUSTAINABLE RENOVATION' RESULTS

The results are split into five phases, corresponding with the action research cycle.

I - Diagnosing: Inflated ambitions

This study started when the clients and local government decided to change the scope of the focal design project to a "circular and NZEB (nearly zero-energy building) renovation" instead of a maintenance variant. They had earlier determined a direction for the project by investigating and opting for "very sustainable" rather than "default" maintenance - a decision that was mainly motivated by their desire to significantly lower the exploitation costs (i.e. energy bill) of the school building. Meeting minutes dating 1.5 years before the researchers' involvement suggested that the project stakeholders already thought of some initial 'circular' measures, such as 'leasing light', by then. Circularity ambitions were only formalized with the change of scope; the goal became to "design the first (natural) gas-free and circular school" of the Netherlands. These ambitions allowed the design team to acquire some national and provincial innovation subsidies - in particular to realize a disconnection from the nation-wide gas grid. The team assumed the renovation to become "a reference project" and several professional publications and news articles promised likewise.
But translating the inflated ambitions into actual circular design solutions turned out to be challenging. The primary focus of the design team was not on circularity, but on reducing the building's energy consumption through adding a new thermal shell - with new materials. While the design professionals had abundant expertise on energy performance, as observed during several technical discussions, knowledge about the concept of a circular economy was limited - especially within the MEP discipline. The architectural design discipline initially treated the concept mainly as about the "conservation of materials." These designers tried to find new purposes for existing materials available on site. One idea was to reuse gravel façade panels to construct seats for an amphitheatre located at the schoolyard - later the idea was replaced by a proposal to reuse them for a "climate proof" rainwater basin. Some other ideas were: reusing the steel window frames to build a landmark structure demarcating the entrances of the two schools; reusing timber window frames to reinforce the steel roof; and reusing mineral ceiling tiles as insulation material in cavity walls. The MEP design team leader argued that such a view on materials is completely new for his team, even though his designers and engineers felt they are "already working towards sustainability" with a focus on energy. Installations were simply deemed "too old" to reuse.

New opportunities to gain insight in and deal with the circularity concept were thus needed. The leader of the architectural design discipline wanted to "investigate" and "gain more experience" in circular design, whereas the first mentioned author suggested potential for other types of circular design measures during some meetings. It was then collaboratively decided to plan for action and further explore the concept.

**II - Action planning: A Circular Project Model**

A Circular Project Model was developed to provide insight into (a transition to) circular construction. The authors aimed to integrate theoretical knowledge about the circular economy concept with domain-specific knowledge. As such, guiding principles for developing the model were: (i) the view of construction as a project-based and location-specific practice, (ii) a material flow perspective and (iii) an explicit distinction between new materials, waste and reused materials. Using these three principles, the first mentioned author developed a Circular Project Model (Figure 1) that captures both linear and circular material flows. Linear construction projects comprise flows of new materials that are being transported to a construction site (arrow 1) and waste that is moved away from the site (arrow 2). In circular construction projects, alternatively, materials recovered from an old building are transported to a construction site (arrow 3), materials are recovered and reused at the same site (arrow 4) and/or materials are recovered and transported for reuse in another new building (arrow 5). While traditional, linear projects rely solely on new materials for construction and treat those same materials as (poorly recyclable) waste at the end-of-life stage, circular construction projects ideally keep all materials 'in the loop' through continuing reuse. In practice, however, projects typically consist of a combination of different types of material flows. The developed model can, accordingly, be used to visualize the degree of circularity for any type of project (new-build, renovation or demolition) through adjusting the arrow thicknesses of the relevant material flows.
Figure 1: Circular Project Model with large arrows (1-5) representing material flows around a construction project and small arrows indicating a 'transition' from linear to circular practice: 1=new materials; 2=waste; 3=reuse of recovered materials (from an old building); 4=recovery and reuse (from and in the same building); 5=recovery of materials for reuse (in another building)

III - Action taking: A workshop to explore potentials

The Circular Project Model was applied and tested during a collaborative circularity workshop at the architectural firm's office. The first two authors presented the model step-by-step and facilitated a structured discussion about the challenges in circular construction. The workshop was attended by 22 design professionals, including the MEP design team leader. All participants got an A3 paper with the model (and some writing lines) and pens/pencils. Not all design professionals were involved in the focal project: as such, the workshop also served as an intervention to share knowledge and generate awareness about circularity thinking within the firm. The architectural design team leader consequently started with introducing the focal case project, describing problems with the existing school building and some preliminary design solutions. The researchers tried to support this project introduction by distributing photos of the building. They then guided the participants through four steps related to the model, asking them to individually: (i) write down 'typical' types of materials for all five flows; (ii) adjust the arrows' thicknesses to indicate the expected volumes of those flows, (iii) specify the expected end-of-life scenarios for materials flowing to/at the site, and (iv) suggest any design measures to improve circularity. This part of the workshop supported design professionals to individually consider whether (or not) a transition from linear to circular construction practice would be possible. The researchers finally tried to collaboratively develop possible ways of addressing circularity challenges through facilitating a structured group discussion about the similarities and differences between the individual responses.

IV - Evaluating: Overview of circularity challenges

The workshop-based action was effective in identifying circularity challenges in the ongoing design project. The researchers and practitioners found that the project intervention resulted in an overview of linear and circular material flows - and the possibilities and impossibilities for change. This was evidenced by an analysis of the individual workshop forms, the transcribed group discussion and an evaluation with two of the leading design professionals on the day after the action took place. That is, the workshop structured around the Circular Project Model revealed several circularity
challenges (Figure 2). These represent aspects of the trade-offs between linear and circular material flows (which typically favour the first).

The workshop participants realized that the great majority of the materials in the renovation project would be new (flow 1 in Figure 1) instead of recovered from other buildings (flow 3). The architect involved in the project explained that they indeed "typically renovate a façade with new timbers and new stucco" and that most materials are thus original. The architectural design team leader then asked the architect whether there would also be a recovered variant available of the proposed timber. While it appeared that had not been seriously considered as an option, the architect hypothesized that the supplier "may be able to give reclaimed timber the same treatment as new ones" so that products would get a similar shade of the desired type of grey. Many other products were also designed as new ones, while several workshop forms suggested that recovered products would be suitable alternatives for typical architectural materials (such as glass, timber, window frames and doors).

Regarding the MEP systems, participants doubted whether recovered installations could meet today's higher (energy) requirements. The MEP design team leader said that they work with new products, because "we also need to deal with NZEB design requirements, which forces us to meet certain quality levels. It is then quite counterintuitive to work with relatively old, reclaimed materials." He exemplified this with the rapid adoption of LED technologies, which made previous lighting technologies - and their fixtures - less interesting to reuse. "Of course one can modify the lamp fixtures, but then costs will increase tremendously," he added. The look and feel of materials also influences reuse possibilities for installations. One workshop participant claimed that "for power outlets and switches, one could perfectly use recovered materials, but an architect often prefers a slightly more modern product."

Other challenges concerned the trade-offs between processing materials at the end-of-life stage as waste or recovering them to enable reuse (flow 2 and 5). For some materials, like asbestos, there was no discussion as it is common practice (and/or required by law) to remove such materials. For other materials, there was less consensus. Regarding the floor covering, for example, one participant speculated that it is cheap and easy for a demolition contractor "to simply order a waste container and get it moved away." The MEP design team leader also argued that it is not interesting to consider reuse for many materials: "we looked at the emergency exit signs [for example], but they have outdated icons" which do not meet building code regulations. He questioned again the "added value" of modifying such materials - in this case to prevent waste. Other people suggested that certifications, for example regarding fire safety, are a significant challenge as well: a door may need to be fire resistant for about 30 minutes now, "but it is very well possible that the test method is completely different than 20 years ago." Other materials, on the other hand, appeared to have more reuse potential. "This project has a nice grid size of 2.50 m. I see that as a modular size," explained a BIM modeller. The balustrades that are attached to some balconies may thus be reused elsewhere, "because their sizes are matching so nicely. And perhaps because it is vintage." Another participant thought that the architectural firm could organize reuse at a firm level: "we have a school building [like here] and, at the same time, we have a new-build project for the police [elsewhere], for example. Well, if 30 doors can be recovered here, we may reuse them for the police office." Another added that this implies "that the architect must then already take that into account" during the design process.
The workshop participants finally discussed design decisions for materials that would be reused for the school building itself (flow 4). "I think most materials are reused, because the foundation, floors, walls and the roof are just kept," said one. The design professionals disagreed over whether or not this could be seen as 'reuse' because those respective materials are not changed or moved during the renovation. For the installations, the MEP design team leader argued that the trade-off is "keeping or new" and that it is difficult to reuse products of the existing building. Such difficulties sometimes require creative solutions, as the project's cost estimator illustrated with an example: "we can reuse the window frames to strengthen the steel roof." This is a more feasible solution than reusing them for the new windows again, because in the latter alternative "they need to be cut, they need to be transported away from the site, they need to be repainted and so on." The possibilities and impossibilities of such activities influence the outcome of design decisions.

Hence, the workshop led to the identification of two types of circularity challenges that were exemplified and discussed during the workshop: on one hand is the move from new to recovered materials limited by quality variations, desired service levels, and expectations regarding the look and feel of materials and on the other hand is the move from waste to recovery for reuse limited by the ease of demolition, code compliance, certification issues, (the absence of) modular sizes and (the absence of) related design projects.

![Figure 2: Workshop results structured along the Circular Project Model. Thickness of large arrows indicates the relative expected material volumes (average of collected forms). Identified circularity challenges (negative or positive) are positioned along smaller arrows.](image)

**V - Specifying learning: Solutions for circularity challenges**

The action research generated new scientific and practical knowledge for circularity thinking in design. The workshop was conducted in response to a need to better understand what design measures could be taken to make a project more circular. This yielded an overview of circularity challenges, from which new ideas were generated that tried to solve some of those challenges in the ongoing design project. The researchers thus acquired knowledge about the effects of using the newly developed Circular Project Model in a workshop format, while the practitioners gained insights to solve actual circularity challenges.
The first insight to solve circularity challenges was to assess the reuse potentials of materials in buildings. A BIM modeller suggested during the workshop that "one could make a checklist of the potentials for materials in [his/her] own project regarding reuse." His idea involved organizing information about the volumes and characteristics of materials that could potentially be reused. Parts of the school building's balconies, for example, could be disassembled with ease and may thus be reused in other projects. Another workshop participant built on the idea by suggesting that such a checklist could follow "a format like the Circular Project Model." After the workshop, the architectural design team leader praised the idea and said the firm would "definitely implement it." In the weeks after the workshop, the researchers observed that an intern was indeed tasked to quantify all material flows for the focal school building and visualize them in the model. This measure thus tries to make reuse potential information available for other, related projects of the firm so that they may reuse materials that can be recovered from the focal project.

The second insight to solve circularity challenges was to design with future disassembly and reuse in mind. According to several workshop participants, a key strategy is to design modular structures (with standardized sizes) which can be disassembled easily later. The MEP design team leader said that most installations can already be disassembled and speculated that the firm's challenge was thus simply "to call things differently." He also acknowledged that such a change does not guarantee reuse though; arguing that "after 20 years, I probably do not want to reuse the [photovoltaic] panels any longer." Other practitioners suggested different measures to increase the degree of circularity though. As such, a BIM modeller proposed to use "timber beams that are larger than necessary so they can be cut to size in a new project." Such design measures target circularity by making it easier to recover (valuable) materials during future demolition.

The third insight to solve circularity challenges was to promote commitment for circular design among clients and other stakeholders. During the workshop, the project's architect argued that "the new way of working" can only succeed if the client is also willing to change from linear to circular practice. Another workshop participant then suggested that client commitment must be formalized in the project brief. During one of the focal project's design meetings, for example, it was observed that one of the client representatives argued that "circularity is quite nice, but it should not increase our costs." Other workshop participants expected that clients who are more committed to circular construction practices would also be willing to pay a bit extra to realize circularity ambitions. One practical solution for moving to that situation is to inform clients about the circular economy concept beforehand and then to formalize commitment in the design brief. Designers in the focal project did so after the workshop by presenting cost estimations of several sustainable and circular design alternatives to client representatives and asking them to choose. Seeking commitment can help to overcome challenges related to the expectations regarding quality variations, service levels or the look and feel of recovered materials.

These three insights hence deal with circularity challenges in the ongoing design project. The workshop with the Circular Project Model helped design professionals to become more aware of expected material flows in the focal school building projects - and to reconsider them. While challenges related to building code compliance and certification issues could not be solved (yet), the action still yielded some concrete insights for taking measures with which design professionals can increase the level of circularity in a project.
DISCUSSION AND CONCLUSION

This paper explored circularity challenges and solutions with an action research approach. The construction industry currently faces the grand challenge to move from a resourceful and wasteful mode of production to a circular model. Such a production model tries to close material loops through a combination of reduce, reuse and recycling activities. The implications of circularity thinking for design projects are fundamental yet understudied. This study hence tried to provide new opportunities for understanding and solving circularity challenges.

It firstly contributes to literature by systematically reflecting on a new way to understand circularity challenges in design projects. Since the construction industry is globally only starting to implement the concept of a circular economy in its projects, documented reflections are scarce. Previous studies mainly depended on self-reported challenges (e.g. Adams et al., 2017). The present work complements such studies with qualitative, in-depth insights of actual challenges. Substantiated with data collected over a six-month period, the authors explained how practitioners aimed to create a pioneering circular design for a school building yet struggled with realizing that ambition. The use of a Circular Project Model during a workshop setting provided a new way to understand challenges at hand. The model visually represented (expected) linear and circular material flows, which opened up discussions about (im)possibilities for change. Several challenges were, accordingly, identified and exemplified, including: building code compliance; complexity of buildings; and ease of demolition. This research thus illustrated such circularity challenges with real-world data and provided a new way to understand them.

The study secondly contributes with solutions for identified circularity challenges. Design professionals in the focal project were searching for more possibilities to implement circularity. They had initially only focused on developing new purposes for existing materials on site - and overlooked reuse possibilities in other projects. The proposed model and workshop opened up a new range of circularity solutions. It suggested on one hand that recovered materials from other demolition projects could be reused in the school building, and on the other hand that materials from the school building could be recovered and reused elsewhere. This concretized the idea that designers can close material loops by rethinking buildings as material banks which allow both giving and taking of valuable materials (Van den Berg, 2019). Three insights to solve some of the identified circularity solutions were developed accordingly: assessing reuse potentials of materials in existing buildings; designing with future disassembly and reuse in mind; and promoting commitment among clients and other stakeholders.

This action research study hence provided new opportunities to understand and solve circularity challenges in design projects. Since the study is limited to just one complete action research cycle, more research is recommended to increase the validity of the proposed model and workshop format. It is similarly unclear whether practitioners could acquire the same circularity knowledge in other, perhaps more efficient, ways than this study's action or intervention. Researchers can also further build on the suggested opportunities by developing new circularity solutions and refining the model. Practitioners can use the presented insights to systematically rethink their conventional design practices.
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DEMAND FOR AFFORDABLE HOUSING: EXPLORING THE EXCLUSIONARY FORCES OF CATEGORISATION

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Growing demand and inadequate supply of affordable housing for low-income households has increasingly become a chronic problem globally. Research in construction management research has tended to focus on supply-side concerns at the expense of considering demand issues. In this paper, we draw on exploratory interviews with 18 key actors in the provision of affordable housing in the UK, including local authorities, housing associations and social landlords to investigate demand perspectives and how these contribute to or constrain action to the provision of affordable housing. Specifically, we focus on categorisation games as a means of setting boundaries over which demand-side actors' matter, and how this has implications for the ways we design and construct solutions to address the challenge of providing affordable housing. The findings highlight that categorising priorities in terms of need can serve to reduce the complexity of demand and make the problem of providing affordable housing more manageable. But, an (intended or unintended) consequence of this is the alienation of other vulnerable groups. Furthermore, the reduction of the problem to numbers (quantity) has implications for the quality of houses that are designed, constructed and managed.

Keywords: affordable housing, social landlords, social exclusion, categorisation

INTRODUCTION

Worldwide, there has been longstanding concern and interest in studying affordable housing from multiple perspectives and by various fields such as urban studies, housing policy, project management and economics. Inadequate supply of affordable housing for low-income households and growing demand of such housing has become a chronic problem (Fingleton et al., 2019). Previous research in project studies and construction management tended to focus on the supply of affordable housing with less attention to the demand-side issues (see Alananga et al., 2015; Lizarralde and Root, 2008; Mehta and Bridwell, 2005; Styhre, 2018), with the emphasis placed more on how affordable housing can be produced more efficiently (Mehta and Bridwell, 2005), more cheaply (Alananga et al., 2015; Styhre, 2018) and with fewer defects (Hopkin et al., 2016). In so doing, demand-side issues that provide deeper understanding of user perspectives in shaping the production of affordable housing have been neglected.

In part, prevailing emphasis on cost and efficiency illustrates how the concept of affordable housing is often defined; such definition tends to focus on the exchange

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Demand for Affordable Housing

monetary value of houses in relation to a multiplier of the owner/occupant's income (see e.g. Mohlasedi and Nkado, 1997; Kavishe and Chileshe, 2016, and; Kavishe and Chileshe, 2017). Thus, construction management researchers often take the view the challenge of providing affordable housing is simply one of producing more houses as a technical commodity, thus downplaying this challenge as a social problem. In this paper, we address these deficiencies - the relative lack of attention by construction management researchers on demand-side issues and on social (and not just technical) aspects - by reporting on findings from exploratory interviews designed to examine the implications of demand-side perspectives in the provision of affordable housing.

To do so, our exploratory interviews point to the significance of language (discursive) games. Specifically, we analyse how categorisations of the needs to those who require affordable housing can have significant impacts on the ways we design, construct and manage the provision of affordable housing that goes beyond cost and efficiency concerns. Our findings also highlight how such categorisations can also serve to produce divisions and barriers, and thus exclusion of those who are in need of affordable housing (Lee and Murie, 1997). In what follows, we review previous studies on affordable housing, paying particular attention to one form of such housing - social housing - in the context of the UK where the exploratory interviews are situated.

Reviewing Previous Studies on Affordable Housing Provision: The UK Context

Over seven decades ago, public housing in the UK was held up as a beacon of success in providing good-quality shelter for millions of people who otherwise would be housed in unaffordable or run-down private housing (Valença, 2015). Pearce and Vine (2014) argued that social housing in the UK had originally served a variety of households with varying income levels, which traces back to the period after the Second World War when considerable progress was made in terms of mass provision of council housing of good quality and at affordable rents (Münch, 2012). However, evidence from successive English Housing Condition Surveys show that the situation has deteriorated and, like many places across the world, housing costs have risen dramatically (Somerville, 1998).

Today social housing remains an important element of providing affordable housing for people with the lowest income in the UK. It is increasingly seen as an “ambulance of service” serving and giving a helping hand to those unable to support themselves (Pearce and Vine, 2014) and those who are least eligible in the eyes of the private market (Cowan and Marsh, 2005). At the same time, because social housing sector is typically associated with the poorest segments of society, this also opens up the possibility for spatial marginalisation and social stigmatisation of those who live in such housing. For instance, scholars have argued that social housing, far from providing a resource for respite for those left-behind in society, is potentially (and actually) a source for driving further vicious cycles of poverty (Forrest, 2014; Spicker, 1998).

In the UK, the provision of affordable housing has traditionally been the responsibility of local authorities. With the advent of more liberal policies since the 1980s, starting with Margaret Thatcher's policies and intensified under Tony Blair's New Labour government, local authorities have shifted from a role of direct provision to a role of indirectly enabling the provision of affordable housing through housing associations that are ostensibly private organisations. This shift towards private-sector provision has been rendered problematic in terms of driving social exclusion. For example,
Spicker (1998) noted how those who are often in need of affordable housing tend to be more vulnerable to other social problems, and that they are subjected to complex webs of deprivation due, in part, to the social ties they have with others in similar conditions of poverty. Indeed, geographical location matters in building those social ties through e.g. education, housing, health and other services. Doney et al., (2013), for instance, found that those in poverty tend not to have a choice in terms of where they live. This lack of choice in an increasingly tense housing market can in turn serve to restrict one's physical and social mobility (Stanley et al., 2011), thereby significantly reducing their chances in life and reinforcing their social exclusion (Brennan et al., 2014). Pearce and Vince (2014) also found that affordable housing tend to be situated in less desirable places, both within inner cities and the outskirts, which serve only to exacerbate conditions of social exclusion.

There is a wealth of research on institutional exclusion in the social housing sector (Somerville, 1998). At its heart, the housing system and policies have played a key role in reinforcing social exclusion. For example, Pawson and Kintrea (2002) point to the unintended effects of segregation especially among vulnerable low-income households by allocating affordable housing in neighbourhoods already suffering from adverse socio-economic conditions. Cowan and Marsh (2005) considered how the selection and allocation of households for social housing, often framed as 'needs based', can create problems of uphold practices of exclusion. Thus, studies have considered how the policy direction for social efficiency has led to practices of reinforcing inequalities and inequity (Doney et al., 2013).

More recently, studies have focussed on the way exclusionary allocation policies play out in the social housing sector (Cowan and Marsh, 2005; Münch, 2012; Pawson and Kintrea, 2002). These studies show that the problem of social exclusion remains persistent and, in many cases, worsening. Bevan and Cowan (2016), for instance, showed that those deemed as "difficult" tenants such as those with rent arrears, or records of anti-social behaviour may find themselves confined to certain disadvantaged neighbourhoods or 'bad' estates, often with poor housing conditions. In much the same way as construction management researchers remain relatively silent on demand-side perspectives when studying the affordable housing challenge, much has also been written on how the supply and allocation of affordable housing to the most vulnerable segments of society in the social housing sector has served only to worsen the problems of social exclusion. Thus, demand-side perspectives are also missing from studies on the provision of affordable housing. In the next section, we describe and explain the exploratory interviews designed to address this gap.

METHOD

Taking a social constructionist position, we draw on a series of exploratory interviews (n=18) with key actors in the housing sector in the North of England. These key actors were mainly senior managers working in local authorities, housing associations and housing charities who have extensive experience in the social housing sector. The interviews sought to explore their perspectives and experiences over their career timespan so as to identify key highlights and challenges in the provision of affordable housing. Table 1 below provides a brief description of the interviewees. The interviews were undertaken between August and November 2018.
Table 1: List of interviewees

<table>
<thead>
<tr>
<th>Participant</th>
<th>Role</th>
<th>Experience</th>
<th>Type of Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA1</td>
<td>Head of Housing Strategies</td>
<td>29 Years</td>
<td>Local Authority</td>
</tr>
<tr>
<td>BB2</td>
<td>Head of Housing Policy</td>
<td>32 Years</td>
<td>Housing Charity</td>
</tr>
<tr>
<td>CC3</td>
<td>Chief Executive Officer</td>
<td>19 Years</td>
<td>Housing Association</td>
</tr>
<tr>
<td>DD4</td>
<td>Head of Housing Strategies</td>
<td>30 Years</td>
<td>Housing Association</td>
</tr>
<tr>
<td>EE5</td>
<td>Housing Development and Investment</td>
<td>30 Years</td>
<td>Housing Association</td>
</tr>
<tr>
<td>FF6</td>
<td>Chief Executive Officer</td>
<td>36 Years</td>
<td>Housing Association</td>
</tr>
<tr>
<td>GG7</td>
<td>Investment and Asset Management</td>
<td>21 Years</td>
<td>Housing Association</td>
</tr>
<tr>
<td>HH8</td>
<td>Chief Executive Officer</td>
<td>25 Years</td>
<td>Housing Association</td>
</tr>
<tr>
<td>II9</td>
<td>Chief Executive Officer</td>
<td>30 Years</td>
<td>Housing Association</td>
</tr>
<tr>
<td>JJ10</td>
<td>Chief Executive Officer</td>
<td>16 Years</td>
<td>Housing charity</td>
</tr>
<tr>
<td>KK11</td>
<td>Head of Housing Strategies</td>
<td>43 Years</td>
<td>Housing charity</td>
</tr>
<tr>
<td>LL12</td>
<td>Strategic Housing Services</td>
<td>12 Years</td>
<td>Housing Association</td>
</tr>
<tr>
<td>MM13</td>
<td>Chief Executive Officer</td>
<td>33 Years</td>
<td>Housing Association</td>
</tr>
<tr>
<td>NN14</td>
<td>Neighbourhood Housing Services</td>
<td>16 Years</td>
<td>Local Authority</td>
</tr>
<tr>
<td>0015</td>
<td>Chief Executive Officer</td>
<td>22 Years</td>
<td>Housing Association</td>
</tr>
<tr>
<td>PP16</td>
<td>Housing Officer</td>
<td>18 Years</td>
<td>Local Authority</td>
</tr>
<tr>
<td>QQ17</td>
<td>Director for Housing Development</td>
<td>27 Years</td>
<td>Housing Association</td>
</tr>
<tr>
<td>RR18</td>
<td>Strategic role team leader</td>
<td>24 Years</td>
<td>Local Authority</td>
</tr>
</tbody>
</table>

The interviews followed a semi-structured protocol, which allowed interpretive flexibility in the way issues were addressed by the research team (Silverman, 2000). Each interview lasted between 50 to 90 minutes; the interviews were recorded following the consent from participants and later transcribed verbatim to aid analysis. In all the interviews, it was clear that the challenge (and in some cases, this challenge was referred to as a "crisis") lay in the fact that there was not enough supply of housing to meet the demand of affordable housing in the social housing sector. Every interviewee then explained the importance of establishing a "needs-based" approach on which to make decisions on the allocation and provision of social housing. For the purpose of this paper, the analysis centres on how these "needs" were understood and assessed by our interviewees, how the conceptualisation of "needs" in turn influenced the allocation policies, and the implications for the ways of designing, constructing and managing affordable housing.

**Emergent Findings**

In this section, we present the key findings from our exploratory interviews in two parts. In the first part, we examine how our key actors, in view of the mismatch
between supply and demand of affordable housing, use categorisations of need to
restrict the relevant social groups for whom they provide affordable housing. In
Reducing the complexity and defining (somewhat narrowly) the group that is deemed
most in need, the second part examines how this in turn leads to a focus on the
quantity at the expense of the quality of housing. Furthermore, with the public sector
seeking solutions from private-sector developers, housing is thus reduced to a
technical commodity rather than an ongoing process of development that is intimately
linked to the social lives of those who live and occupy these properties.

Categorising Demand in Supplying Affordable Housing

In the olden days […] you included [the families you were allocating the houses to] by
asking them, 'How do you want your home to look? How do you want the kitchen to be
laid out? Colours of tiles, and all that.' We don’t tend to do that a great deal currently
because the housing supply is so low compared with demand, we don’t usually […]
have that time and that luxury to actually involve them earlier on. (Participant QQ17,
Director of Housing Development at a Housing Association)

A key point raised by all the interviewees is how supply of housing, affordable or
otherwise, lags behind demand. Along with the shifts in the public sector from a role
of provision to a role of facilitation, and greater involvement of the private sector, our
interviewees appear to highlight the importance of reducing and organising demand to
match the available properties. To do so, a critical step is to assess and decide who is
most in need and who makes the most deserving case for allocation of housing. For
instance, Participant EE5 who is responsible for development and investment
decisions in a Housing Association remarked,

[…] the only people who manage to get through or who are more likely to get through
are people in extreme housing need. So, they’re homeless, they’re people escaping
domestic violence, you know, people - those are very well-defined groups, and its part
of the residualisation of social housing

Thus, by narrowing the categorisation of who is most in need, local authorities and
housing associations are then able to manage demand. Even in the category of
"homeless", this is not without problems. In allocating the short supply of housing,
there are also different priority bands within the "homeless" category. An allocating
officer can, for instance, deem a person in need to have intentionally made him or
herself homeless simply by falling into rent arrears as a result of losing a job. Thus,
the safety net for supporting the vulnerable segments in society is increasingly
becoming much smaller and tighter, as Participant BB2 the Head of Policy in a
Housing Charity commented, "the biggest reason for homeless now is people using
private renting tenancy", but when it comes to allocation of social housing, the highest
priority goes to those suffering from

violence and domestic abuse […]and it is usually women experiencing violence from
men but that is not saying men do not experience domestic violence or it does not
happen in same-sex relationships either because it does

There appears to be a somewhat paternalistic order of priority where women (and
children) suffering from domestic abuse are allocated housing first before other
groups of people who suffer abuse… and those who are not but find themselves
evicted as a result of missing rent payments to a private landlord are then deemed to
have intentionally made homeless and have no recourse to allocation of housing.

But, as Spicker (1998) had already highlighted, even those who are deemed in-need of
affordable housing according to such categorisations potentially find themselves in a
"take it or lose it" situation, which in turn means that they are allocated housing in
locations away from the support of their social networks. And this precariousness is further underlined by policies that prescribe that those who refuse to be rehoused and who subsequently find themselves homeless are then in turn deemed to have intentionally made himself or herself homeless, which in turn leads to automatic disqualification of being rehoused.

By prioritising and categorising groups of people who demand affordable housing differently social landlords can ease the pressure of finding available properties and reducing their obligations by defining the social groups that are deemed to be deserving of affordable housing. For those who fall out of this safety net, there is a tendency to frame these individuals as being unprepared to work with the authorities to sort out their basic accommodation needs. As the Head of Housing Strategies in a local authority, Participant AA1, emphasised,

we can work with them to get them into accommodation […] if people work with us, there is no reason for them to be on the streets

despite acknowledging the contradiction that there is an insufficient level of supply of affordable housing to house every vulnerable person.

**Addressing the Quantity and Quality of Demand in the Provision of Affordable Housing**

By categorising segments of the vulnerable population in need of affordable social housing, providers seek to reduce the complexity of demand to a managerial range, quantitatively and qualitatively. For instance, the CEO of a Housing Association, Participant MM13 noted, with an ageing population, there is a need to rethink housing where the "traditional three-bed houses with stairs and bathrooms upstairs" are no longer fit-for-purpose since this makes accessibility problematic for older people. He added that, over his 33 years of experience working in the sector, that "We're spending twice as much now, adapting houses, so putting handrails in, putting showers in […] just because demand is just increasing." At the same time, he also recognised the other end of the spectrum, the younger people in need of affordable housing, as he recounted,

we were having a debate with our tenants last week. Why aren't you building more one-bedroom flats? Well because they're not massively sustainable. Okay, a couple maybe okay, or a single, but then if they have children or a family comes, that's no good. So, you're much better off with two rooms.

Indeed, while much debate on affordable housing tends to focus on the numbers, there is also ongoing assessment of the quality of housing that needs to be supplied to meet the needs of those who demand. The quotes above by MM13 show, to some degree, the complexity of meeting those demands from a diverse range of users, young and old. These quotes also illustrate how housing is not just a technical object that can be reduced in aggregate numbers. Rather, there is a social life of housing that corresponds with a person's life course, and that these experiences of housing must be disaggregated and understood more deeply. This aligns with more recent scholarship that pays attention to the social practices that condition the ways we think about housing, and which is also why there is a distinction to be made between a house as a technical commodity and a home that is made (or in the making) for living (see e.g. Tjørring and Gausset, 2019 who draws this distinction in the context of the energy transition in housing).

Yet, when it comes to designing and constructing affordable houses to meet the needs of those vulnerable populations who demand such houses, such nuances of the social
life of housing are missed. In another quote, the CEO of another Housing Association, Participant OO15, reiterates the well-rehearsed claim that life is such that there is no "bottomless pit of grant" monies, and so one looks to private developers for coming up with solutions. Often, these solutions are not always optimal:

if you get, what they call Section 106, which means that, you know, in theory the developers building fifty homes, and ten of them are for social housing. You can always guarantee those ten homes are looking over the railway line, or the sewage works, or they’re smaller somehow, or you know, they’re never quite the same as the forty that they’re selling.

Another CEO, Participant II9, concurs by stating,

there are also real questions about the quality and properties that are being built […] we still have some back-to-back houses, you know, in the country, we still have tiny terrace houses that are almost straight onto the street, you know, with limited quality foundations and lots of damp, and that, you know, he might have a bathroom, leave it in, but that they’re not attractive. You know, people don't want to live in them anymore, people aspire to something different.

A corollary of reducing the complexity of demand to numbers and ignoring social aspects and the quality of needs is that, in the context of private-sector provision of affordable housing, developers are motivated simply to produce a standardised (and at times, poor standard of) housing. Yet, in facilitating such provision, local authorities and regulators have a role to play in developing and enforcing standards that can push current envelop of design and construction practices such that providers and developers are not simply producing a higher quantity of houses as commodities for the pre-determined categorisation of tenant (e.g. those most in need which, according to the interviewees, include those suffering from domestic abuse). As a number of participants (GG7, HH8 and II9) explained, it is critical that we design neighbourhoods and places where people would want to live in and thrive, close to employment opportunities and amenities for recreation. The Head of Housing Strategies at a Housing Charity aptly sums up, there is a need to move beyond current situation where "the demand side of the voice is getting no say at all [and that] you have almost no choice about where you go", and indeed

There is so much to learn from people about how they want to live and how that translates in to good housing design.

CONCLUSIONS

The housing crisis - as our interviewees aptly described - is, we would argue, persistent because much emphasis has been placed on supply-side considerations at the expense of demand-side perspectives. This problem is likely to persist (Valença, 2015) if we continue to focus purely on the numbers and neglecting the quality of housing that could create and perpetuate inequalities (see e.g. Marcuse and Madden, 2016). Furthermore, as our interviews highlight, by seeking a 'standard' category of tenants who are most in need, the allocation and provision of housing can serve to promote social exclusion. Such exclusion can be seen, for instance, in the allocation of social housing where groups who fall through the safety net (e.g. those who cannot keep up with their rental payments in the private sector due to job losses) are denied their basic right to shelter (Somerville, 1998). At the same time, the focus on numbers meant that the design and construction of affordable housing continues to seek standardised ways of provision that are, at times, delivered to a poor standard.

As Tjørring and Gausset (2019) recently argued in the context energy transition in housing, there is a need to move away from viewing houses as just a technical
commodity to be counted, to viewing houses as part of the wider fabric and life course of society that counts. The same argument can thus be applied in the context of affordable housing. We have argued in this paper that construction management researchers have hitherto emphasised supply-side concerns at the expense of demand-side issues. Our interviews served to address this deficiency by exploring the nuances of categorising demand, and the potential implications for the ways affordable housing is designed, constructed and managed. Further research needs to be undertaken to examine how, taking into account the complexity of demand from a social perspective, can influence more positive change in the design and construction of affordable housing not only for vulnerable populations in society but also for everyone.

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ARE WE LOOKING AT THE SAME THING? MULTIPLE METHODS TO FRAME 'OCCUPANCY' OF A LIBRARY BUILDING

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The user occupancy patterns of a building are an important factor influencing the performance of that building. The occupancy patterns influence the technological performance of a building such as its energy use, indoor air quality and thermal comfort. The occupancy patterns are also linked to the socio-material practices in which a building is embroiled. A range of different research methods can be utilised to study a building’s occupancy. However, the influence of different methods in framing the conception of occupancy is under-articulated. This paper draws from a multi-method research on occupancy patterns of the 50-year old University of Reading’s library building. Methods used include archival method, ethnographic method and ‘sweeping’ method. A comparison is also made with the published findings of this building’s occupancy pattern using Wi-fi-based indoor positioning method. The data and findings from different methods are analysed using the concepts of ‘method assemblage’ and ‘ontological politics’. The findings reveal that the ‘occupancy’ of library building is framed differently by each method. Moreover, these framings do not suggest that the conception of occupancy is either singular (i.e. methods framing occupancy from different perspectives) or plural (i.e. methods framing occupancy in a mutually exclusive way). Rather, the framing of occupancy is multiple, such that different versions are linked to one another in a variety of ways. The findings also allude to the ontological politics of choosing one version over the other and what is at stake when making such decisions. The paper concludes that the research methods are not a set of technical procedures. But the methods are performative as they are a process of crafting and enacting the research object.

Keywords: archival research, occupancy, ethnographic research, method assemblage

INTRODUCTION

Improving the performance of buildings, over its life-cycle, has been identified as one of the key objectives for the UK construction Sector (HM Government, 2018). The topic of building performance has been interrogated for many decades but has pertinently struggled to locate itself within the structure of the UK construction industry (Bordass and Leaman, 2015). More recently, the architectural profession made a clarion call to reinvigorate post-occupancy evaluation (POE). POE was identified as integral to the agenda of the Royal Institute of British Architects (RIBA) to promote research culture and continuous learning within the profession (Hay et al., 2016). Despite several efforts, building performance evaluation (BPE) has not succeeded to gain prominence within architectural education, and mainstreaming BPE within the architectural profession remains a challenge (Stevenson, 2019). However, architects have demonstrated frustrations with current POE toolkits that favour

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quantitative measures focusing on technical aspects only (Hay et al., 2017). Architects are interested in POE methodologies which explore how buildings work for their clients and the experiences of users. The definitions of POE and BPE are not definite and many versions co-exist. Mallory-Hill et al., (2012) suggested that BPE emerged out of POE. BPE is a more comprehensive process spanning the life-cycle of a building (from strategic planning to adaptive re-use). POE often focuses on the evaluation of the newly completed buildings for a period up to 3-5 years. Government Soft Landings is one such example where aftercare is stipulated for up to three years (Bateson, 2015). The use and adaptations of a building beyond that time-frame are not being considered by many approaches to POE and BPE. Such notions of BPE and POE do not embrace the ongoing adaptations that occur in everyday practices.

Current debates around BPE argue for adopting a socio-technical or practice-based approach to study performance in order to incorporate technical as well as social factors. The performance of buildings as perceived by the occupants have been studied via occupant questionnaire surveys, building walk-throughs and focus group techniques. Responding to the technical performance of buildings, such studies focus on indoor environmental factors or their effects on work and productivity. Tweed and Zapata-Lancaster (2017) argue that an interdisciplinary approach is required to study building performance as existing POE methodologies provide a limited understanding of user behaviour. Recent studies have explored alternative methodologies for post-occupancy evaluation. Koolhass and AMO’s (2006) post-occupancy study of Seattle Central Library analysed social media content and discussions with scholars and critics. The use of Seattle Central Library was further studied through phenomenological approach and computer-eye tracking (Dalton and Holscher, 2017). However, these studies do not explore the potentiality of cross-method analysis to improve the understanding of buildings in use.

Occupancy of a building is an important aspect to understand user behaviour and user practices. It is also a crucial aspect that influences a building’s energy demand, indoor air quality and utilization of spaces (Wang and Shao, 2018). As part of the Post-Occupancy Review of Buildings Engineering (PROBE) project, Elizabeth Fry building on the University of East Anglia campus was surveyed in 1998 and achieved excellent energy performance and good comfort levels on Building Use Studies (BUS) survey metrics (Standeven et al., 1998). At the time of a subsequent survey in 2011, the building had undergone various changes in the layout. Overall, the building’s occupancy had increased, which had resulted in a decrease of perceived occupant comfort (Bordass and Leaman, 2012). Moreover, occupancy of a building might explore the number of people in a building at a given time, their location and their activities in the building using a range of methods. This paper aims to explore how different methods frame the occupancy of a building using the ideas of method assemblage (Law, 2004) and ontological politics (Mol, 1998). Occupancy of the 50-year old University of Reading’s library building is studied through archival method, ethnographic method and ‘sweeping’ method. A comparison is also made with the published study of this building’s occupancy using Wi-Fi-based indoor positioning method. The findings allude to the ontological politics of enacting a research object and imply a reflexive approach towards foregrounding a certain version of reality.

The Problem of Method

Sailer et al., (2013) studied space use in a university building using RFID wearable technology, manual observations and an online survey to ascertain if these methods
generated comparable, complementing or contrasting findings. They found that the
data sets differed in terms of how they framed the objects of their study; the manual
observation data included all building users, while the sensor-derived data was based
on the participants who volunteered to wear the RFID tag. The temporal resolution
varied across the datasets as manual observation was based on snapshots, while the
sensor-derived data provided a longitudinal view. The authors concluded that manual
data gathering methods do not result in the same findings as the automated ones.

Building on Sailer et al. (2013), this paper explores the comparison of other methods
in addition to sensor-derived data, observations and an online survey. Particularly,
this paper investigates the occupancy of an academic library building using archival
method, ethnographic method and observational ‘sweeping’ method in conjunction
with the published study using Wi-fi-based indoor positioning method. This study
aims to understand how these methods frame the research object 'occupancy'.

The problem of the method is a matter of concern when studying buildings in use and
adaptations made to buildings over long periods of time. Many methods to study
building performance assume a building as a fixed technical object and fail to take
into account the fluid nature of the building. Alternative theoretical and
methodological approaches are needed to conceive buildings in flux. For instance, a
praxiographic approach to conceive buildings as enacted in socio-material practices
opens the possibilities to take into account the heterogenous nature of a building
which is always in making (Patel and Tutt, 2018). Such approach also affords to take
into account entities other than the physical building as crucial actors in enacted the
reality of a building.

Method Assemblage and Ontological Politics

A method enacts the research object it sets out to study. Law (2004) suggested that
the research methods are not an innocent set of technical procedures but are actively
involved in shaping the realities about which we theorise. He thus suggests that
research methods are performative. He did not conceive method as a set of technical
procedures. Instead, he proposed the idea of method assemblage, which is “a
continuing process of crafting and enacting necessary boundaries between presence,
manifest absence and Otherness” (144). The method is a continuous enactment of
boundaries that create the reality-in-here (presence), reality-out-there (manifest
absence/context) and whatever is absent (Otherness). These three concepts are used to
analyse the methods to study occupancy.

If the conception of method as enacting the reality is accepted, there is a need to
attend to the politics of method. Law (2004) suggested that as method is the
continuous process of crafting boundaries, there is a possibility of shaping the reality
in more than one way. However, it does not mean that each method enacts a different
version of the research object, which in turn are unconnected (i.e. the research objects
are plural). Neither does it mean that each method offers a different perspective on a
singular research object. Mol (1998) proposed the idea of ontological politics to
address this issue of singularity and plurality. She posited that the different versions
of an object are not mutually exclusive but are connected in various manners. de Laet
and Mol (2000) observed different ways in which the Zimbabwe bush pump (the
research object) is enacted from one region to another. At one site it is a hydraulic
pump, at another site it is a community pump. Each of these enactments involves
different networks. The practices around the pump as well as the identity of the pump
changes in these different networks. Using the example of atherosclerosis disease,
Mol (2002) has further argued against the perspectivism view. She contends that exploring an object from different perspectives does not mean that those perspectives are looking at one single object. Rather, each of those perspectives or research methods in our case generate a version of the object, which are linked to the other versions. The different versions of the object sometimes cohere and sometimes contrast with each other. As Law and Singleton (2005) suggest “difference is no longer a matter of different perspectives on a single object but the enactment of different objects in the different sets of relations and contexts of practice” (342). Law and Mol (2008) through the example of Cumbrian sheep, explain how different versions of the sheep do not suggest plurality. Rather these different versions are intricately linked and suggest a multiplicity of the object, which was the sheep in their case. Relating to the research object ‘occupancy’, this paper explores how different versions of 'occupancy' relate to each other.

Given that there is a possibility to enact 'occupancy' in multiple ways, it demands reflexivity on part of the researcher to attend the crafting of boundaries between presence, manifest absence and Otherness (Law, 2004). Mol (1998) articulated four questions to attend the ontological politics. Firstly, she suggested to explore the sites of the different versions of the object to understand the decision-making process of which version to foreground. In terms of occupancy, this question helps to explore how a particular method is chosen over the other. Secondly, she pointed towards the concept of 'interference' to explore the effect of a certain crafting of an object on other realities. It is not just the crafting of occupancy that is at the stake. The enactment of occupancy implies how other entities such as the building and the users are enacted as well. Thirdly, she questioned whether the different versions of an object are in fact discrete options. She suggested it not to be the case as different versions of an object are not mutually exclusive but depend on each other in different ways. This raises the question of whether different versions of occupancy are linked in any manner. Fourthly, she attended to the problem of how to choose between the different versions of the object. In case of occupancy, the question becomes which method gives a 'good' understanding of the occupancy and who should have a say in discerning that. Through the analysis of the findings from the different methods to study the occupancy of a library building, an attempt is made to address these four questions.

**Methods to Study Occupancy of a Building**

The University of Reading Library building is centrally located on the University’s Whiteknights Campus. The library opened in 1963 and has been undergoing phased refurbishments since 2012. Four methods are proposed to study the occupancy of the library building are discussed below: Wi-Fi-based indoor positioning method, ethnographic method, ‘sweeping’ method and archival method. The Wi-Fi-based method is discussed on the basis of a published study by Wang and Shao (2018).

**Wi-Fi-based technology**

Wang and Shao (2018) investigated the occupancy of the Knowledge Exchange room on the ground floor of the library building using Wi-Fi-based indoor positioning method. The data was collected for 30 days - from 27th May 2016 to 26th June 2016. Six Wi-Fi sensors were installed in the room to trace the movement of Wi-Fi-enabled devices. The data collected included latitudinal and longitudinal values of Wi-Fi devices, their truncated MAC addresses (to protect the privacy of the users), and the test time. The occupancy of Knowledge Exchange room was measured by analysing the duration for which a a Wi-Fi enabled device was present in the room.
Ethnographic method
I ‘shadowed’ library users to understand their practices of using the library building during 2013-14. Czarniawska (2012) suggested that “…shadowing consists of watching over people’s shoulders as they work and receiving explanations” (132). I shadowed and interviewed four library users: two undergraduate students, one postgraduate taught student and one postgraduate research student. The data amounted to observations for 8 hours and 30 minutes and 6 hours of interview recordings. None of the users were shadowed in the Knowledge Exchange room which was the room studied in Wi-Fi-based method. The users were shadowed in following locations of the library building: the second-floor study spaces, the first floor PC lab, the book-stack areas and fifth-floor study spaces.

Observational ‘sweeping’ method
In my ethnographic study of the library building, conducted during 2013-14, I observed that the library staff members often did a headcount of library users at certain times of the day. A member of staff would walk around the library areas, punching a counter and writing the numbers on a sheet of paper. This practice of library staff to measure occupancy was based on the number of people in the building. However, I was interested in a more detailed survey to understand user practices in various study spaces. Given and Leckie (2003) described the sweeping method to study social activities in a public library. They collected information on the users’ profile, possessions and activities. However, they did not link that data to physical space i.e. where those activities happened. Inspired from Whyte's (1980) use of sighting maps to study outdoor plazas, I firstly populated the building’s floor plans with all the study furniture. I then carried out observations at regular intervals from 17th - 23rd January 2014 and plotted dots on these furniture plans, each one representing an occupied seat. The areas studied by me were those to which I had access as a student. Hence, I could not study staff areas or other restricted areas. The data analysed in this paper relates to Knowledge Exchange room on the ground floor (the room studied in Wi-Fi-based method) as well as study spaces on the second and fifth floor of the building (the areas studied in shadowing method).

Archival method
In order to understand the changes in practices and adaptations of the library building over time, I undertook archival analysis of various documents pertaining to the library. The University Records Centre holds archives pertaining to the operations of the library as an organisation as well as records of the building. A data-set of 307 student responses from a survey titled ‘Survey of University Library use of Undergraduates’ dated 8th May 1969 was found in the archives. The responses were filled by University of Reading's undergraduate students who visited the library on that day. The proforma of the survey was created by the Library Management Research Unit, Cambridge. The key purpose of the survey appeared to be understanding the use of the books in the library by undergraduate students. The respondents were also asked to fill in the time of entry and exit from the building as well as the year of their study. This data could be inferred to understand the duration of occupancy in 1969 and offer a possibility for comparison to the findings from the Wi-Fi-based method. For the purposes of this study, 47 responses were deemed invalid as the data regarding the entry or exit timing were missing. Also, three responses did not have data regarding

2 The dataset can be found in Box 9, University of Reading Records Centre.
the year of the study. In addition to this dataset, I analysed other archival records from the University Records Centre to understand the issues around occupancy in the library building. All the archival sources are referenced in the footnotes.

**Multiple framings of occupancy**

*Occupancy - availability of seats*

In 1958, the Reading University Library’s initial building design stipulated 500 reader seats. This figure was based on a 1 seat per 4 students, with an expected student population of 2,000 in 1963.\(^3\) The ratio was deemed appropriate in comparison with the seating provisions made for other university libraries constructed at that time.\(^4\) When the library building opened in 1963, total seating provision was 583 seats.\(^5\) In the following years, as the University’s student population increased, the number of seats in the library were increased as well. In 1968, the number of seats in the library was 751 seats, which included all chairs, stools on the ground floor main hall and lecture room seats. However, by this time the student population had increased to 4000\(^6\), and thus the ratio of seats to student population was no longer 1:4. The gap has been widening ever since. In 2014, there were 1436 library seats\(^7\) for a student population of over 17,000\(^8\). However, the 2013-14 library refurbishments did not attempt to re-establish the original seating accommodation ratio of 1:4. Rather, the focus was to provide a variety of study spaces to suit different user needs. The number of seats was maintained in 1455, only slightly higher than the pre-refurbishment total.

Over time, the University’s student population has increased from 5000 in 1969 to over 17000 in 2014. Students often complain that seats are not available in the library. The situation is exacerbated during exam period which is generally spans from May to early-June. However, not all seats in the library are occupied at all times. The findings from the sweeping method demonstrate that at no time during the survey all the seats in the library were occupied. Wang and Shao’s (2018) discussion of representative days suggest that number of users at any given time on those days was less than 18. The number of seats in Knowledge Exchange room were 38.

The Wi-Fi-based method revealed that the peak time for occupancy in the Knowledge Exchange Room was between 15:00-22:00 pm. This finding complements the findings from the sweeping survey for the Knowledge Exchange Room which demonstrate higher occupancy of seats from 12:30pm onwards. However, the sweeping method, which surveyed other areas of the building as well, revealed that

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3 Minutes of the Curators of the Library dated 17th November 1958. University of Reading Records Centre Box 256.

4 A note dated September 1958 lists the new library buildings from four universities and the ratio of reading places to the students. The ratios ranged from 1:3.1 to 1:5. University of Reading Records Centre Box 256.

5 University of Reading (1964) New Library. University of Reading Library.

6 Paper ‘Future development of the Library: a report for submission to the Committee of Deans’ prepared by the Library, approved by the Curators of the library. Dated 16th October 1968. Box 595, University of Reading Records Centre.

7 Annual Review 2013-14, University of Reading Library.

occupancy in other study areas is much higher during this period. The occupancy demand in the Knowledge Exchange Room might be related to the availability of other spaces in the building. Thus, the demand for space in a building or part of it might be related to the availability of space in or beyond a building. This observation demonstrates the different craftings of the reality-in-here (Law, 2004). For the sweeping method the occupancy related to the spaces in different areas of the library building. On the other hand, the Wi-Fi-based method focused on one of the areas, the Knowledge Exchange room. Wang and Shao (2018) noted that future study could focus on monitoring which involves larger number and more types of spaces. This note might acknowledge the 'reality-out-there' (Law, 2004), which is manifested absence in the enactment of Wi-Fi-based method by Wang and Shao (2018). Moreover, the duration of presence was not investigated in the sweeping method. It could be considered as the 'Otherness' (Law, 2004) in the framing of occupancy based on this method. Similarly, the number of seats could be considered as the 'Otherness' of the Wi-Fi-based method. Rather than the occupancy in terms of occupied seats, the occupancy in Wi-Fi-based method was based on the number of Wi-Fi-enabled devices present and the duration of the presence.

**Occupancy - duration of presence**

They identified four patterns based on the duration of occupancy: observers (0.5-1 minute), intensive learners (0.5-1 hour), inspectors (those who returned once or several times for occupancy duration of 0.5-1 minute following an absence duration of 2-8 hours) and normal learners (those who stayed for a long duration of 0.5-1 hour followed by short absence duration of 10 minutes-2 hours). Wang and Shao (2018) found that the total amount of observers and inspectors (those who stayed in the room for a very short duration) was much higher than intensive and normal learners.

In comparison to the Wi-Fi-based method, the archival questionnaire data-set provides data for undergraduate students at a building level. The observation of pattern A is unique to the granularity of observation offered by Wi-Fi-method and no comparable data could be found from other methods. However, in relation to pattern 'intensive learners', the questionnaire data set revealed that only 13 respondents reported leaving the library building within half an hour of their arrival. Majority of the questionnaire respondents stayed in the library building for more than two hours. Wang and Shao (2018) also found that as the occupancy duration increased, the number of times a user was absent (probably taking a break) also increased. The archival data-set shows that students studied for up to 13 hours. While not all of those students noted the intermediate periods of absence, 11 respondents recorded multiple entries and exit times or a note indicating that they took breaks. This occupancy pattern could be related to the pattern 'normal learners' revealed by the Wi-Fi-based method.

Mol's (1998) first point pertaining to the ontological politics was to unpack the sites of decision-making when it comes to choose a particular framing of the occupancy. I choose to analyse the archival records to understand how recent the concerns were pertaining to occupancy. But this method is also dependant on the availability and preservation of archival records. Similarly, with the sweeping method, I was able to draw the floor plans as I have the skill to create furniture layouts owing to my architectural education. I am not well-versed with Wi-Fi-based method and the analytical skills entailed. Moreover, the Wi-Fi-based method depends on the possession of Wi-Fi-enabled device, the sensors and the Wi-Fi network. Thus, the decision-making regarding which version to foreground could depend on the skills of the researcher, the tools which are available and the kind of access available to the
data. The enactment of occupancy is related to a network of other entities which are involved (de Laet and Mol, 2000).

**Framing of occupancy interfering with framing of building and users**

During the shadowing of the users, I observed how users shared a laptop:

They begin working. User 1 reads notes on User 2's laptop … User 2 goes to get some prints. User 1 then gets up and goes somewhere. User 1 comes back and looks at the prints … User 2 goes down to buy a snack. He returns in five minutes … User 1 stands up … He wants to see if he can get a book. (Field notes, 30 May 2014)

The two users had one laptop which they both shared. During the duration of shadowing, the laptop remained at the study desk while the users took turns to go away from the desk. Thus, the Wi-Fi-enabled data might be affected by such user practices projecting the laptop-proxy user as the intensive learner, while the users might actually be away from the desk. Wang and Shao (2018) clarify that the Wi-Fi-enabled device serves as a proxy for the user and discuss the issue of a user possessing more than one device which might inflate the occupancy. While the Wi-Fi-based method did not collect any demographic data, the questionnaire analysis reveals that long-occupancy visits were made by students in second, third and fourth-years students. Moreover, 142 third-year students visited the library as compared to 24 first-year students, 93 second-year students and 24 fourth year students. Thus, the user in the Wi-Fi-based method is anonymous, while that in the archival method is rendered as a student of a particular subject and studying in a particular year. In contrast, the Wi-Fi-based method captures any person with a Wi-Fi-enabled device, whether that is a student or a member of staff.

Similarly, the building enacted by Wi-Fi-based method involved the presence of a Wi-Fi-enabled device. In this method, the enactment of the building is not linked to the seats. However, the sweeping method is inextricably linked to the seats and furniture. Any changes to the number of seats will affect the findings from the sweeping method. The enactment of building in the sweeping method accounts for the fluid nature of the building. There were instances during the sweeping survey when the furniture was moved by the users. These observations echo Mol's (1998) second point of stakes involved in choosing one version over other. The enactment of a certain version of occupancy in turn entails the version of user and the version of the building that is enacted. The implications of such dependencies might demand a reflexive approach towards existing BPE and POE methods.

**Are these different versions of occupancy mutually exclusive?**

Wang and Shao (2018) conducted an observational study to arrive at a value to approximate number of devices, which was integral to their algorithmic analysis. The findings from the unobtrusive observation method is thus 'included' in the findings of the Wi-Fi-based method. Wang and Shao (2018) suggested that during the term time, short-occupancy visits to the Knowledge Exchange room peaked during late-morning and lunchtime. In contrast, the long-occupancy visits peaked around 14:00-16:00. However, the archival questionnaire data-set reveal that for all occupancy durations, and especially long-occupancy visits, the arrival time between 9:00-12:00 was more frequent than other times of the day. In this instance, the findings from the two methods contrast despite the similar framing of the occupancy based on the time of arrival. It might because of the manifest absences involved in the framing of occupancy: the Wi-Fi-based method was limited to a particular room and the archival method only accounted for undergraduate students. Comparison between different data sets such as shadowing, observation survey and Wi-Fi-based data revealed the
intricacies of how the object of analysis for these different methods are connected. Shadowing data reveals the limitations of proxies for occupancy in the Wi-Fi-based analysis. This re-affirms Sailer et al., (2013) suggestion that both manual and automated methods add value in understanding user behaviour and could not substitute one for another.

The politics of enacting occupancy
As discussed by Law and Mol (2008), the methods framed the object of the study differently, which in this case was occupancy. Through the analysis of a questionnaire survey, the occupancy was analysed through the time of entry and exit from the building. For Wi-Fi-based analysis, the occupancy was analysed in terms of the duration that a Wi-Fi-enabled device was present in the Knowledge Exchange room. The observation survey analysed the occupancy in terms of whether a seat in the building was occupied or not. Occupancy in the Wi-Fi-based analysis was not dependent on occupying furniture but on possessing a Wi-Fi-enabled device. Occupancy in the observational study was based on occupying a seat and those passing or in motion were not considered. The findings from each method were limited in terms of the granularity, temporality or spatial coverage. The potential of combining big data and small data to understand user-behaviour in buildings is yet to be realised. The politics of enacting occupancy is not conclusive. It opens up several questions. How we might study occupancy to improve performance of the buildings? Is it a matter of asking the buildings users how they want to be represented in occupancy studies? Who should decide the measures to study? Such questions foreground the performative nature of methods.

CONCLUSIONS
In this study, the framing of ‘occupancy’ as a research object was explored using a range of different research methods. The findings suggest that each method frames ‘occupancy’ differently. However, these different versions of occupancy relate to each other in a variety of manners. Thus, it becomes critical for the study of building occupancy, and building performance in more general, to be attentive and reflexive about the agency of research methods in shaping the realities about which we theorise. Methods are not innocent set of procedures. Methods are a process of enacting and crafting realities. Methods are political.

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Patel


AN EXPLORATION OF NETWORK LEARNING CAPABILITIES OF COMMUNITY ENERGY ORGANISATIONS IN THE UK

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Community energy organisations have been credited for approaching the energy transition from three fronts. These are, addressing issues related to climate change, creating economic activity within local communities and social outcomes through the reinvestment of profits within their local communities. However, a changing external landscape has put their long-term viability into question. In response, community energy organisations have been growing more reliant on networks. This is perceived as a key way to engage in knowledge and resource sharing activities, thus through network engagement they ensure their survival and continued development. The aim of this study is twofold: Adopting an organisational learning perspective with a focus on network learning to understand how such a network is formed, and how it can evolve to create strong ties between otherwise unconnected organisations, as well as conducting an extensive review of previous community energy literature to identify key characteristics of community energy organisations, these characteristics are believed to contribute to the overall effectiveness of the learning and adaptation processes across networks and within individual organisations.

Keywords: network learning, low carbon transition, feed-in tariff, social enterprise

INTRODUCTION

Commitments to mitigate the effects of climate change have targeted the energy transition from three fronts. Addressing environmental concerns, ensuring financial feasibility and recognising social justice (Healy and Barry, 2017). The UK transition plan of 2009, a pursuant of the Climate Change Act 2008, highlights the key role which bottom up approaches by individuals, communities and businesses will play in the low carbon future (Seyfang et al., 2013). A holistic transformation of this magnitude would involve the co-evolution of several interdependent factors at all levels of the energy sector (Murphy and Smith, 2012) calling for major alternations in both demand and supply side practices.

Several disruptive innovations have emerged as a result of the proposed transition. Community energy organisations are one such example. They are formally defined as a form of collective action, driven by a common goal to reduce, purchase, manage and generate energy, in the form of electricity and/or heat (DECC, 2014; CEE, 2017). Incorporating a variety of initiatives, which target both energy demand and supply (Seyfang et al., 2013) for achieving a sustainable, decentralised and socially driven energy transition.

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Introduction of the Feed-in Tariff (FIT) scheme in 2010 provided an important financial incentive and promoted the uptake of low-carbon based bottom-up developments (Ofgem, 2019). Allowing for several community energy organisations to gain a foothold in the energy market as a result of government support. While a number of projects, especially newly found, are solely dependent on the FIT mechanism, reductions in tariff rates combined with its earlier than expected removal in 2019 (Ofgem, 2019) has led to increased volatility within this niche sector (Hillman et al., 2018). Although current projects are secure through a price guarantee, the overall growth of the sector has been hindered as the emergence of new organisations is now limited, which in turn has put the long-term viability of the community energy sector.

Against this backdrop, the community energy sector must now strategically adapt to the changing environment to ensure its survival. One-way community energy organisations have attempted to adapt to this precarity is through network engagement. Forming strategic alliances can be a way to facilitate resource and knowledge sharing throughout the sector, allowing for collective development of the community energy sector and ensuring that these organisations remain relevant in a wider energy transition.

The main question this paper is trying to address is whether network engagement and learning in a network setting are able to offset the negative impact of the removal of key financial mechanisms. It is believed that the defining characteristics of community energy organisations will play a vital role in determining the effectiveness of network engagement across the sector, as such, two aims guide this paper. These are identifying they key characteristics of community energy organisations through a thorough desk top search based on keywords and snowball sampling, and the adoption of organisational learning theory with a focus on network learning to explore how these key characteristics are mobilised in practice and how they contribute to the Network Formation and Effective Engagement.

Organisational Learning Theory and the Network Learning Perspective

Learning has long been recognised as a crucial aspect of organisational development. The emergence of learning as a theoretical perspective in organisational studies can be traced back to the seminal works of Cyert and March (1963:1992), which challenged the traditional, neo-classical, view of organisations previously put forward by Coase (1937). In summary, the theory of organisational learning differs from the theory of the firm in three aspects: Rational choice is substituted for bounded rationality, perfect competition is substituted with adaptation and the recognition that organisations change and evolve overtime (Cyert and March, 1992), and profit maximisation is substituted with organisational sustainability (Beauregard et al., 2015).

Organisational learning theory can be viewed as a method of inquiry into expected and actual outcomes. Where learning is a product of interactions, feedback processes and amendments to existing practices and structure's (Argyris and Schön, 1978). While this revised theory did not transform economic thinking, it extended the consideration to the microeconomic aspects involved within organisational actions.

By efficiently conveying information across individuals within an organisation, the acquisition, distribution, integration and creation of knowledge must be efficient at all levels within an organisation (Argyris, 1999). A combination of these factors will result in incremental changes in practices which ultimately lead to a more efficient and competitive organisation (Senge, 1990).
Traditional organisational learning approaches mainly focus around learning within an organisation (Argyris, 1999), giving a priority to social constructivist approaches at the micro and meso levels (Beauregard et al., 2015). It is recognised here that organisations are multi-levelled and complex, consisting of individuals and groups governed through rules, norms and culture (Senge, 1990).

While this view has allowed for significant developments in our understanding of the purpose and function of an organisation, Argyris and Schön (1978) suggest that a narrow view of organisational learning has oversimplified an otherwise complex world. Holmqvist (2003) furthers the argument by suggesting that intraorganizational learning distorts reality due to its unit of analysis, being the organisation itself. This does not allow for the consideration of external forces which influence and are influenced by organisational practices. Interactions between organisations, regulators and other agents constitute a large aspect of the learning process and therefore organisational learning studies must incorporate aspects of interorganisational interactions within their lens for further exploration.

Organisations are growing more interdependent. Collaborations exist on even the most central of organisational activities (Holmqvist, 2003). Such collaborations take on several forms, of which networks constitute a large share (Dyer and Hatch, 2006; Dyer and Nobeoka, 2000). Network engagement is believed to greatly contribute to an organisation’s overall ability to learn and adapt. Through pooling resources, information and practices, organisations are able to become more effective at responding to environmental changes collectively as opposed to individual approaches to adapt (Gibb et al., 2017). A change in the unit of analysis from intraorganisational to interorganisational learning allows for a structural functionalist approach (Beauregard et al., 2015) to organisational learning. Exploring learning processes between organisations (Weck and Blomqvist, 2008) and through networks (Dyer and Nobeoka, 2000).

Within the interorganisational perspective, a distinction must be made between its two main directions, these are: Learning between organisations (Argote et al., 1990) and learning through networks (Dyer and Nobeoka, 2000). Learning through networks, which is the main focus of this study, considers the network itself to be a learning entity (Gibb et al., 2017; Knight, 2002). Network learning can be defined as collective learning by a group of organisations (Knight 2002) with a shared goal and is considered to be achieved if the group’s behaviour, structure or practices are altered as a result of group interactions (Gibb et al., 2017).

Networks create both transactional exchanges as well as relational exchanges between parties (Teece, 1992) and thus facilitate the exchange of tacit (Holmqvist, 2003) as well as more explicit forms of knowledge. However, this does not automatically entail performance improvements (Knight, 2002) as increased competitiveness simply equips an organisation with the necessary tools to adequately respond to external forces (Dyer and Hatch, 2006). Learning can be seen as a set of incremental changes which accumulate and contribute to the overall long-term sustainability of organisations through a series of ongoing incremental adjustments as opposed to transformational, short term solutions.

**Changing External Landscape**

Subsidies and grants have both been major drivers of the community energy sector. These mechanisms have allowed for the sector to achieve a high degree of growth by insulating community energy organisations from external environmental pressures.
(Hillman et al., 2018), thus providing this niche sector with a safe space for incubation, development and the exploration of new forms of knowledge (McDowall, 2018; March, 1991).

The FIT mechanism was only intended as a short-term solution to encourage the uptake of low carbon projects. However, premature cuts in tariff rates as well as its removal in April 2019 have led to several spill over effects in the energy sector, which are especially being felt by community energy organisations. Increased perceived risk for potential investors and low financial attraction of the uptake of such projects are two examples of the negative impact caused by changes in the tariff. These effects are highlighted in figure 1, it can be seen that since the introduction of the FIT, the number of issued share offers has been steadily increasing, peaking in 2015 before a dramatic drop due to the announcement of the removal of the FIT. Its removal has left the community energy vulnerable to external market forces. Consequentially, the community energy sector must quickly adapt to new environmental conditions, otherwise it is perceived that they will be eliminated from the energy sector through market forces and environmental selection.

An organisation’s ability to adapt is dependent on several factors, these can be categorised as mechanisms for adaptation and they include willingness, capability and opportunity to adapt, each of which varies across organisations and depends on the respective characteristics shaped by its mission, culture and norms. For community energy organisations, these characteristics can be found when exploring their definition.

Exploring Key Characteristics of Community Energy Organisations

While the term ‘community energy’ has been applied to a diverse array of projects, different opinions and classifications of what the term should constitute have arisen. Walker and Devine-Wright (2008) attempt to address this through an all-inclusive approach, recognising that the reason for diversity is due to different degrees of prioritisation given to key defining characteristics of the term, based on the immediate needs of the respective community, this is illustrated in figure 2.
Network Learning Capabilities of Community Energy Organisations

Figure 2 (Adopted form Walker and Devine-Wright (2008))

Figure 2 attempts to highlight the defining characteristics of what the term ‘community energy’ should constitute based on previous literature around the topic. It can be seen that terms such as openness, participation (Walker and Devine-Wright, 2008), locality (Walker et al., 2007) and social drive (Seyfang, et al., 2013) in key aspects of employment (Hoffman and High-Pippert, 2010), decision making (Hicks and Ison, 2018) and ownership (Walker, 2008) constitute the main characteristics of community energy organisations.

These organisations tend to be socially driven and have the potential to deliver social benefits far beyond their environmental and economic outcomes to their respective communities (Hillman et al., 2018). Their democratic and participatory nature seeks to empower individuals and provide them with a platform to enter and engage and potentially influence an otherwise restricted industry.

It is argued that these defining characteristics, highlighted in figure 2, will greatly contribute to the ability of these organisations to further their cause and develop the sector, due to their organic like structure and approach to management (Burns and Stalker, 1961). These characteristics have shaped a strong collective vision of a sustainable and socially just energy future, and it is for this reason that they have been classified as a form of social enterprise operating within a wider energy sector (Becker et al., 2017; Hillman et al., 2018).

Networking as a Solution to Changing External Landscape

As a response to changing regulations and the removal of the FIT, the community energy sector must find a new means of support for further development. Child (1972) suggests that different organisational structures will determine the effectiveness and level of performance of an organisation in relation to external conditions and relationships with other organisations. This argument is further expanded upon by Burns and Stalker (1961) whom highlight modes of management as a key indicator of adaptive capability of a given organisation, suggesting that organic modes of management prevail when operating under volatile conditions.

Engaging in network related activities is perceived as a key way to respond and adapt to the changing external landscape. As it is an important aspect of niche development (Geels, 2011) it will contribute to the development of the community energy sector on
three fronts. Firstly, networks are able to connect organisations together, as community energy organisations are not natural competitors and they view themselves as a collective movement against the established regime, they will collectively benefit from cooperation (Teece, 1992). Secondly, networking allows for the pooling and redistribution of resources (Geels, 2011) and finally, networks facilitate the knowledge sharing process (Dyer and Nobeoka, 2000).

Community energy organisations have recently started to engage in such forms of cooperation. Through networking activities, they have been attempting to counterbalance the negative effects of the leaner external landscape. Community energy networks provide a number of services to their members amongst which include financial pooling of resources and other financial tools for trading energy as well as other forms of knowledge sharing mechanisms (CEE, 2019) to ensure the continued development of the sector. By bringing together several organisations across the sector, they are able to connect investors with new projects and struggling organisations with exemplars within the sector.

An example of network learning in the community energy case is the adoption of battery technologies. It was observed that a number of organisations started to engage in energy trading activities by adopting battery technology for peak time trading (CEE, 2018) as a result of network engagement. Hence, in this case the network is both a facilitator of knowledge as well as a learning entity as it was able to learn that by adopting battery technologies, organisations would then be able to store excess supply and sell during peak hours to increase profit margins. The network was then able to diffuse that knowledge into individual organisational practices.

A network however can only act as an enhancer of current practices, an organisation must already possess certain cultural, institutional and structural mechanisms for the accumulation and diffusion of knowledge (Argyris, 1999). Hence, these organisations are assumed to engage in learning activities as individual organisations through experience, based on routines (Cyert and March 1992), history (Levitt and March 1988) and goals.

Network Design

The Community Energy England network has been selected as the primary subject of this study. This network displays characteristics of both an extended network, with connections and involvement from external actor in the wider energy transition as well as a direct network, involving the community energy organisations themselves. A similar network structure to that described by Dyer and Nobeoka (2000) is followed, whereby a single organisation acts as a ‘hub’, whose role is to coordinate network activities and facilitate the transfer of knowledge. Unlike Dyer and Nobeoka (2000), the community energy network is not as knowledge intensive, whereby the main purpose of the community energy network is the collective development of the sector. Community Energy England makes clear that the purpose of their network is to ‘Support and accelerate the transition to a fair, low carbon and community-led energy system’ (CEE, 2019) indicating a prioritisation of a socially driven transition (Hillman et al., 2018).

In their study about a knowledge sharing network in the automobile industry, Dyer and Nobeoka (2000) identify three potential difficulties which may arise in a collaborative setting. Firstly, addressing the problem of participation and encouraging other organisations to share valuable knowledge. They argue that the most beneficial forms of knowledge are generally the kind of knowledge that organisations wish to
keep to themselves. Secondly, networks have the ability to create public goods and knowledge intended for the use of all network members. This could give rise to free-riding organisations whom seek to acquire the benefits of the network without contributing in return. Finally, to ensure effectiveness, certain mechanisms must be developed to maximise the efficiency of the learning processes and diffusion of knowledge across the network. As a network grows, it has to process more information and a challenge becomes identifying ‘useful’ and ‘beneficial’ knowledge and how then to convey it to the other members in such a manner that it is transferred and diffused within individual organisational settings.

Exploring the evolution of a community energy network can provide an empirical lens for investigating the underlying mechanisms which make learning in a network setting possible. Academics have long recognised the complexities associated with learning in an organisational setting, such complexities are only exemplified in a network as organisations not only have to coordinate internally but externally as well. Networks are susceptible to several problems such as free-riding and opportunism (Dyer and Nobeoka, 2000) and therefore eliminating these possibilities is of an upmost priority. Once these mechanisms are in place, and the network is considered to be developed and ‘mature’ we will expect to see community energy organisations changing behaviours, structure and practices as a result of network engagement. Hence, network learning will be achieved.

![Initial Network and Mature Network](image)

**Figure 3: Evolution of a community energy network - Adopted from Dyer and Nobeoka (2000)**

During the initial network formation stage, weak ties are displayed between participating organisations, they only display strong and direct ties with the network facilitator, in this case Community Energy England, as opposed to with one another. Attracting new members as well as building a network identify are some of the key processes involved during the initial network phase (Dyer and Nobeoka 2000). Community Energy England has attempted to build a strong identity by providing a unified voice for the sector, thus advocating for unity and cooperation as well as providing support for new market entrants (CEE, 2019). In this stage, only explicit forms of knowledge are exchanged.

In the community energy sector, sub networks exist based on activity, geographic location and financial tools (CEE, 2019) to ensure effective exchanges of knowledge, routines and resources. By creating several sub networks, the hub organisation ensures that any ‘useful’ forms of knowledge and best practices are stored within the network’s memory and can be made available to all members for their individual organisations.

A network is considered to be mature when strong ties are observed between member organisations amongst themselves and all members have a clear idea of what the goal of the network is and how they will go about achieving it, therefore several pathways exist for different forms of knowledge transfer (Dyer and Nobeoka 2000). As a result
of strong ties, the transfer the tacit knowledge is ample in the mature phase where it was almost non-existent during the initial phase. Problems such as opportunism and free-riding are also considered to be phased out, or at least minimalised, during maturity as any remaining organisations will have clearly demonstrated commitment to the network.

Thus, the network learning perspective explains that organisational learning by a single organisation is achieved through network engagement. Learning at the organisational level is therefore adopting practices based on knowledge acquired internally and externally (Dyer and Nobeoka, 2000). While both forms of learning occur simultaneously across several member organisations, best practices are quickly diffused across the organisations. In turn, such forms of learning will lead to a more competitive network, supporting the findings of Dyer and Nobeoka (2000) and Dyer and Hatch (2006).

CONCLUDING REMARKS

This study set out to explore organisational learning by a network of socially driven organisations operating within a wider energy sector. Community energy organisations have been negatively impacted by the removal of government led incentives, what was once considered a lifeline for the sector is now gone and these organisations have had to engage in network activities to offset these effects.

Through a systematic review of the literature, the main characteristics of community energy organisations have been identified. These characteristics include a collective identity, democratic decision-making processes, local ownership and local embeddedness. It is believed that these characteristics will greatly contribute to the overall ability of these organisations to adapt and thrive amidst a changing external landscape.

Developing a network from its initial stage to what can be called maturity has been demonstrated alongside the conditions and potential problems which the network may face during the development stage indicate the responsibility placed on the network coordinator to ensure that mechanisms are in place to facilitate the learning process. As the coordinator, Community Energy England must build and maintain mutually beneficial relationships with member organisations (Gibb et al., 2017).

It is concluded that the community energy sector is taking the necessary steps to ensure its long-term viability and that these networks will continue to grow and shape the collective movement, contributing to a decarbonised, decentralised and socially just energy transition.

REFERENCES


CHALLENGES TO EMBEDDING SOCIAL VALUE ACT 2012 IN THE STRATEGIC AND OPERATIONAL PROCESSES OF PUBLIC SECTOR CONSTRUCTION PROJECTS

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This research focuses on the Public Services (Social Value) Act 2012, which came into force in January of 2013. The Act appears to challenge the traditional perception of value and proposes to one that encompasses social, environmental and economic benefits to the communities these businesses operate. The Act has received some criticisms for being a soft touch as it essentially asks commissioners to ‘consider’ embedding the Act when making their procurement decisions and this flexibility has been attributed to the lack of its uptake by some Local Authorities. However anecdotal evidence suggests that some of these issues are stemming from strategic and operational processes with regards to how it is implemented in everyday practices. Therefore, this research seeks to investigate how the Social Value Act (2012) has been embedded into the strategic, operational and technical aspects of public sector construction projects. An explanatory case study approach, consisting of three case studies, specifically focusing on the Act’s applicability within a construction context, was used in this research. Facts and perceptions were collected from Local Authority policy documents and from senior managers representing four Local Authorities. Furthermore, a contractor’s perspective was also obtained from a specialist Social Value delivery consultant associated with one of the selected Local Authorities. Findings show that Local Authorities at the heart of this Act have welcomed the way in which it is not prescriptive. The flexibility of the Act was perceived to be an incentive and allows them to use the Act not just for procurement but other Local Authority functions. However, the Act is still surrounded by confusion with regard to specifications on delivery and this could be attributed to the lack of clarity on measuring Social Value outcomes.

Keywords: Social Value Act, public services, policy, local authorities, procurement

INTRODUCTION

The construction industry has been renowned for its inefficiencies, most notably for its procurement practices whereby most clients were intent on over-emphasising the acceptance of the lowest bid, effectively leading to key project delivery problems. There was and still is a call for the shift away from such practices as championed by Egan (1998) and to focus on best value. The Public Services (Social Value) Act 2012 appears to underpin this shift (Allen and Allen, 2015), thus challenging the traditional perception of value. It could be reasoned that the overarching validation for

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introducing the Social Value Act (SVA) was to change the commissioning practices adopted by Local Authorities (LAs) and not only ensuring that the ‘lowest cost’ practices are abolished, but also ensuring social, economic and environmental value is delivered to the community at large via this Social Value (SV) policy.

As claimed by Social Value Hub (2019), the SVA has been adopted by Third Sector Organisations and some LAs. This endorsement of the SVA is based on the potential positive outcomes it is anticipated to bring about. However, Boeger (2017) called for a review into the Act indicating lack of awareness issues associated with the Act and its non-prescriptive nature. It could be said, however, the apparent issues with the SVA for those LAs that have adopted it could possibly be stemming from a strategic or operational viewpoint with regards to how it is implemented in their everyday practices. The murkiness surrounding the Social Value (SV) philosophy can be due to the lack of its clear definition. While there have been attempts at defining the meaning of Social Value, it is probably applied or interpreted differently depending on the vantage point of the applier, be it end-user, contractor or commissioner. This ambiguity has left it open to various applications, reinforcing the problems apparent with its understanding, uptake, and operation. To ensure the SVA is truly achieving what it is intended to, there is a need for strategic planning, mobilising the strategy through intensive stakeholder engagement activities and finally operationalising the strategy on the ground, ensuring successful delivery. A ‘deepening’ of this policy might thus create greater accountability on commissioning and contracting authorities to proactively adopt it. These issues highlighted will, therefore, be investigated to attempt to unravel the principles versus practice and the overall perception of the SVA today.

LITERATURE REVIEW

The Public Services (Social Value) Act 2012 was introduced in the UK which defines Social Value as a concept that seeks to maximise the additional economic, social and environmental benefits to citizens and the community at large through how public goods and services are procured (HM Government, 2012). However, Social Value is an ambiguous term and is often interchanged with other related terms such as ‘social benefit’, ‘community benefit’, ‘social impact’, ‘social output’, ‘social outcomes’ and the broader concept of Corporate Social Responsibility (Raiden et al., 2019). Although the SVA has since been embedded in the procurement of the majority of UK’s public organisations, its purported benefits have been contested for various reasons.

In construction, the procurement approach traditionally emphasises on the lowest price to ensure the best deal for the clients. This practice effectively forces the contractors to lower their bid price but leads to many delivery problems such as over budget, delay and poor quality as contractors will attempt to maximise their own profits through cost-cutting and claims (Holt et al., 1995). Even though this price-based selection method can facilitate the creation of an objective criterion (Lo and Yan, 2009), Ruparthna and Hewage (2015) argue that such practice gives rise to adversarial and trust-lacking relationships which are detrimental to a project. Both Latham (1994) and Egan (1998) condemned this ‘lowest price wins’ philosophy. It also exacerbates the fragmentation in the construction. It has been agreed that the procurement in construction has not realised its full potential and there is a need for its continuous evolution (Oyogoke et al., 2009).
Clients have been known to choose procurement methods that have worked in the past (Miller et al., 2009), possibly due to the risk-averse nature in the construction industry. Trust-based relationships have a major influence on procurement decisions (Rees et al., 2012) because trust is a key requirement within the supply chain relations which can enhance the partnerships and effectively yield better results (Jelodar et al., 2016). Clients are therefore more inclined to engage with long-established suppliers. But in practice, partnerships tend to work more effectively when they are underpinned by voluntary trust-based relationships rather than those imposed by mandate or by competitive arrangements that undermine trust (Rees et al., 2012). This poses a challenge on the Social Value Act (SVA) as it is trying to achieve a new way of working that will no longer be based on long-standing relationships and trust but on the wider benefits for society.

The SVA stipulates that commissioners undertake SV assessments during the pre-procurement stages to ensure the greatest positive outcomes. It calls for a transition in procurement practice from the ‘lowest price’ or ‘trust-based relationships’ to a new way of procuring hence the neologism ‘social value procurement’. It is different from the traditional procurement practices in that it seeks to leverage extra social profits whilst creating ‘social value’ in the respective communities (Loosemore, 2016). However, this SV assessment is only conducted at the pre-procurement phase by involving prospective suppliers completing a set of pre-qualifying questions to demonstrate how they can deliver a specified element of SV prescribed by clients. Therefore, clients are still in control of their PQQ’s and can still manipulate these to work in favour of their preferred suppliers. Furthermore, Hampton (1994) argues that the pre-qualification process is biased against the minorities within the supply chain who are mainly SMEs lacking in financial resources. This casts a doubt whether the pre-qualification process is socially sustainable as it appears to somewhat work against exactly what the SVA is trying to achieve.

Although SVP aims to move from the traditional focus on the short-term cost savings, reduced rates and instantly measurable outcomes presented by established suppliers to the long-term and wider outcomes, there are obvious barriers including the lack of clarity when it comes to measuring and assessing SV, limited experience on the public sector’s procurement departments and limited organisational capacity (Barraket and Weissman, 2009). Newman and Burkett (2012) argue that the positive SV outcomes tend to be long-term and they are only achievable if the strategic benefits are felt from inception level through to implementation. Consequently, SVA requires that procurers identify the key aspects of delivering long term social, economic and environmental value to the community at large. The identification process is prescribed to be through stakeholder engagement to establish what the community needs from the project (HM Government, 2012), so the stakeholders can define and identify their local priorities of the communities. But in practice, the decision on a construction project is seldom influenced by the end users’ needs or preferences. This is because the community in a construction project is predominately perceived as a liability as opposed to being an asset with regards to project delivery (Close and Loosemore, 2014). Reinforcing this school of thought is the claim that at the project level, the hype associated with these social initiatives is not seen through the operational stages (Boeger, 2017).

While significant progress has been made in the environmental aspect of construction projects, social issues are normally relegated to a distant third priority, a long way behind economic and then environmental objectives (Loosemore, 2016). This
philosophy is underpinned by the format and structure of the PAS91 (BSI, 2013), the standard Pre-Qualification Questionnaire (PQQ) adopted by most LAs as part of a contract tender submission to be fulfilled by the prospective contractors. While Supplier Identity, Financial Information, Business and Professional Standing, Health and Safety Policy and Capability are the mandatory ‘Core’ questions, the rest of the questions wherein SV is optionally asked are termed as ‘Other’ questions, effectively, additional SV requirements are notably inserted as addendums within the PQQ. This clearly shows the social aspects in construction contracts are mostly perceived to be peripheral in comparison to the other tender requirements.

Most contractors are in business for a profit which is derived from their primary construction project objectives. With the SVA, they are required to fulfil certain extra obligations as a basis of securing a contract. This means the LAs are looking to obtain value but at the expense of the contractor and its supply chains who have to deliver these secondary obligations whilst also delivering over and above their hard deliverables, the primary contract to build. The construction market is extremely competitive which in turn leads to small profit margins. This raises the question if this practice can be sustainable and allow respective organisations to thrive. With regards to the operational process for delivering SV in construction projects, it appears that it is not clear who is responsible, how and by whom that delivery is managed, within what time frames and what benchmarks to explicitly determine the delivery of SV for a construction project. This raises the questions of whether the SVA is merely being added on as an afterthought or it is fully entrenched in the whole procurement process within public sector projects.

In order for the policymakers and public organisations justify their spending decisions and funders seek transparency on how to direct their money for the most effective projects, SV outcomes have to be measured. But this can be problematic due to the lack of a single authoritative definition of SV (Wood and Leighton, 2010), as a result, some non-financial SV outcomes such as wellbeing, environment and social capital are difficult to quantify and therefore have been seen as ‘soft outcomes’ (Dewson et al., 2000). Although some measurement tools such as Cost-Benefit Analysis, Key Social and Cooperative Performance Indicators and Social Return on Investment (SROI) have been attempted for measuring SV outcomes, there is no one standardised single method. While it is important that LAs can have the flexibility to develop their own SV measurement tools to fit their specific needs, too many methods can also unintentionally create confusion and inconsistency with understanding what and how to measure and restrict LAs from being benchmarked against any other organisations. Operationally, quantifying SV is an arduous task, often requiring creating a new role and intensive staff training. This inevitably results in LAs opting for SV activities that have easy metrics for success (Wood and Leighton, 2010). If the measurement activities are time-consuming and costly, then this whole activity outwardly takes away the rationale behind the whole process, seeking value.

**METHODOLOGY**

Case study approach was used to collect data for this study. Keeping LAs as the unit of analysis, this research focuses on finding out how the SVA has been embedded into public sector construction projects. Four LAs were selected based on accessibility, size and social value provision. However, due to page limitation, three case studies and their findings are shared in this paper. Semi-structured interviews and LA policy documents were used to capture data from each LA. At least two individuals from
each LA were interviewed to understand LAs’ attempt to provide SV. Interviews were conducted with those in managerial levels within their respective organisations. The rationale for specifying the sample type was that they are predominantly hands-on and key players within the implementation of the SVA frameworks by which their respective procurement policies are based on. These participants are also greatly involved in setting out and driving the operational requirements as dictated by the SVA to the corresponding contractors. It was reasoned to be also beneficial to capture the contractor’s perspectives on the Act, and an interview was secured from a specialist contractor’s consultant who specialises in the operational aspects of the SVA and has historically worked with LA1. The Table 1 provides a summary of presented data for this study.

Table 1: Case study data

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Interviewees</th>
<th>Document reviews</th>
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<tbody>
<tr>
<td>LA1</td>
<td>1. Procurement framework manager</td>
<td>1. Procurement policy</td>
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<td></td>
<td>2. Strategic category manager for construction</td>
<td>2. National procurement concordat for SMEs</td>
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<td></td>
<td>3. Category manager for health and social care</td>
<td>3. Benchmarks for infrastructure social value</td>
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<td></td>
<td>4. Contractor specialist consultant on Social Value</td>
<td>4. Tailor-made employment and skills strategy</td>
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<tr>
<td>LA2</td>
<td>1. Procurement manager</td>
<td>1. Social Value policy</td>
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<td></td>
<td>2. Social Impact manager</td>
<td>2. Social Value charter</td>
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<td>LA3</td>
<td>1. Procurement manager</td>
<td>1. Social Value statement</td>
</tr>
<tr>
<td></td>
<td>2. Procurement controller</td>
<td>2. UK sustainable development framework indicators</td>
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Organisational Context on SV Related Activities

Case Study 1- Local Authority 1 (LA1):
LA 1 is based in the West Midlands and one of the most affluent areas outside London, serving a population of just over 200,000 with a higher nominal Gross Value Added (GVA) per capita and most residents having a larger disposable income than the UK average. LA1’s approach to procurement is underpinned by a Procurement Policy which is implemented alongside a National Procurement Concordat for SME’s. LA1’s strategy to entrench their Sustainable procurement policy is via a Client-Based Approach, which emphasises the development and implementation of Employment and Skills Strategy in construction projects. The project budget will set the project specific requirements in terms of what is expected of the contractor to fulfil, the philosophy is that as these employer-led benchmarks for employment, skills and apprenticeship delivery are weighted against procurement lot sizes of £1 million going up thus making them accessible to the SMEs in the way of promoting local supply chains. Thus, the prospective suppliers are supported by this information to enable them to deliver the SV outcomes as per contractual requirements. In driving this approach, they have formulated an Employment and Skills Strategy, which is a tailor-made strategy supporting contractors in delivering the best value in ‘price and non-price’ aspects of the tender.

Case Study 2- Local Authority 2 (LA2):
The LA2 business charter for social responsibility sets out key principles in a bid to boost the local economy through maximising its SV. This is facilitated by the LA2’s £1 Billion purchasing power through making this money work to improve the citizens of this authority. This means is any commissioning and contracting decisions will incorporate the principles set out in the charter to ensure the creation of employment
opportunities, supporting local supply chains and fair wages for contractors’
employees that are associated with the policy. LA2 has a SV policy (from 2016), in
which it illustrates concisely their expectations from signatories of this charter.
Current and future suppliers were therefore urged to accredit themselves to the
charter, which will, in turn, commit the supplier to deliver the principles by fully
adopting the Charter into both existing contracts through addendums and future
contracts. In order to bid for new work, the supplier must, therefore, provide a
Charter registration number, if this is not available, they should comply with an action
plan that ensures that registration will be complete within a clear time frame. LA2’s
SV Policy reiterates the Government’s definition of SV showing no attempt in
interpreting the SVA for LA2 works.

Case Study 3- Local Authority 3 (LA3):
LA 4 is a Metropolitan Borough Council located in the West Midlands, the Black
Country area with a population of just over 300 000 across 24 wards. Upon
attempting to collect SV related documents available on their website, it became
apparent that they do not highlight the SVA in any of its publications plus its
procurement related data is limited. What they do have is a slightly simplistic ‘myth
buster’ which states their ideals when it comes to assessing ‘best value’ when
awarding contracts. Their stance is not only to consider economic factors but also
social and environmental factors. Similar to LA1, tenders are also scored against a set
of criteria and weighted accordingly by the tender panel ‘the organisation with the
highest score wins the business’.

FINDINGS AND DISCUSSION

Embedding Policy

HACT (2015) emphasises the need for Public Sector commissioners to be clear in
what it is they want to achieve particularly in the pre-procurement stages to embed SV
policies into their strategic objective. Interviewee 1 from LA1 emphasised a similar
approach stating, ‘it’s about getting the commissioners to instil this into the
stakeholder’s minds much earlier on into the process so they start thinking of how
they can deliver SV’. However, the analysis shows that LAs appeared to rely heavily
on charters, SV Action Plans or Sustainability frameworks for this purpose. For
example, LA2 has mandated that all parties privy to a contract for works must be
signatories of its SV Charter. Interviewee 2 from LA2 stated that ‘SV require
ments
on their tenders
is
weighted at a minimum of 10%; however, for construction
projects,
this may be higher particularly around jobs and skills’. On further probing, the
respondent stated that weighting was anything between 10-45% for construction
projects. On the other hand, LA3 has been using Sustainability Impact Assessment
Tool, which is an outcome driven framework, utilised to assess the Borough’s needs
in terms of priority to drive SV. Interviewee 1 from LA3 mentioned ‘…council
makes use of Sustainability Impact Assessment tool to make decisions based on
guidance in the UK SD Framework indicator’. However, these frameworks have been
interpreted differently by individuals from LAs especially when relayed to the
contractors. Mainly, LAs have struggled to clearly articulate and incorporate the
policy into their core procurement strategies. This fuzziness or lack of clarity could
be owed to the lack of a clear understanding and or definition of the term SV for each
respective LA.

Furthermore, the implementation process appeared to be overlooked by LAs; all LAs
confirmed that it is left up to the contractors’ project manager to ensure that delivery
is as planned. This differs from HM Government’s (2012, p.27) proposal for the parties “…to work together to work out how service delivery can be enhanced in collaboration with each other as well as service users and other stakeholders...”. The main reason for the lack of client involvement was echoed by most respondents to be the lack of resources. At present, most LAs need to consider ensuring the resources are available to conduct operational activity because as it stands only the larger LAs stated that they had specific Economic Development departments that oversee the delivery. Whilst this may be commendable, one respondent mentioned that these Economic Development departments are not well versed on the procurement process let alone the SVA to be able to efficiently manage the delivery process. Another common theme that was highlighted from this research was the involvement of elected Cabinet Members, who are highly active during delivery and monitor and try to ensure that purported SV has been created post completion. They are therefore ensuring that commissioners and contractors alike are delivering the purported SV as demonstrated by the strategy and contract award requirements. Whilst this is an admirable activity on the Councillors’ side, it is worrying how the commissioning bodies do not chase up on a process that they would have instigated. This area of SV can be perceived to be an area where commissioning bodies can improve because it is unclear whether the SV is being delivered as per the specification of the client. On further probing Interviewee 2 from LA3, interviewee responded ‘… we really aren’t involved if I’m honest, we sort of leave them to it and hope for the best’. Based on the findings it is fair to note that procurement contract is still being treated as an end of the SV delivery process as there are no logically set pathways or plans implemented by the LAs to monitor how the above targets are met and satisfied. Interviewee 1 from LA3 acknowledged ‘nobody wants the responsibility of overseeing what happened post-procurement’ and suggested to revisit a project 6 months later to complete a post-completion review.

**Supply Chain Selection and SV Capabilities**

Furthermore, it emerged that commissioners would ideally prefer to work with a contractor with whom they have long-established relationships. This notion is largely based on trust and reputation of that contractor and palpably does not consider their ineptness to deliver the SV. This fact supports Jelodar et al., (2016) who purport that trust, therefore, enhances the partnerships and effectively yields better results. It can, therefore, be argued based on this notion that through previous experience, mitigating risk whilst attempting to maintain reputations, the clients will generally be more inclined to engage with long reputable contractors. This is supported by Rees et al., (2012) who argued that in practice partnerships have tended to work more effectively when they are underpinned by voluntary trust-based relationships rather than those imposed by mandate or by competitive arrangements that undermine trust.

Most of the respondents echoed that the SVA has not directly influenced the way in which the bids have been coming in. This finding differs from Loosemore (2016) who states that the future of procurement will be led by contractors fulfilling the ‘social credentials’ demonstrated by the PQQ. Findings suggest that trust-based client-contractor relationships outweigh their social credentials; this is because clients consider underlying requirements such as H&S, insurance and competency before any SV requirements. Respondents pointed out that even if a contractor fails to achieve the promised SV as per contract, they are not to be oversighted in the next procurement cycle for that reason as this is against EU Procurement law. It shows that clients will still envisage working with the contractor who has failed to satisfy ‘social
credentials’. The common consensus with the interviewees across the LAs was the fact that the SV policy was still new, and most contractors were not familiar with the concept. On this note contracts are still awarded regardless of this lack of awareness and the Public Sector argues that they will ‘support’ contractors to ensure that they achieve this value. On analysing the interviews, it became apparent that clients are willing to ‘work with’ contractors that they know will deliver primary project objectives in ensuring they can furthermore satisfy the SV requirements. What this could mean is that the SMEs that have not yet set their own reputations in the market will still find it a challenge by having to compete against the mainstream contractors who are to receive additional support to ensure they deliver. This argument poses a challenge on the SVA and what it is trying to achieve as a new way of working that will no longer be based on industry norms but on the wider benefits for society. Having failed to do so makes this a weak policy that is being overshadowed by existing practices and has thus not achieved or made a significant impact on procurement practices.

**Non-Prescriptiveness Nature of the Act**

Low uptake of the SVA with only 25% of the LAs embedding SV aspects in their procurement strategies (Burke and King, 2015) have been owed to the lack of prescriptiveness in the Act. Boeger (2017) proposes the SVA to be more prescriptive and set down as legislation. In contrast, the findings show that most of the respondents welcomed the ‘flexibility’ within the act. The main rationale was that it gave them ‘give’ on how to implement the policy and tailor it to suit their strategies. In contrast, the LA1 contractor indicated that LAs can impose some form of penalty on contractors that do not consider or attempt to implement SV as required when submitting their tenders. However, this idea was not supported by LAs. Once again, the main reason for this associated with the existing relationships between the clients and contractors that are predominantly based on trust. This reasoning leads back to the notion on trust-based relationships over any form of mandate. On the other hand, most LAs pointed out that lack of uptake was predominantly due to ‘lack of resources’ as well as the size of the LA in question, with the small LAs having even tighter constraints on resources and were therefore not as keen on embedding the Act yet. This is unfortunate because smaller LAs are more engaged with their local communities which are tight-knit and delivering SV would have been an easier and most rewarding task.

**Stakeholder Engagement and Measurement Tools**

The SV Procurement Note (2012) and the HACT (2015) Social Value Toolkit place emphasis on the importance of Public Sector clients in engaging with the communities as they shape their SV strategy through those they serve. Findings show that the decisions are mostly up to the project commissioner and communities are consulted as opposed to shaping the SV outcomes. Most of the stakeholder engagement activities were carried out between the client and suppliers which is likely another result of the way in which the Policy is not prescriptive and somewhat allows the authorities to translate stakeholder activities in the best way they see fit. On the other hand, Barraket and Weismann (2009) highlight that this vagueness in the concept creates challenges in ensuring SV is defined and delivered. The findings show that most LAs measuring SV provision by utilising tools such as ‘lessons learnt’ or cross-checking with their KPI score sheets. Whilst this might provide some sort of picture it still does not quantify the outcomes. Dewson et al., (2000) suggest putting a monetary value on
social aspects is complex as these are subjective outcomes and therefore immeasurable.

CONCLUSIONS

The findings of this study show the importance of socio-economic impacts triggered by the industry. As Myers (2013) points out, economic growth signals higher societal needs such as essential infrastructure and housing needs. Through recognising the domino effect in societal needs initiated by the industry, it is only reasonable for the construction sector to be at the forefront of fulfilling SV to the respective societies. This could potentially improve the image of the industry. However, the issue of embedding SV is more to do with ensuring that there is a mutual understanding across the supply chain, and all stakeholders are working towards the same measurable outcomes, via agreed methods and monitored mutually.

This research shows how some LAs have become innovative in obtaining societal value and have used procurement and planning processes to ensure SV provision. This flexibility is also supported by the Act’s lack of prescriptiveness and non-legislative application, meaning the LAs could potentially do more with the Act with no overarching restrictions. However, measuring SV still remains an issue for LAs. Furthermore, due to the lack of resources LAs have partnered with voluntary third sector organisations to manage the SV delivery process. SV Procurement Note highlights the necessity for LAs to work in partnership with contractors to manage delivery. Perhaps the fact that it does not stipulate ‘direct partnership’ allows the under-resourced departments to facilitate sub-partnerships now between the contractor and voluntary sector organisations. With no penalties implementing the policy appears to be the ‘right’ thing to do. When not subscribed, it has a negative knock-on effect from the client to the contractor and then to the community that will eventually miss out on obtaining value. However, findings from this study show that the ‘soft’ touch in which the Act is set out is advantageous as it allows most authorities to utilise its flexibility to benefit other local priorities and maximise the potential of the Act.

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THE WORK OF GREATER ABSTRACTION IN CONSTRUCTION

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The built environment is literally and metaphorically concrete. However, the creation of the built environment from conception through design and construction involves many degrees of abstraction. This contrast of existence between concrete and abstract is complex and unexplored in construction but, it will be shown that, a deep understanding of this is required to make successful buildings in a modern age of building information modelling. Abstraction is the simplification of an entity with a degree of generalisation of purpose and causality. Abstract entities like mathematics have a great distance to the concrete. This paper unpacks the nature of abstraction in the creation of the built environment through a series of short vignettes of practice; considering drawings, project planning and building modelling. Each uses abstraction in a different way and this use has been developed over time to accomplish the physical activity of designing and constructing. The tasks require the abstractions being presented in representations which in themselves further abstract the original intent. These representations are assumed to be useful, not just to the individual creating them, but also to the social organisation that is involved in making the greater purpose of the building. Thus, abstraction becomes a key aspect of making buildings. This is of growing importance because of radical technological changes in design and construction practices; including the adoption of BIM. BIM involves multiple levels of abstraction and separates data from the representations. Using themes of loss of meaning, loss of control and loss of understanding of process, it is concluded modern construction practice, requires not just learning software tools, but an education developing critical skills for handling abstraction.

Keywords: modelling, representation, practice, learning

INTRODUCTION

There is a degree of irony that the philosophical opposite of abstract is concrete. This metaphor of concrete references the construction industry (cf Bröchner, 1990) and means drawing together of conglomerates to form a hardened mass. However, the distinction between abstract and concrete is important both in knowledge terms but also in social terms (Rosen 2018). Concrete embodies the idea of practicality and being relevant to action whereas abstract suggests a distancing from practice (Back 2014). This distinction is not absolute being dependant on context and subject. Socially the cognitive ability to engage in abstraction is regarded as part of the development of a child (Piaget 1929) and so abstraction is taken as a superior activity. The ability to think abstractly provides the ability to transfer knowledge from one context to another. It is in this activity that theory is conceived which connects abstract entities to establish connection or even causality. The most abstract level of
theory may be referred to as grand theories which can be universally applied. Whereas micro-level theories connect specific observations in practice.

The move to a modern world has produced great changes in thinking away from religious scholastic purity to empirical observation and most recently to a universal concept of information (Gleick, 2011). Abstractions is involved in all thinking but the use of this for practical and commercial purposes is recent. Thus, McAfee and Brynjolfsson, (2014) promote the new high levels of abstraction involving machine intelligence, big data and the sharing economy, for business.

The idea of abstraction in construction has been discussed in many forms but here the encroachment of a more abstract world through BIM will be explored. This will be initiated through studies of language and action which brings out the difficulties of generalisation. The ability to design is in itself a use of abstraction and buildings are a demonstration of success of this human ability to connect abstraction to the concrete. However, the rise of modernity, involving science and technology, leads to developing systems of abstraction. Taking these ideas, three construction activities are studied: design drawing, time programming and BIM modelling. Each demonstrates a developing abstraction. Three themes emerge from this; the loss of meaning, the loss of control, and the hiding of process. These problems are fundamental to our modern practices and the limits of abstraction need to be better understood.

**Background to Abstraction**

Abstraction involves the way we think; thus, it controls our outlook and engagement with the world both physically and socially. This review considers some aspects of the development of the use of abstraction in thinking and action.

**Language in Thought and Action**

As Hayakawa (1990) states 'this process of abstracting, of leaving characteristics out, is an indispensable convenience'. It involves finding a general term to refer to a number of examples of specifics. Hayakawa (1990) cites Korzybski (1933) in presenting a Hierarchy of Abstraction. Korzybski (1933) derived a theoretical view of the use of human knowledge through his general semantics involving a consciousness of abstracting to provide a powerful tool of analytical thinking and action. The hierarchy involves creating a set of levels from a specific example upwards to increasing degrees of abstraction. In order to make abstract thought into action then we need to come down the hierarchy to operationalise the abstract concept. As Hayakawa (1990) muses this is seldom done explicitly and often arguments are confined to levels of abstraction where they are merely principles and there are great jumps in assumptions of meaning. Language is driven by such abstraction which allows us to obfuscate. Thus, words are abstract, and they are not the thing they refers to. Many have looked at the symbolic nature of language and distinguished between signifier and the signified of objects (e.g. Pierce 1931-36). It is this that gives meaning to abstraction in art where gross simplifications represent meaning in the learned eyes of the viewer. Pierce (1931-36) distinguished 3 types of signs: icons which have a physical resemblance to the signified; an index which shows evidence of what’s being represented; and symbol which have no resemblance between the signifier and the signified. For symbols such as numbers the meaning needs to be culturally learned. This problem also occurs in computer programming where the 'symbol grounding problem' (Harnad 1990) shows the limits of the overtly abstract nature of information systems and how they struggle to connect to reality.
The Work of Greater Abstraction

Visual Abstraction in Design
The use of iconic signs in drawings is the basis of building design (Lidwell et al., 2010). Drawings are a composition of iconic representations that together form an abstract representation of a whole. This use of drawings and abstractions is centuries old and it is impossible to dissect the interactions between design creation and design representation. Latour (1986) sees the use of sketches as incomplete, but staging points in design, that involve the abstract essence (form, space, rhythm etc.) that the designer has in their imagination. Latour (1986) sees drawing requiring immutability and mobility to give them meaning socially; however, also argues that there are two functions of ‘paperwork’ firstly (quoting Heidegger) that drawing ‘thinking is hand-work’ giving affordance to the minds-eye and secondly as social, the communications and control of design. This control results from descriptive geometry which allows three dimensions to be represented in two dimensions and visual abstraction allows the control of universals “by working on papers alone, on fragile inscriptions that are immensely less than the things from which they are extracted” (Latour 1986)

Systems of Abstraction
A number of authors have seen abstraction as the key feature of working in the modern world. This takes abstraction not just as a single aspect of thinking but as the move from a pre modern to a modernist construction of the world. Fundamentally as Saitta and Zucker (2013) state “Abstraction is a fundamental mechanism underlying both human and artificial perception, representation of knowledge, reasoning and learning”. Thus, the choice of simplification made in abstraction is not neutral but a political choice to prioritise some features over others and this choice is always made by power interests. Baudrillard (1994) takes such ideas further and deconstructs simulation and simulacra as abstract systems governed by power interests. Simulation being the abstract representation of systems to perform as the system. Whereas simulacra is the substitution of reality by a simulated system. Baudrillard (1994) states:

Today abstraction is no longer that of the map, the double, the mirror, or the concept.
Simulation is no longer that of a territory, a referential being, or a substance. It is the
generation by models of a real without origin or reality: a hyperreal.

These ideas have been used by Grandy and Mills 2004 to analyse strategy in organisations. Abstract strategic models are very similar to the forms of planning of buildings that are considered in this paper; which Grandy and Mills 2004 critique showing "reality having been replaced by hyperreality”.

Other work on simulation also critiques the change in thinking that hyperreal models require. Leonardi (2012) analyses the change in thinking about the design of safety in cars now done substantively through models rather than through testing. There is a problem revealed which sees the limit of trust in abstract complex models to the extent that they change the way organisations work. Turkle (2009) goes even further and observes a change in thinking whereby young technologists trust the code whereas older ones want to see the code before trusting the answers. Thus, simulation is used for a different purpose in the new hyperreality, it is used to direct actions and have control whereas before it was used to merely understand situations.

METHODOLOGY
This paper is a critical analytical discourse based in a critical realist view of the world following Mingers (2003). Thus, reality exists but it is only known about, analysed
and reported from a socially constructed perspective. This paper involves a reflexive investigation into the socially constructed perspective of abstract design artefacts in order to facilitate the surfacing of their greater meaning and to question the underlying assumptions. This is particularly important as we move to a more digital world that is effused with positive rhetoric and commanded by vested interests, making it very difficult to determine truths and alternative ways to move forward. Thus, there is a deeper question about whether our digitally modelled world is a form of hyperreality that is undermining thought about the realities of construction.

To undertake this critical analysis, three examples of real-world design artefacts have been chosen: traditional drawings, construction programmes and BIM models. It is contended that these represent changes over time in the way we think about and act in constructing our future buildings. Following Grandy and Mill’s (2004) deconstruction of management strategy, these design artefacts are discussed through the language of abstraction, representation and simulation. The choice is not representative nor is there an intention to prove or even show a better reality but merely to disrupt the current discourse so that we can see the possibilities of a different view than is currently dominating construction. This is done solely from the researcher’s perspective.

Examples of Abstraction

Design Drawings

Drawing is often seen as a language. In that sense it has elements and structure equivalent to words and sentences and narratives. The purpose of language is communications and working together collectively. However, the purpose of drawings is more complex. Bafna (2008) makes the distinction between notational and imaginative function of drawings. The first is the technical drawing where “pre-specified elements are matched to their pre-specified referents” Bafna (2008). The imaginative drawing has low syntactic density and high semantic density which is used to provide greater meaning in the observer; this is the position of an object of art. Indeed, sketches have this imaginative character.

The building drawing shown in figure 1 is a conventional example that could have been produced by hand or by various forms of computer. It is a plan which is a horizontal section through the imagined building, thus is a projection of important features onto a 2D plane. It follows the rules of technical drawing based on descriptive geometry. This output then has a number of characteristic abstractions. Firstly, the main abstraction is geometric, and this is iconic in that it is a scaled representation of the space created by walls. These walls are themselves iconic however their representation is less complete than the geometry in that the internal composition has been idealised and does not show e.g. internal surfaces such as plaster. Many other features are extremely abstract or have been omitted but may be included in other drawings. Items such as stairs do not represent reality strongly but follow convention.

It is clear that much is missing technically from this representation, but this is necessary to avoid complexity and make the representation understandable. This missing technical information is commonly dealt with by having a suite of drawings each showing different aspects plus a textual specification. This fragmentation of representations gives rise to the problem of coordination and the need for integration. BS1192 sets a standard for this information and coordination by fixing naming and coordination requirements but does not recognise the different requirements of
abstractions used by different roles. Drawing information is assumed so abstract that it is ubiquitous and universal rather than something that is to be learned and interpreted.

This abstraction of ideas and affects that are imbued in buildings are not represented in technical drawings. Thus, an understanding of what is also missing in drawings such as Fig 1 is key to working with drawings. This includes technical aspects such as materials and constructional junctions but also, more complicatedly, human aspects. Attempts are made to represent some of this in isometric and artistic representations.

Figure 1: Conventional construction drawing

The role of drawings tends to focus on the finished product; however, the production of the drawing also determines this finished product. Similar to the imaginative qualities, drawings are an expression of the imagination and are involved in thinking about buildings and building. This role is embedded in the final drawing as it is more replete and correct. Drawing then are part of an intermediate production which is used for testing of the imagination. They are particularly good at testing 2D geometry when done to scale. Sketches are also useful for testing form and massing. Thus, the affordance that drawing provides for thinking about buildings is critical to being able to conceive complex buildings. In addition, the tools of production, initially pencils, rulers, squares and compasses enable particular forms and make others more difficult. They are additional determinants of abstraction. However, what can be seen by the architect/engineer as they draw and develop their understanding, may be less clear to someone else; that is the thinking processes of production are abstracted out and it is left to convention and the skills of the viewer in re-composition of the thinking. Indeed, Booker (1979) states even with multi-plane orthographic views “the interpretation of drawings, in which one object is represented by a number of pictures, is a difficult matter sometimes even for those with considerable experience”.

Construction Programmes

The construction programme shown in Figure 2 has a different level of abstraction to the representation of geometry shown in Figure 1. It is still an iconic abstraction in that it directly relates to what is being represented but it is a metaphorical relationship. Thus, time is proportional to the length of a bar and activities are discretely identified. Thus, one key aspect of this abstraction is the belief in the discreteness of activities, which of course are not possible in practice.

The idea of linear time is also a problematic abstraction although a foundation of modern science. In the past much time was circular and certainly phenomenological
time is not experienced linearly because of our awareness of critical moments to get things done (Boyd and Madzima, 2017). Chan (2012) sees a sense of time being structured socially to experience productive and non-productive periods, and referencing Henri Bergson, rejects ‘the causality of time’. This challenges the degree to which rational planning can be achieved in practice such that it is ‘the way time and temporalities are conceptualised and mobilised in organisations’ that determines success not the accuracy of the abstract rational planning (Chan, 2012).

In fact, the tool of time planning, as demonstrated in the construction programme, can be seen as an exercise in power rather than in just assisting construction. It is a critical aspect of contract certainly in sub-contracting being used to both direct and to show compliance. Planning is a top-down activity which is seldom challenged on its assumptions/simplifications about resources required to deliver the construction programme. The programme is also a tool of determining productivity, a further abstraction which has become symbolic of the failure of the construction industry (McKinsey 2017). In this productivity abstraction it becomes possible to compare the construction industry with the financial industry as if they were similar activities.

A further abstraction is that the programme is used for payment. Thus, this purpose is unacknowledged in the operationalisation between money, time and activity. This induces behaviour to secure more money earlier, such as front loading, hiding the meaning. Equally the completion of activities can be questioned to prevent having to pay money and so the programme becomes a confrontation of purpose. The players in this game tend to be very aware of the limits of the abstraction and have learnt to manage it and the consequences; however weaker parties often lose if the stronger party needs to find either budget or cash flow.

Similar to abstracted use for payment, the use of the project programme for delay analysis (Braimah, 2013) adds another dimension to already abstracted thinking. In this scenario, the consequences of an event, or the failure to perform an activity, can be determined for proving liability or demanding payment. This is speculative and is based on presenting an argued case utilising constructed data and logic. As this involves great complexity, even though based on multiple simplifications, then it becomes a specialist tool for presentation to courts and arbitrators.

**BIM and Models**

What BIM is, is often disputed between a process and software but it is the geometric modelling, involving parametric objects, that makes it possible (Kensek, 2014). BIM exists with multiple layers of abstraction. Behind the model is a database that contains the reference information for all software operations. Thus, the visual outputs, building object tables and automated building-object-interaction are all stored
in this database. At the most abstract are binary code. This is structured into the database where the structuring gives some meaning to the code. This structuring has purpose for the BIM task but also for the efficient operation of the software that uses it. There are generic data structures for buildings, most notably IFCs, however this is not efficient for software and most have a proprietary native data structure. Software providers can have modules that take their native structure and output data in formats for others to use. These translations can never be perfect thus further abstracting and losing data and meaning. The operation of the software on the data is a further abstraction. The creation of geometric representations in a digital information world works because of the rule-based nature of geometry. BIM objects are further abstractions being both physical objects and data objects and there is no distinction between geometric data and parametric data. This abstraction hides the fact that non geometric data does not operate with the same rule base exactitude.

![Figure 3: An output representation from a BIM model](image)

In BIM, unlike with conventional drawings, the data and representation of the data are separated. The representation is produced through the visualisation software and, although this is fundamentally based on geometry, this manipulation is partly imaginary. In that sense, the visualisation needs to look correct for people to believe that the data is correct, and this becomes critical in complex geometries and non-normal interconnections between objects. There are a number of ways of making the visualisation look correct in order to overcome the software limitations. This hides the assumption/simplification that if the visualisation looks right then the data is right.

The use of the non-geometric data is more complicated as it is not possible to apply a similar clash detection logic. Without such a check then the data looks right but may be wrong. This is a danger of multiple abstraction; it embeds error by looking correct but without the ability to check. In addition, many non-geometric manipulations are based on models that are abstractions and so the outputs need to be carefully studied for value. This is well known in the performance gap with energy models (Gram-Hanssen et al., 2018) but occurs elsewhere with connecting abstraction to reality.

**DISCUSSION**

Abstraction has great benefits as it allows us to see wider aspects and changes in time that are obscured when we focus on specific aspects. In addition, it allows us to see similarities across events and artefacts that mean we can deal with them collectively and learn across them. Indeed, this ability to abstract has made building, particularly building at scale, possible. However, as the examples have shown we need to take care with the work of abstraction. To assist this, this discussion considers three critical themes derived from the literature review and the analysis of examples:
abstractions are reductions thus there is a loss of meaning, abstractions are socially
selected thus lose control for some parties, and, lastly, operating the abstraction
system becomes the task thus the internal processes are hidden and even lost to the
operators understanding.

All the examples showed the loss of meaning. This is partly due to the simplification
of the abstraction but also to do with the separation from grounded reality. As the
opportunity for abstraction increases, the loss of meaning becomes more critical. The
danger is that abstraction becomes the thing or activity such that the connection back
to the grounded specifics is unimportant. This is the fallacy of reification or
misplaced concreteness (Whitehead, 1925) and has been problematic in the
application of science. It is argued here that BIM is heading in this direction which
means that there are discussions about the abstractions of BIM without acknowledging
its problematic connection to reality (e.g. ISO 19650: 2019) and this omission suits
the social and political circumstances that back it.

The modelling involves the creation of an extremely large amount of geometric data
and given that the information content is much greater than normal drawing, it is
promoted (erroneously) that we are getting to very nearly perfect data for building
(e.g. Laing O'Rourke 2016). The aspect of visualisation in BIM is particularly
problematic. On first impression it is a pragmatic representation of the real world.
That this, itself, is an abstraction of an abstraction gets lost in the apparent reality of
what we are seeing. It is marketed as seeing the building built before it has been built.
The aspiration of this is laudable but the reality is not as easy or complete. This belief
that we are not losing meaning by using BIM and indeed it is often sold as delivering
greater meaning, must be challenged. Such expressions as a ‘single version of the
truth’ abound almost to assume, at least to the lay participant, that this is not an
abstraction but nearly reality (e.g. Excitech, 2017). Although this is a computerised
data management term where data is held only once, it is used as an illusion that the
data provides a truth. Similarly, the notion of Digital Twin as an exact digital replica
(e.g. Pbctoday, 2019). This confuses lay audiences and aggrandises IT systems
people. The loss of meaning is not challenged in the media and seldom academically;
this in itself loses control. That abstractions are chosen, rather than being natural,
means that they always represent a perspective, and this gives control by this
perspective over others. This is embedded in the software and presents a loss of
control. For example, the roots of Revit favour building design and the input of data
is through the geometrical design programme; conversely the roots of Tekla are
structural design and so benefit engineers. In addition, for BIM software to work,
there needs to be standardisation and a fixing of design approaches and even design
solutions. This is a further abstraction and loses not just meaning but also control.

Abstractions in use, was also shown to be problematic. Drawings allow more general
application because their data and representation are combined. This allows the tool
to be manipulated for the operators' benefit. The construction programme separated
these more because of the selection of the abstract variables and their
operationalisation. BIM however separates data and representation completely and
places this behind hidden proprietary processes. The connections between digital
geometric objects involves data describing the connections and algorithms of how
these data objects need to change with changing parameters. Apart from the simplest
decimal geometric connections this involves abstracting the connection and also software
arrangements to maintain consistency. How this is done is proprietary and so hidden
from the user. Then, because of this hiding, the proof of the viability of BIM relies
only on its use. It is possible to put data in and get outputs which meet the needs of designers; however why this works is not known. Such use of abstract systems is known as 'blackboxing' (Glanville 2015). Latour (1999 p. 304) comments on this "the way scientific and technical work is made invisible by its own success. When a machine runs efficiently, when a matter of fact is settled, one need focus only on its inputs and outputs and not on its internal complexity. Thus, paradoxically, the more science and technology succeed, the more opaque and obscure they become.”

CONCLUSIONS

Abstraction is at the heart of the way humans think and comprehend the wider world in extended time. This has allowed us to create tools to assist with design. The advent of systems of abstraction like BIM place a whole new burden on participants because of loss of meaning, loss of control and hidden processes. It is essential that all participants recognise that abstraction involves a reduction of the world. That this is done selectively to miss out aspects which are unimportant to the promotor allowing them to take command through the abstracted world. Thus, they are not just used to conceive the world but to manipulate the world and take command organisationally. Finally, the processes are hidden worlds which can often only be operated by high priests who maintain their positions of authority through the proprietary world. Participants can only do what they are allowed to do. The danger then with this system abstraction is that it is a 'blackbox' with no checks on its viability. We are living in hyperreality with no reality checks. Thus, major problems will ensue if participants do not challenge the authority of the abstraction and demand knowledge of processes. Such moral duty and skills must be taught alongside teaching of software and placed in software contracts.

REFERENCES


Boyd


ACADEMIA-INDUSTRY ENGAGEMENT
THE STRUGGLE TO CAPITALISE ON THE VALUE OF COMMUNITIES OF PRACTICE

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Communities of Practice (CoP’s) can perform an important role in the creation, accumulation and diffusion of knowledge within and across organisations. The project-based structure of production and extensive use of tacit knowledge in civil engineering and construction provide barriers for continuous learning and the exchange of knowledge over time. Several studies have indicated the potential of CoP’s to mitigate the consequences of these barriers for learning and the exchange of knowledge. However, it can be difficult to obtain and capitalise the value of these communities in practice. In this study, a CoP is set up on the use of Public Procurement of Innovation (PPoI) in construction. The study reports first insights and experiences on how to set up and manage the dynamics within a community of practice across several organisations. The results of this study suggest that a strong focus on the value of a CoP for its participants is required to ensure the longevity of the CoP needed to capitalise its value. Further, it suggests that a balance between short and long-term value for different participants and their daily practice is needed in the programming of the CoP.

Keywords: innovation, knowledge sharing, public procurement, social learning

INTRODUCTION

Learning and the diffusion of knowledge in project-based organisations are considered to be major challenges for improving the performance within civil engineering and construction (Swan, Scarbrough et al., 2010, Bartsch, Ebers et al., 2013, Hartmann and Dorée 2015). There are several reasons for this. The temporary and one-off nature of construction projects and changing team compositions for each project limit possibilities for continuous learning and diffusion of knowledge to the wider organisation (Ruikar, Koskela et al., 2009, Swan, Scarbrough et al., 2010). This is amplified by the extensive use of tacit and project specific knowledge which are difficult to transfer through the codification of knowledge (Hartmann and Dorée 2015). Several studies have indicated the high potential of Communities of Practice (CoP’s) as a way to improve learning and the exchange of knowledge in construction (Love 2009, Ruikar, Koskela et al., 2009, Lin and Lee 2012).

The concept of CoPs was coined by Lave and Wenger (1991) in a study on situated learning. They defined a CoP as: “a system of relationships between people, activities and the world; developing with time, and in relation to other tangential and overlapping Communities of Practice”. The driving forces behind CoP’s are a genuine interest, mutual engagement and desire to learn and exchange knowledge and experiences on a specific practice by its members (Wenger 1998). As such, CoP’s can

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also be described as: “groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and experience in this area by interacting on an ongoing basis” (Wenger, McDermott et al., 2002).

Despite the potential of CoP’s as a way to improve learning and the exchange of knowledge in construction, it can be difficult to obtain and capitalise the value of these CoP’s. This paper presents a case study on the creation and management of a CoP on the use of Public Procurement of Innovation (PPoI) in construction. Using an action research approach, this study provides first hand experiences and insights in:

1. The potential value which can be obtained from the use of CoP’s.
2. Why it can be difficult to obtain and capitalise value from CoP’s.
3. The necessary conditions for obtaining value from CoP’s.

Further, it provides several recommendations for improving the use of CoP's to foster learning and the exchange of knowledge across different organisations. A CoP on PPoI in construction was selected as a case study for two reasons. First, the use of PPoI in construction is relevant topic which is becoming more and more important for addressing societal challenges (Edler and Yeow 2016). Yet, at the same time public procurement is often found to be restrictive for stimulating innovation. Second, only few people have knowledge and expertise on the use PPoI in public organisations and they tend to struggle with similar challenges across different organisations. Due to the lack of expertise within their own organisation, collaborative learning and sharing knowledge across organisations on the use of PPoI can be highly valuable according to practitioners.

The paper starts by explaining the action research approach, including the role of the researcher and methods for data collection. Then it discusses previous research with respect to the potential value, critique and limitations of the use of CoP’s before diving into the case study. The first part of the case study focuses on the initiation phase of the CoP in which the potential value was assessed, and the scope and goals of the CoP were determined. The second part focusses on the organised CoP sessions with respect to: a) the obtained value within the CoP sessions, b) the experienced difficulties and dynamics within the CoP, and c) the lessons learned and recommendations. The paper concludes with a discussion of the results, conclusions and policy recommendations.

**METHODOLOGY**

A cyclical action research approach (Lewin 1946, Dickens and Watkins 1999) is used in a case study on the creation and management of a CoP across multiple public organisations in construction. The organisations involved in the CoP are: The provinces North-Holland and South- Holland, the municipalities of Amsterdam, Rotterdam and Eindhoven, the University of Twente, and PIANOs (the national expertise centre on public procurement). In addition, a literature review on the value, critique and limitations of the use of CoP’s has been performed.

Within the action research approach, the initiators of the CoP continuously cycle through three steps of experimental learning:

1. Create and/or adapt a plan of action,
2. Perform action and observe results, and
3. Evaluate the result of the action (Kemmis, McTaggart et al., 2014).
The first author is one of initiators of the community and is actively involved in management of the CoP. During the CoP sessions he takes the role of an active participant. In addition, he writes a short report of each session based on his own experiences and input from other participants. Between the CoP sessions the initiators have meetings to reflect on the progress and experienced dynamics within the CoP and adapt the plan of action accordingly.

Up till now three CoP sessions have been organised and a fourth session and a plan to organise a trip abroad are in preparation:

- **Exploration session**: to get acquainted and collaboratively assess the value and determine the goals of the CoP.
- **Innovation partnership Quay Walls**: to learn from and provide feedback on the project and procurement strategy of the project.
- **Bridge of Boekelo and the Cruquius-bridge**: to discuss the experiences in the realisation of the Bridge of Boekelo project and provide feedback on concept project and procurement strategy of the Cruquius-bridge.
- **Process market approach**: to discuss and reflect on the process market approach and development of a suitable project and procurement strategy.
- **Trip abroad**: to organise a two/three-day trip to visit an innovative project abroad and create a stronger bonding between the participants through shared experience.

Several sources were used for data collection: participant observation, documentation of the initial preparation of the CoP, notes regarding the management and reflection on the dynamics in the CoP, notes and short reports of the CoP sessions itself, and e-mail conversations and other messages related to the CoP.

**THEORETICAL BACKGROUND**

**Potential of Communities of Practice and how to facilitate them**

CoP's are considered to have a high potential to improve learning and the exchange of knowledge for several reasons. First, CoP's are found to be useful for developing and exchanging best practices (Wenger 1998, Wenger and Snyder 2000). Second, they are suitable for transferring tacit and project specific knowledge through interaction and mutual participation in the community (Duguid 2005, Love 2009). Storytelling is an important part of this, as it supports the exchange of knowledge in its original context (Brown and Duguid 1991). Third, the social context of and the expectation of reciprocity in the CoP’s motivate members to share their knowledge more easily (Wenger 1998, Roberts 2000, Love 2009). In addition, it is suggested that CoP’s can be stimulated and used to create strategic advantage (Wenger, McDermott et al., 2002).

Due to their informal and self-organising nature CoP’s cannot be established by the management like a project team or formal working group. Yet, the management can play an important role in identifying potential communities in existing informal networks and supporting their development (Brown and Duguid 2001, Roberts 2006). For example, they can support CoP’s by providing time and funds to the community and stating their legitimacy and importance in the organisation (Wenger and Snyder 2000). Further, they can stimulate the alignment and interaction between CoP’s (Brown and Duguid 2001).
Critique and limitations on the use of Communities of Practice

Although CoP’s are considered to be highly suitable to improve learning and exchanging knowledge in organisations, they come with a number of weaknesses as well. First, as communities develop a shared perspective and resources over time, their internal focus can make them prone to groupthink (Wenger, McDermott et al., 2002). Second, as meaning is continuously negotiated within CoP’s, this meaning will be influenced by power relations within the community and the negotiation process is likely to be troubled by misunderstandings and disagreements (Roberts 2006, Wenger 2010). Third, since the value of CoP’s to organisations are difficult to measure, they may lose priority over time within organisations. Fourth, it is difficult for the management to develop, sustain and integrate CoP’s in the organisation, as their informal, spontaneous and self-organising nature makes them resistant to supervision and interference (Wenger and Snyder 2000, Wenger 2010).

Roberts (2006) state that the ability to use the CoP approach in a broad range of organisational settings can also be seen as a weakness, whereas this may stimulate improper use of the approach. CoP’s are for example far less suitable in hierarchical structured organisations where workers have less autonomy over their work or when knowledge can easily be codified and transferred through other means (Roberts 2006). Further, they are not suitable when there is a lack of willingness to share knowledge within the community or when the interests of the community members are not aligned with those of the organisation (Kimble and Hildreth 2004). Lastly, CoP’s can only flourish in organisational environments that stimulate the existence of these communities (Wenger, McDermott et al., 2002).

CASE STUDY

Starting the Community of Practice initiative

In the spring of 2018 the university, PIANOo, and the municipalities of Amsterdam and Eindhoven started an initiative to actively facilitate learning and knowledge exchange across public organisations with respect to the use of PPoI in construction. The ambition was to develop a structure for continuous learning and knowledge exchange across different organisations and improve this structure over time. During the months that followed the initiators developed and discussed a plan of action to create this learning structure.

As part of the development of the action plan we interviewed the national expertise centre on public procurement (PIANOo). PIANOo is responsible for the professionalizing public procurement and facilitating learning and knowledge exchange on public procurement in the Netherlands. In this context, they publish vision documents, guidelines and share best practices related to public procurement. Moreover, they regularly organise meetings, give advice and facilitate knowledge networks to stimulate learning and the exchange of knowledge on public procurement. Despite their significant contribution to the field, PIANOo faces similar challenges as CoP’s with respect to stimulating active participation to keep initiatives from fading out. One of the ways they deal with this is to always organise initiatives and events in collaboration with people from other organisations to create a shared ownership for initiatives and events. Further, they regularly contact a broad range of stakeholders in practice to know what trends, challenges and best practices are going on in the field.
Organised CoP sessions:

In September 2018 an exploratory session was organised to assess the potential value of and support for starting a CoP on PPoI in construction. The session started with several short rounds of speed dating to get more acquainted and facilitate networking. This was followed by a short workshop and plenary discussion on success factors, challenges and learning experiences on the use PPoI to support group bonding. At a certain point in this discussion the chairman asked the participants if they saw value in organising more sessions like this one more regularly. The general consensus was that there is quite some value to be gained from these kinds of sessions. Although, they also indicated a strong need to go more in-depth into actual projects and challenges to generate sufficient value. Further, they questioned how this initiative relates to and distinguishes itself from other initiatives and networks. From the discussion that followed the group determined three goals for the CoP to obtain the most value for the participants:

- Learning from other organisations and projects: peeking into how others have done it; not only how they succeeded, but also what challenges they faced and what went wrong.
- CoP as a sounding board: presenting and discussing concrete plans of action and issues within a group of experts with knowledge and expertise on the matter.
- Staying informed on current practices and advances in knowledge:
  - Current and finished projects including who are/were involved.
  - Use of different PPoI approaches with respect to project goals and objectives.

In line with the points above the group decided to organise two additional sessions and see from there how the CoP develops. Further, it was decided to make overviews on current and finished projects, and other initiatives and networks in which participants are involved in. In November the second CoP session was organised which focussed on the project and procurement approach of the innovation partnership on Quay Walls in Amsterdam. The aim was to learn together in an intensive session and to ensure that all participants go home with some new insights. Furthermore, the project team of the municipality brought in three topics to get feedback on from the group: a) inclusion of price, b) allowance for opportunities introduced by market parties, and c) risk and collaboration.

The session started with a short interactive plenary discussion on recent developments and notable experiences related to innovation-oriented procurement projects. The project team prepared a short presentation of 15 minutes to introduce the project and have plenty of time to get feedback on the topics they brought in. Yet, this short presentation became a constructive yet critical discussion of approximately 75 minutes on the decisions they took up till this point in the project. Where the depth into actual projects was lacking in the exploration session this was certainly made up for in this session. The discussion focused on the three topics brought in by the project team.

The third CoP session took place in February and focused on two innovative bridge projects. The first was the Bridge of Boekelo which was already realised to a large extent. The second project was the Cruquius-bridge where the project team was preparing for the first market consultations and the tender of the project. The aim of this session was to learn from the experiences in the Bridge of Boekelo project and to
provide feedback and brainstorm on the project and procurement strategy of the Cruquius-bridge project.

The session started with a presentation on the project Bridge of Boekelo, including: the context of the project, the project and procurement approach as well as the experiences of the municipality of Hengelo in the realisation phase. After the break, the initial project and procurement plan for the Cruquius-bridge project was presented by the province of North-Holland. Here, was noticed that it took some time to get into the topic and to get an in-depth discussion going. In fact, several participants indicated that the most valuable part of the discussion took place after the scheduled closure of the meeting.

Value obtained from the CoP

During the exploratory session three goals for the CoP were determined to create the most value for the participants: a) learning from other organisations and projects, b) the CoP as a sounding board, and c) staying informed on current practices and advances in knowledge. In addition, the need to go more in-depth in actual projects and challenges was taken into account in the organisation of the following CoP sessions.

The project team of the Quay Wall project were not sure what to expect in terms of value from the second CoP session. However, afterwards they indicated that they obtained valuable new insights from presenting and discussing their project and procurement strategy with the group. Moreover, they could use these insights directly in their project. The others also indicated that they obtained several new insights from the session, yet they could only apply a small part of this in their projects. The project leader from the Bridge of Boekelo project indicated that she obtained some useful insights from the third CoP session. Though, since the project was already almost completed the other participants could learn more from the project compared to the other way around. The third CoP session was also beneficial for the project team of the Cruquius-bridge project in terms of new insights. Yet, for the other participants this part of the session was a bit less valuable because the project was still in the exploration phase. Many things were still uncertain, and the presentation was less structured compared to the Quay Wall project for example. As indicated before, the most valuable part of this discussion for the project team as well as the other participants occurred after the scheduled closing of the meeting.

Experienced difficulties and dynamics within the CoP

One of the most difficult parts of starting a CoP was to stimulate group bonding and a feeling of ownership within the group. Especially, as people participate on a voluntary basis and take the estimate value, they obtain from it, compared to the effort they have to put, into account when deciding. In addition, they may have other obligations or things to do which they consider either more important or urgent. We performed several interventions to stimulate group bonding and stimulate a feeling of ownership within the group:

- During the exploratory session we organised several rounds of speed dating and a collaborate discussion on success factors, challenges and learning experiences on the use PPoI to prepare for the discussion on the value of the CoP and the collaborate determination of the goals.
In a meeting between the exploratory session and the second CoP session, the initiator from the municipality of Amsterdam asked his colleagues to be the first to step up and present their project in the second CoP session.

During the second session the participants were encouraged by the chairman to ask critical questions and provide solicited as well as unsolicited feedback on the plan of action for the project. Further, we put three tables closer to each other and the presentation screen to create a more intimate setting.

During the third session we asked the participants what they would like to discuss in the next CoP session. This brainstorm did not go as smoothly as we expected because most people were reluctant to provide input, especially in the beginning.

An overview of the organisations, number of participants and number of cancellations can be found in Table 1. For the first meeting the initiators of the CoP sent an invitation to a group of 22 people originating from various public organisations based on existing personal networks. Eleven people from five organisations participated in the first session. Further, there were five cancellations on short notice of participants who could not make it. For the second and third session there were even more people who cancelled on short notice, although the number of participants present remained similar. On several occasions people indicated that they had no time whereas something in their daily practice came up what they considered to be more important or urgent.

Table 1: Overview participants in CoP sessions

<table>
<thead>
<tr>
<th>Organisations present</th>
<th>Number of participants</th>
<th>Cancellations on short notice (x &lt; 10 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploratory session</td>
<td>One municipality, two provinces, PIANOo (national expertise centre), and the university</td>
<td>11</td>
</tr>
<tr>
<td>Innovation partnership</td>
<td>Two municipalities, one province, PIANOo and the university</td>
<td>9</td>
</tr>
<tr>
<td>Quay Walls</td>
<td>Two bridge projects</td>
<td>13</td>
</tr>
</tbody>
</table>

The necessary conditions for obtaining value from CoP’s

Several lessons were learned with respect to the necessary conditions for obtaining and capitalising value from a CoP during this study. The first condition we found was to collaboratively discuss and determine the scope and goals of the CoP. On one hand to stimulate group bonding, active participation and a feeling of ownership in the community. On the other hand, to align the expectations of the CoP within the community and direct the programming within the CoP. Based on our experience we would recommend starting such a discussion only after participants are acquainted and spend some time discussing on the topic to avoid an awkward silence.

The second condition we found was the leadership to get a CoP of the ground, while group bounding, a feeling of ownership and the obtained and capitalised value by the participants is still limited. As Wenger (1998) states this requires different types of leadership in the community. Day-to-day leadership is needed to take the initiative to actually organise activities. Interpersonal and cutting-edge leadership are needed to create group cohesion and get people enthusiastic by thinking out-of-the-box. This is how the idea came up to organise a trip together for example. The third condition we
found was the importance of commitment within the group to the CoP. Up till this point we had a small core group within the community and a larger group who attend CoP meetings when it suits their interest and agenda. This hampers group bonding, a feeling of ownership and active participation within the group. As such we decided to use the trip abroad to continue the CoP only with the participants who commit to being present and actively participate in the majority of the CoP sessions. Lastly, since the value of CoP sessions will vary across participants, we found that a good balance between the short and long-term value for different participants and their daily practice in the programming of the CoP sessions is required to increase the value overall.

**DISCUSSION**

This paper presents a case study on the development and management of a CoP across multiple organisations. In line with previous research, the results of this study indicate that CoP’s have a high potential to stimulate learning and the exchange of knowledge on a specific practice (Wenger, McDermott *et al.*, 2002, Love 2009). Through mutual learning and engaging in specific practices CoP’s can complement formal learning structures which focus more on the codification of knowledge. Moreover, CoP's seemed to be useful for transferring tacit knowledge in specific contexts (Duguid 2005, Roberts 2006). The group discussion on specific issues in the project and procurement strategy of the Quay Walls project in Amsterdam in this study is a good example of this.

However, the results of this study also indicate that it is often difficult to obtain and capitalise the value of CoP’s. We found several reasons for this. First, participating in a CoP requires a significant amount of time and effort from participants, while the value to them on the short term can be limited. In fact, participants need an opportunity in their daily practice to implement the knowledge they obtained from the CoP to fully capitalise its value and this can take quite some time. This also implies that the value obtained from the CoP sessions will vary across the group. For example, a discussion on the procurement approach of Cruquius-bridge project is likely to be more valuable to the team of that project compared to other participants.

Second, it is not that easy to stimulate group bonding, a sense of ownership and active participation within a CoP, and this can only be facilitated to a certain extent (Wenger, McDermott *et al.*, 2002). In other words, it largely depends on the members whether or not they bond as a group, feel a sense of ownership and decide to actively participate in a CoP. Yet, without group cohesion, sense of ownership and active participation the community will lose its value and dissolve over time.

Third, current issues in daily practice are often perceived as more important or urgent by participants compared to participating in CoP sessions. When this occurs from time to time, it is not a major problem as long as there is an active core in the group. However, if there are only few participants present during the sessions can seriously hamper the effectiveness of the CoP. Within this study we received quite some cancellations for the CoP sessions on short notice. Yet, up till now there were always sufficient participants to have a productive meeting.

Although the ability of CoP's to create value for its members is largely dependent on the members itself, the results of this study indicate that one can facilitate this process through a number of ways. In line with Wenger and Snyder (2000) we found that legitimacy and support from senior management in organisations are helpful
conditions for CoP's to thrive. In fact, two senior managers are part of the CoP, which helps to create momentum. Further, we agree with Wenger (1998) that the scope and goals of the CoP should be determined by its members. Along with a strong focus on the value of the CoP for its members, this is required to ensure the longevity of the CoP needed to capitalise its value.

Since the findings of and lessons learned in the study are based on a single explorative case study their external validity is limited. To test to what extent the results can be generalised to other situations more case studies and/or quantitative research on CoP's in construction are needed. Further, we see that the results of this explorative study suggest or indicate several causal relations on which we base our recommendations. However, it is difficult to exclude alternative explanations at this point. In addition, the first author acknowledges that despite his best efforts to present an honest account of the case, the results of this study may be biased due to his active participation in the creation and management of the CoP.

CONCLUSIONS

Several studies indicate a high potential for CoP's as a way to improve learning and the exchange of knowledge within construction. However, despite this potential it can be difficult to obtain and capitalise the value of these communities for stimulating learning and the exchange of knowledge. Based on first hand experiences the results of this case study indicate three possible reasons for this:

4. Participating in a CoP requires a significant amount of time and effort from participants, while the value to them on the short term can be limited and vary across participants.
5. The extent of learning and knowledge exchange are strongly influenced by group cohesion, a sense of ownership and active participation within the community. Moreover, these characteristics are difficult to stimulate whereas they are largely dependent on its members.
6. Current issues in daily practice are often perceived as more important or urgent by participants compared to participating in CoP sessions. One could even state that practitioners can be hindered by their daily practice to learn and exchange knowledge in CoP's.

Further, several lessons and policy recommendation are presented in this study to address these issues in future CoP initiatives. The first is the importance of actively stimulating group bonding, a sense of ownership and active participation within the community sessions. Second, to actively discuss and determine the scope, goals and programming of the CoP with its members. That is to organise with its members instead of for its members. Third, to put a strong emphasis on, and balance between, the short and long-term value of the CoP for its different members in relation to their daily practice. In addition, support from senior management if found be helpful to state the importance and create initial momentum for CoP's.

REFERENCES


DEVELOP A RESEARCH METHODOLOGY TO IDENTIFY THE RELATIONSHIP BETWEEN STUDENT SATISFACTION AND EXPERIENCE WITHIN THE BUILT ENVIRONMENT AREA AND THEIR GRADUATES' EMPLOYABILITY WITHIN THE UK

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Previous studies, such as Douglas, McClelland and Davies (2008) investigated the relationship between student satisfaction and experience. However, no framework has yet been developed to identify the relationship between student satisfaction, student experience and graduate employability, especially within the built environment discipline. The aim of this paper is to discuss the research methodology investigating the relationship between student satisfaction, experience and employability. The research method for this project is a mixed method, using both qualitative and quantitative approaches to ensure triangulation is achieved. A questionnaire survey will be given to the final year of students studying an undergraduate built environment degree programme in the Midlands region. An internet search will be performed to identify the contact details of the relevant programme leaders of relevant courses. An email will be sent to all programme leaders requesting that they forward the web link for the online questionnaire survey to the final year students studying their courses. On completion of the questionnaire, the students will be invited for a follow-up interview. The importance of the research with the students is to gain an understanding of their experience studying their courses and to gather their views on how and to what extent their courses have prepared them for the working environment. Interviews with employers of built environment graduates will also be conducted to gain their views on how the graduates are equipped for employment. Interviews with programme leaders will be conducted at a later stage to gain the universities perspective on developing students’ experience in order to enhance graduate employability. The framework for identifying the relationship between student experience, student satisfaction and employability will be developed based on the research findings identified from the studies with the students, employers and programme leaders.

Keywords: Academic-Industry engagement, employability, performance, satisfaction

INTRODUCTION

Higher Educational Institutions (HEIs) play an important role in the development of students and their programmes or courses not only benefit students but society as well. One of the aims of higher education is to provide students with the skills and knowledge that they need to be successful in the working environment. Another key expectation required by HEIs is to build students’ capacity to take effective action in all areas of knowledge. Students seek institutions that provide them with unique,

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memorable and personal education experiences as academic and educational options increase.

Abdullah et al., (2014) suggest that graduates enter the labour markets equipped with the specialist skills which are related to their relevant degree programme but not equipped with the transferrable skills required for the wider labour market. Therefore, the work is important as employers are currently looking for the talents and skills of new employees who can make a difference in their organization and have transferrable skills that are required. HEIs can assess their students’ performance in and after their education by exploring and understanding the attitudes and perceptions of students. Education needs to help students reach life goals and therefore the role of HEIs in the lives of students should be evaluated (Bright and Graham 2016).

The approach that will be used in this paper is an inductive approach. This is to investigate student satisfaction impact on built environment students’ decision-making about universities in the Midlands. Moreover, how satisfaction can lead to recruitment in order to develop a new theory. The objective of this paper is to critically evaluate the current literature on student satisfaction and graduate employability. It also discusses the research methodology investigating the relationship between student satisfaction, experience and employability.

Previous Work

Previous work on student satisfaction has been done by many researchers and they have developed models on student satisfaction which can be summarized below in table 1 however the originality of this research would be a framework that will identify the relationship between satisfaction and employability.

Table 1: Students’ satisfaction models (Weerasinghe and Fernando 2017)

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pascarella, Tetenzini</td>
<td>1983</td>
<td>Student Satisfaction Model</td>
</tr>
<tr>
<td>Parasuraman, A; Berry, L; Zeithaml, V</td>
<td>1985</td>
<td>SERQUAL Model</td>
</tr>
<tr>
<td>Hatcher, Prus, Kryter and Fitzgerald</td>
<td>1992</td>
<td>Investment Theory</td>
</tr>
<tr>
<td>Noel-Levtiz</td>
<td>1994</td>
<td>Noel-Levtiz Student Satisfaction Index</td>
</tr>
<tr>
<td>Keaveney and Young’s</td>
<td>1997</td>
<td>Satisfaction Model</td>
</tr>
<tr>
<td>Dollard, Cotton and de Jonge</td>
<td>2002</td>
<td>Happy Productive Theory</td>
</tr>
<tr>
<td>Elliot, K;M; Shin, D</td>
<td>2002</td>
<td>Student Satisfaction Model</td>
</tr>
<tr>
<td>Abdullah, F</td>
<td>2005</td>
<td>HEdPERF (Higher Education Performance)</td>
</tr>
<tr>
<td>Douglas, Jacqueline; Douglas, Alex; Barnes, Barry</td>
<td>2006</td>
<td>Service Product Bundle Method</td>
</tr>
<tr>
<td>Jurkowski, Silke; Vignali, Claudio; Kaufmann, Hans-Rudiger</td>
<td>2006</td>
<td>Student Satisfaction Model</td>
</tr>
<tr>
<td>Alves, Helena; Raposo, Mario</td>
<td>2010</td>
<td>Conceptual model for satisfaction</td>
</tr>
<tr>
<td>Shuxin, Guo; Fei, Teng; Jiannan, Guo; Yang, Sun</td>
<td>2014</td>
<td>Satisfaction Evaluation Model</td>
</tr>
<tr>
<td>Thor-Erik Sandberg Hanssen and GiselleSolvoll</td>
<td>2015</td>
<td>Satisfaction Framework</td>
</tr>
</tbody>
</table>

LITERATURE REVIEW

Defining Student Satisfaction

Student satisfaction is the short-term attitude of the student, derived from the evaluation of the educational service received (Elliott and Healy 2001). Student satisfaction results when the actual performance either meets or exceed the
expectations of students. Student satisfaction can be defined in many other ways and some of the definitions by different authors are summarized below in Table 2.

**Table 2: Definition of student satisfaction by different authors**

<table>
<thead>
<tr>
<th>Definitions</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>The satisfaction of students is multi-dimensional and depends on the clarity of the student objectives.</td>
<td>(Hartman and Schmidt 1995)</td>
</tr>
<tr>
<td>Trust has significantly influenced student satisfaction. Universities can build confidence in the consistent and fair treatment of students, meeting their needs and handling student complaints in a caring way.</td>
<td>(Grossman 1999)</td>
</tr>
<tr>
<td>Quality perceived of an educational experience is a result of student satisfaction.</td>
<td>(Athiyaman 1997)</td>
</tr>
<tr>
<td>The product of a university is the sum of academic, social, physical, and even spiritual experiences of a student.</td>
<td>(Sevier 1996)</td>
</tr>
<tr>
<td>Most students are satisfied with their university programs but are not happy with support services, such as university counselling and professional consulting.</td>
<td>(Kotler and Fox 2002)</td>
</tr>
<tr>
<td>The chances for a student to suggest the university to friends/relatives was heavily determined by the extent to which university personnel, such as faculty interact with students.</td>
<td>(Browne et al., 1998)</td>
</tr>
</tbody>
</table>

After various definitions of student satisfaction have been highlighted in the paper, the first author of the paper has developed a definition that "student satisfaction is when the expectations of students have been met, it can be long term or/and short term. Every student may have different expectations when they come to the university and therefore the researcher believes that student satisfaction definitions cannot only be limited to the quality of education only. There are other factors that should be considered as well."

**Why is Student Satisfaction Important?**

Education is a key driver of economic growth (Browne 2012), particularly in the higher education sector. Higher education is becoming an increasingly competitive market. University students are classified as consumers of higher education as argued by Thomas and Galambos (2004). Many reasons can be identified why student satisfaction is important. Student satisfaction has become an important component of quality assurance; student satisfaction not only helps to support to position UK HEIs in various league tables but also helps in student recruitment.

Student satisfaction has become extremely important to institutions as satisfied ‘customers’ supports the enrolment of additional students or ‘customers’. Ratings of student satisfaction are becoming more transparent and readily available, for example, National Student Survey (NSS) and Postgraduate Taught Experience Survey (PTES) in the UK and Australian Graduate Survey (AGS) in Australia. As a result, most universities in the UK and around the world are constantly looking for ways to improve the satisfaction of students at their institutions.

Students’ satisfaction has individual, institutional and social implications. From a university point of view, satisfied students are more likely to continue in their studies and are more likely to succeed academically and this is likely to enhance the reputation and financial position of the university. Satisfied students also make effective public relations agents. High student satisfaction helps in attracting and retaining high achievers who in turn increase the reputation and standing of the
Identifying the Relationship Between Student Satisfaction and Experience

The university plays a big role in the overall experience of a student's journey.

Maintaining and improving students’ satisfaction has been considered an important goal for universities (Harvey and Knight 1996) with the assumption that student satisfaction is indicative of institutional effectiveness (Naveh, Tubin and Pliskin 2012). One key factor of student satisfaction is the quality of the teaching staff. As a result, the use of student rating scales as an evaluative component of their teaching system has increased. Majority of the teaching staff at most universities have been required to administer some type of teaching evaluation form to their students during each course or module offering for some time.

Assessing student satisfaction provides a way that universities can focus directly on issues of quality development in order to ensure that educational standards are high (Wiers-Jenssen, Stensaker and Grogaard 2002). Measures of student satisfaction can also assist in identifying and implementing areas for development.

Graduate Employability

Graduates can be defined as students who have left education with qualifications above A-level standard. This can also include those with higher education and those with under graduate degrees (Clegg 2017).

Previous research shows that for many undergraduate students, their goal is to gain employment in their respective field of study (Dacre Pool and Sewell 2007). Students believe that by obtaining a degree, the probability of finding employment in competitive labour markets increases in the students' favour (Godofsky, Zukin and Van Horn 2011). It has been said that the choice to invest in a degree is based on the ability to achieve higher income after graduation for the duration of one’s career (Elliott 2002). Recent studies show that the expectation upon completion of an undergraduate degree is that the student would earn ten per cent on average, more than someone who has a high school certificate (James and Yun 2018). These earning expectations and the successful transition to the labour market have proved to be motivators for the worldwide growth in degrees (Uhlig et al., 2015). It is important for HEIs to understand before student enrolment and throughout the student academic experience that the students are making decisions to attend HEIs with expectations of income and employment.

How Are Universities Skills Related to Employability?

While university studies are recognised as a praising goal in themselves, they are increasingly regarded as a primary tool for preparing students for future work (Martin et al., 2000). In addition to that, students do not consider HEIs to be responsible for job searches and employment, but to provide the qualifications, skills and knowledge that allow them to employ (Godofsky, Zukin and Van Horn 2011). However, analysis of the universities and the workplace’s functions showed that universities have difficulties in preparing students for their future roles in the work environment. There is a number of reasons as follows. University learning activities are usually individualistic whereas work is often carried out in a social cooperative context; university tend to encourage broad learning, while work is often task-specific; University often transmits and instils decontextualized knowledge, while work is more connected with contextualised knowledge; university tends to concentrate on individual competitions, while work involves teamwork and the absolute diversity of
professional aspirations makes it difficult for universities to prepare every student for every possible career path (Candy and Crebert 1991).

Terenzini, Theophilides and Lorang (1984), looked at the factors predicting undergraduate perceptions of skill development at university and found that class participation, professional contact frequency with the academics and the quality of this contact were the biggest factors. It was then said that not only in class but outside the class is what influences students' perceptions of skill development whilst at university. The programmes leaders or course leaders must understand that they need to encompass contexts beyond those that are considered to be instructing at classroom and academic settings.

Previous studies show that the important factors of satisfaction were beliefs about the functioning of the academics and their ability to meet students' needs and career opportunities provided by their course, however, Morgan and Shim (1990) showed that satisfaction with one's course was associated with preparation for employment, variety of course content and the interest value of subject matter.

**Improvement in the Way HEI Prepare Students for the Employment**

Students, HEIs and graduate employers are very critical how well the education system has prepared the student for the labour market. About forty-two per cent of students think that the university prepares them well for their first job and for building professional career paths. HEIs are doubtful with the performance of education systems as they believe only thirty-six per cent think it helps them to build a professional career path, even though most of them consider it to be their responsibility. Graduate employers are more critical when it comes to employing graduates as less than one in four are positive about the contribution that education system makes. This data was taken from Ipsos (2019).

Some universities like Westminster University has launched a scheme that offers training to unemployed built environment graduates. The university has won the funding for the Build Up scheme from the Higher Education Funding Council for England (HEFCE)'s Economic Challenge Investment (Clegg 2017). Trainees receive free training in a wide range of subjects that includes construction to accounting and negotiation skills. This programme is very new and one of its kind, therefore, it is only limited to a specific number of students. More schemes like these are needed in other HEIs.

**Skills Graduate Employers Expect**

Shahrin et al., (2004) state that new and fresh graduates these days confront more challenges and competitions in getting employed compared to previous graduates. Employers require from potential graduates for competencies and capabilities in soft skills since globalization demands the firms to be more competitive in the management system and therefore excellent academic degrees alone are inadequate.

Trends and economic recession have influenced the labour market globally. In order to survive in the labour market, employers have begun to use new approaches to recruit graduates. As seen in the advertisement for vacancies, most companies require graduates to have sufficient skills and abilities to work immediately. As a result, the number of unemployed graduates increases.

Built environment graduates are required to possess the employability skills to help them practice their knowledge and technical skills effectively. Previous studies by Juhdi, Jauhariah and Shaharudin (2007) show that graduate employers find that
Identifying the Relationship Between Student Satisfaction and Experience

Graduate level job applicants these days are lacking generic skills. Graduate employers and leading engineers agreed that built environment graduates are lack of verbal and written communication skills (Al-Munifi and Aleryani 2019). Hassan et al., (2007) show in his studies that there is a need for built environment degrees to improve in the majority of the areas, especially the non-technical aspects of the programme. The courses are recommended to enhance employability skills by emphasizing on improvements in the non-technical skills aspects amongst undergraduates. The employability skills framework developed by Hassan et al., (2007) highlights the top five generic skills required by the graduate employers in table 3.

Table 3: The employability skills framework

<table>
<thead>
<tr>
<th>Skills</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication effectively</td>
<td>The ability to present ideas with confident and effective through verbal and written modes, not only with engineers but also with the community at large</td>
</tr>
<tr>
<td>Competent in the application in practice</td>
<td>The ability to use the techniques and skills</td>
</tr>
<tr>
<td>Interpersonal or team working skills</td>
<td>The ability to function effectively as an individual and in a group with the capacity to be a leader or manager as well as an effective team member</td>
</tr>
<tr>
<td>Engineering problem solving and decision-making skills</td>
<td>The ability to undertake problem identification, apply problem-solving, formulation and solutions</td>
</tr>
<tr>
<td>Apply knowledge of engineering principles</td>
<td>The ability to acquire and apply knowledge of engineering fundamentals</td>
</tr>
</tbody>
</table>

Although this table highlights the top five generic skills that are required by the employers, however, the researcher feels that not all of these skills are important to all the built environment graduates, e.g. quantity surveyors, the basic skill they require is surveying skills and numerical literacy/skills.

METHODOLOGY

The type of research method chosen for this project is a mixed method. Both qualitative and quantitative methods shall be used in order to achieve triangulation. Qualitative research aims to gather in-depth understanding which will help to research on built environment students’ experience as qualitative research will give the students a certain degree of freedom and permit spontaneity rather than forcing them to only select from a set of pre-determined responses (Alzheimer 2009). The interview will investigate the ‘HOW’ and ‘WHAT’ of their experience that has prepared them for the work environment. Along with the interviews, surveys will be given out to the students for the statistical representation of the findings in the study.

Sampling Method

The research sampling method that will be used in this study is random sampling to obtain a more logical result that could be used to represent the total of the population. A list of all universities in Midlands region that have built environment courses to offer was acquired from the ‘the complete university guide’. From six universities in the West and East Midlands, four of them will be chosen based on the university that offers the highest number of built environment courses. The third-year undergraduate built environment students will then be the target respondents by the researcher. The programme leaders of built environment courses will be contacted via email in addition to a request letter from the researcher and with the stated support from the
Director of Studies to obtain consent to administer the survey to the respective universities. Following that, a letter of consent will be sent along with a sample copy of the survey. However, if the researcher fails to get a reply from the programme leaders then the researcher will place phone calls within the department and arrange a meeting to explain the importance of this research. Data collection will be conducted during the university working hours and on university campuses.

Survey

The survey will require information about the demographic backgrounds of the students. It will also have questions related to satisfaction levels they have with the courses, how well prepared they are for the work environment and whether they have and exhibit suitable skills that graduate employers are looking for.

Respondents

The respondents in this research will be coming from four different universities. Specifically the randomly selected universities from the West and East Midlands region. The researcher chose universities in the Midlands because of the number of built environment courses present in the area that is relevant to the study and also as it fits the time frame and resources available to the researcher who conducts this research as part of her PhD study. The randomly sampled respondents will be asked by the researcher to express consent to fill out the survey until the desired number of respondents has been acquired. On completion of the questionnaire, the students will be invited to accept a follow-up interview.

Interviews with employers of built environment graduates will be conducted to gain their views, whether the graduates are equipped for employment and what can HEIs amend in their courses to make sure that the graduates are ready for the labour market. Interviews with built environment undergraduate programme leaders will be taken at a later stage to gain the universities perspective on developing students’ experience in order to enhance graduate employability.

The framework for identifying the relationship between student experience, student satisfaction and employability will be developed based on the research findings identified from the studies with the students, employers and programme leaders.

Analysis Plan

The survey results from the students will be analysed using software called SPSS. The reason why SPSS is chosen because of its familiarity with both academic and business colleagues. It is also a suitable data analysis package for this research and addresses the cost constraint concern as it is available in the University’s system. SPSS is a versatile package that allows many different types of analyses, data transformations and forms of output. Regression analysis and t-testing will be used as a method to analyse the data using the tool SPSS.

Data will be analysed by grouping respondents through different age, gender and ethnicity groups. As in previous research, there are differences in satisfaction levels by age with younger students being more satisfied overall than mature students, (Zuhair, Hall and Arambewela 2004). Males tended to be less satisfied overall than females. Both age and gender differences may be more related to the courses undertaken than genuine differences. For the second year running, students domiciled outside of the UK were less satisfied overall than home students. In particular, they were less satisfied with most aspects of teaching and assessment - especially the
fairness of the assessment. Some of this data will be compared with the new data set that the researcher will get after the surveys are completed.

Interviews recordings with all the participants will be transcribed and the data will be analysed using thematic analysis to identify themes. The thematic analysis focuses on identifiable themes and patterns of living and/or behaviour. The researcher wants to find out the behaviour patterns that can help the researcher to identify the themes and develop the relationship.

CONCLUSIONS

An important point to note is that employer's expectation should be taken into account as part of the graduate's decision-making process so that it has an impact on “their job-searching” performance. The important skills have been highlighted that are required by graduate employers. The results in the future will provide graduates with valuable insight as they will be determined towards getting employed with a competitive company. This study will represent a useful source of information for built environment third-year undergraduate students planning to find a job, and for higher education institutions managing undergraduate programs to produce highly skilled graduates.

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Identifying the Relationship Between Student Satisfaction and Experience


MEASURING THE IMPACT OF A BLENDED LEARNING INTERVENTION ON NON-COGNATE STUDENTS IN A MEASUREMENT MODULE

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As the current skills shortage and ‘talent war’ of attracting and retaining individuals to the professional disciplines of the construction industry intensifies, professional bodies, employers and universities have supported and accommodated the growing numbers of applicants from increasingly diverse non-cognate backgrounds into the world of Quantity Surveying. As a consequence, Masters courses, particularly within the surveying disciplines, are composed of both cognate and increasingly, non-cognate students. Combining these two diverse groups with varying knowledge bases within the one cohort presents a complex challenge for educators with respect to delivering content in a suitable manner and enabling all to achieve the desired learning outcomes without alienating a particular group. The aim of this research is to investigate the influence of a blended learning environment in further developing the currently practised pedagogical approach to teaching a mixed cohort of cognate and non-cognate students within measurement; a core task of the quantity surveying profession. The research will be undertaken in the form of a comparative case study within a higher education institution and will primarily utilise qualitative data obtained over consecutive academic sessions from mixed cohorts within a Masters measurement module. By implementing a blended learning approach within the second cohort, the results are expected to demonstrate that providing ‘foundational knowledge’ in an online learning format prior to the physical classroom environment will benefit the students understanding and learning within the classroom, and critically, assist non-cognate students. Adopting alternative solutions in academic delivery to aid understanding, as the research’s main rationale, is hoped to better engage and equip more productive graduates for the workplace and their role in a demanding, innovative industry.

Keywords: blended learning, non-cognate, RICS, virtual learning environment

INTRODUCTION

The increasing student numbers and greater variety of non-cognate students within built environment postgraduate qualifications is endorsed by the professional body, Royal Institution of Chartered Surveyors (RICS) and, more increasingly, by industry employers as a means to satisfy the current demand for construction professionals, and in particular, quantity surveyors (RICS, 2015). As a consequence, entrant requirements have changed over time to include a far broader range of ‘acceptable’ degrees, such as computing or data analytics, in addition to those with cognate degrees or vocational backgrounds. Birch et al., (2005) explain that both the employers and the graduates seek the professionally accredited degree and membership in a comparable timeframe and equal manner to those with a vocational degree. There is, in the United Kingdom at least, an appetite from industry, professional bodies and

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educators for a postgraduate qualification in quantity surveying, which does not currently show signs of being appeased.

As a result, a current work-based challenge the educating staff of a higher education institution are experiencing occurs within the delivery of a 15-credit module ‘Quantification and Costing of Works’ - a core module within the MSc Quantity Surveying programme. The module is currently being taught in two campuses with the occasional distance learning students, all of which can cause minor changes to delivery, although not insurmountable or overly problematic. The module centres around a practical activity of quantifying, or ‘measuring’ construction works from technical drawings using measurement conventions and a measurement standard, New Rules of Measurement 2 (NRM2), which is a tabulated document. The subject is entirely discipline specific and is taught only to the Quantity Surveying students, however, it does require fundamental knowledge of construction technology and interpreting construction drawings, which many non-cognate students do not have.

The institution is, in effect, dealing with two distinct cohorts within the one class make up; cognate and non-cognate students. Those with the basic skill set and exposure to construction themes, terminology and technology and those without. For instance, it may be the case this is the first time non-cognate students see detailed technical drawings and are exposed to any form of construction technology and/or terminology. The difficulty lies in where to ‘pitch’ the lesson in the limited 2-hour face-to-face class time; it may be far too basic for some students and far too challenging for others; the educators are operating at entirely different ends of the scale, despite the module being taught to only one programme of students. Birch et al., (2005) correctly identify that as a Scottish Credit and Qualifications Framework (SCQF) Level 11 qualification, postgraduate courses are expected, and should be, at a greater depth and level of complexity. This sentiment is echoed by Schaffer (2017) who questions whether this diverse student group allows for ‘equitable and effective delivery.’ No one group within the cohort should benefit over the other and all must demonstrate the same learning outcomes in order to demonstrate they are prepared for the demands of the workplace.

LITERATURE REVIEW

Utilising Technology for Diverse Cohorts

The issue of a divided and diverse cohort is addressed in a study by McKenzie et al., (2013) who found in their study that the difficulties in delivering courses to large and diverse cohorts are alleviated by adopting a blended learning approach. It is reported that the most efficient and valuable use of face to face time in class is when it allows learners, of all ages, to build on prior knowledge. Therefore, they argue that by using online learning prior to the physical classroom environment, students will be more prepared and should have a more comparable and evenly distributed level of understanding which will enhance the value of the face to face time. By having this ‘learn before the lecture’ approach, it is also recognised that cognate students will not be disadvantaged, or essentially revisiting information, by the lecturer explaining those basic concepts they are already familiar with (McKenzie et al., 2013). The proposal by McKenzie et al., (2013) is that this approach would incorporate an online ‘overview’ lecture and an ‘advanced issues’ lecture with an aim of encouraging discussion and interaction with activities both in class and online. A limitation, which the researchers recognise, is the reliance upon students engaging in independent study, which is essential for this delivery approach to be successful. Lee et al., (2013)
Morrison discusses that different personality types dictate initiative and levels of engagement and concludes that ultimately, the onus for progression is upon the individual. Interestingly, Lee (2013) also discovered within their study into interactive approaches to teaching measurement that the greater the time students spent engaging in self-study, there was an increase in their satisfaction and benefit from the interactive resources. Similarly, Hadley (2012) also found that the use of information communication technologies (ICTs) in a blended learning environment enhanced and furthered student satisfaction and face to face engagement. The study concerned the use of ICTs to create an authentic, well aligned learning environment within a diverse cohort of cognate and non-cognate students. The research argues that ICTs facilitate the different learning styles and responses to learning tools from cognate and non-cognate students, allowing students to engage in a dynamic virtual learning environment and enter materials at the level most appropriate to their current understanding. Again, the authors recognised the diverse backgrounds, aptitudes and styles from the different groups and documented the challenge to an educator of how to create and deliver innovative solutions to “the phenomenon of ‘different worlds in the same classroom’” (Perry 1998). As the research and programme desired students to be able to adapt and apply all of the foundational theoretical knowledge within the complex real-life working environment, the curriculum had a large focus upon experiential learning such as case studies and real-life scenarios. Hadley (2012) states the criticality within a vocational subject of knowledge being fully and wholly integrated with practise and reflection on that practise as paramount. The study itself used an evaluative framework which measured student reaction, student learning, student behaviour and student results and ultimately found that ICTs made possible a dynamic environment which students engaged with and it was “an effective way of satisfying different learning needs, styles and stages in a single subject” (Hadley, 2012).

The findings within the studies by Lee (2013) and Hadley (2012) are consistent with those found in Schaffer (2017) whereby immersive visualisation was used to enhance learning to a diverse cohort. The themes surrounding the idea that learning spaces are not contained to the physical classroom environment and that by employing different techniques will engage differing learning styles are explored resulting in students achieving a deeper understanding of materials. Schaffer (2017) explains that the aim of creating quality teaching and learning experiences should be to deliver ‘equitable, authentic learning opportunities that satisfy the needs and objectives of the diverse student cohort.’ This sentiment is elaborated to recognise that the expectations of a student have evolved to include use of technology. Regarding technology, Schaffer (2017) believes that factors such as varying industry requirements, learner diversity and multi-campus delivery enable new and innovative uses of technology. Additionally, Schaffer (2017) advocates the use of constructivist peer-to-peer learning within diverse cohorts and found within the study that 63% of students benefitted from discussing or questioning someone with first-hand experience and that this active engagement resulted in advancement of skill and/or understanding.

**Utilising Technology for Measurement**

Higher education generally and within the engineering and construction disciplines, has seen a greater focus on utilising technology to make teaching more effective and adaptable to differing learning styles (Naismith et al., 2017). This too is in conjunction with the changing needs of students and what Judd (2014) calls a response to the high level of ‘digitisation across the industry.’ Research conducted by
Lee (2013) specifically looked at interactive approaches to teaching quantity surveying, primarily using video and interactive power-points. The participants were a mix of undergraduate and postgraduate students from Glasgow Caledonian University. It must be noted that the research does not differentiate the response between undergraduate or postgraduate, nor does it allude to non-cognate students within the postgraduate group. Another point to be cognisant of is, at the time of conducting the research, the student numbers were significantly lower than present times and technology, both within and out-with the academic setting, has advanced in such a way that the students’ expectations have changed and the institutions capabilities (and appetite) to incorporate technology has also changed. None the less, the respondents felt at the time that the interactive approach had enriched their learning experience whilst it was found that 39% of respondents felt the video and interactive power-points had efficiently delivered the module and 32% felt they had aided in their understanding of construction drawings (Lee, 2013). This last finding in particular is beneficial to the current challenge whereby there is a lack of fundamental knowledge in reading construction drawings by non-cognate students. This research builds upon the study by Lee and seeks to address the differentiation between cognate and non-cognate students’ responses within the mixed cohort of a taught post graduate programme to observe whether the adoption of a blended learning approach increases the learning, teaching and understanding of each set of students.

**METHOD**

**Current Delivery**

Having inherited the module two years previously and being exposed to this documented problem, students have consistently communicated their difficulties; via email, verbally or within the feedback week (carried out in week 6 of the 12 week teaching trimester) and module evaluation surveys (undertaken at the end of the academic trimester). As an immediate fix or ‘band aid’ to assist in understanding, in the 2017-2018 academic session, a remedial class was held where, as expected, only non-cognate students chose to attend. This recurring problem, and the changing demographic of the cohort in line with industry appetite for quantity surveyors, lead the module team to consider the effectiveness of the long-practised delivery of the module. All information; drawings, measurement standard, solution, power-point explanations of both the measurement standard and solution for each weekly theme are uploaded and released on the virtual learning environment (VLE) in advance of the module starting. Supplementary to the foregoing weekly themes are learning resources which are populated with relevant sources and any additional resources as a result of queries uploaded as required with an announcement posted to notify students of any changes. The students are presented with the drawings and solution as hard copies in class on the day of the theme, however, the team do not actively facilitate engagement with the materials in advance of the class by means of activities or some such on the VLE. Unless a student has self-engaged with the content, which had not been found to be common, they are generally seeing the materials for the first time in class which can be overwhelming due to the collation of multiple new and different information types, particularly for those who are non-cognate. This conventional approach involves relatively limited use of technology besides power-point and the challenge of teaching measurement by these means has been documented in literature (Hasan and Rashid 2005 cited in Lee, 2013; Wong et al., 2018).
Enhancement: Virtual Forum

Considering the reviewed literature and studies within the context of the work-based challenge, the proposed enhancement of a blended learning approach to the current delivery of the Quantification and Costing of Works module was trialled in Trimester B of the 2018-2019 academic session. The module consisted of 55 students; 27 Glasgow based, 23 London based and 5 Distance Learners.

An immediate action for the module’s virtual learning environment was to establish a Q&A forum through the use of ICT, a tool which was established as effective within the research by Hadley (2012). Padlet, a collaborative electronic platform, was embedded into the University VLE. It was important to choose a platform that could be integrated with the current VLE as it was felt this could increase the likelihood of students engaging with the platform. Another benefit of choosing Padlet was that questions could be posted anonymously which would again, increase the likelihood of student engagement and provide equal opportunity for quieter students. A benefit for staff and students alike was that when answering queries on the forum, this would ensure that all students, irrespective of their location, would receive the same guidance, thus ensuring fair and equitable guidance and support.

In terms of the implementation, an announcement notifying students of this forum and its preference for queries was made and again reinforced as well as shown on the projector within the module induction sessions. As this was the first instance the students had seen this platform, instructions on how to utilise the forum were also given both electronically and demonstrated in class. A change in the face-to-face classroom delivery that was incorporated was to facilitate a discussion on any updates that had been made to the virtual Q&A forum and the lecturer could provide further clarification of their responses to ensure student understanding, effectively providing further feedback. This often devolved into a class discussion whereby cognate students elaborated to provide first-hand experience or anecdotes on related matters. This peer to peer learning approach enriched and added value to the face-to-face time for students to allow them a broader and deeper mode of learning as is consistent with the social constructivist theory of learning (Yardley et al., 2012). In order to maximise the use of the forum, students were informed at the beginning of the module that for technical content queries, the forum would be prioritised over email queries. It was also recognised that it was important to demonstrate to the students the staff commitment to this teaching tool. Therefore, it was updated regularly to ensure it would not become redundant as the trimester progressed. The daily Padlet notification email of new posts on the forum became critical to the management of the forum amongst competing work priorities. Should there be a post requiring a response, the lecturer would be notified of it daily. If there were no new post notification emails within a week, the lecturer would update the forum with helpful best practice tips or links to relevant articles or news stories which may have been discussed in class time.

Enhancement: Interactive Voiceover Power-Point Videos

Building upon Lee’s (2013) Research of interactive approaches to teaching measurement, staff were keen to confront the disparity in construction technology knowledge and found that the use of voiceover presentations would allow them to explain technical matters in more detail than visual power-point alone when students were studying independently. The use of Camtasia, a video tutorial software, was employed for three of the twelve module themes. The considerations for creating and
implementing voiceover video presentations for three themes were the time constraints and skill level to implement and learn the software, converting only one theme would not be appropriate for comparison to the current delivery mode and the student evaluation would provide the evidence of whether this approach was suitable and successful to be implemented.

Each theme was split into an Introduction, explanation of the measurement standard and technology knowledge required, the practical measurement activity and to complete the process, production of a bill of quantities with an additional tab for supplementary information. The practical measurement activity itself was broken into defined sections to assist student understanding. In producing a tabulated breakdown of the entire theme, staff managed to mirror the process expected of the students for their assessment. Module materials have also become more accessible as this video format includes both written visual text and audio. Interactive learning materials and techniques were also incorporated in addition to the voice over power-point videos, this varying format made the activity more engaging for the student (Wong et al., 2018). For instance, in addition to text and images, there are drop down information tabs for specific sections, which upon clicking on, further information will be revealed. Also used are ‘pop out’ extracts from the measurement standard with pertinent areas highlighted to emphasise importance, thus collating the various sources of information the students are also required to do for their understanding and assessment. Materials for the entire module, including the interactive video materials were again made available for all students at the beginning of the module, allowing students from the multiple delivery modes the module caters for to access them at their own pace and giving students ownership of their own learning. The decision to release materials before the timetabled class delivery enabled lecturing staff to suggest students should review the preliminary technology section prior to the classroom. This was primarily for the benefit of the non-cognate students although this was not made clear or distinct in communications to the students.

DATA COLLECTION AND METHODOLOGY

Qualitative data, with supporting quantitative data, has been collected over recent academic sessions in order to compare previous delivery modes with the enhanced delivery and achieve the research aim which is concerned with the student perceptions, experiences and narrative in whether they have been effectively and equitably supported in their learning and understanding (Amaratunga et al., 2002; Dul and Hak, 2008). The evaluative tools are the mid trimester feedback week and the module evaluation questionnaires (MEQs) At the conclusion of the module to provide the comparison between previous cohorts in evaluating the student reaction and engagement to the differing delivery styles.

The module surveys allow the student’s to honestly provide feedback on the module and the enhancements in a format they are familiar with as it is a standard University wide process and they have also been informed the data would be used to inform teaching practise on the module. In the event the enhancement was not successful a review of the implementation and evaluation would take place and a plan devised to rectify the problem for the following academic session, perhaps trialling the other enhancements which the literature has identified as successful. Should the proposed solution be effective, it is hoped all themes and/or other modules would adopt the approach. The evidence based blended learning enhancement should be a positive addition to the postgraduate quantity surveying programme whilst resolving the
problems inherent in the teaching of, and in the learning of, a diverse cohort consisting of both cognate and non-cognate students.

EVALUATION OF RESULTS / ANALYSIS AND FINDINGS

Pause for Feedback Week Survey

There were 10 questions which determined the method of delivery (Glasgow, London or Distance Learner), something going well on the module, something going not so well, their engagement on the module and with the material, whether they had difficulties and if they had been resolved, their progression on the module and lastly, if they had any further comments to make. The survey was issued to 55 students in the 2018-2019 academic session with only 10 choosing to respond, a response rate of only 18%. This compares with a previous response rate of 55% in the 2017-2018 academic session. Within the 2018-2019 cohort, of the 10 responses, 50% were Glasgow based and 50% London based, with no Distance Learner responses. The low response rate can be attributed to the engagement and incentive of any individual student as also found by McKenzie et al., (2013). There is no graded element or incentive to completing the survey, and therefore, some students do not see any merit in completing an evaluative survey. The response rate has limited the authenticity of the research in terms of it’s capturing a sufficient sample of the cohort. Nonetheless, for those respondents asked what was going well on the module, 6 mentioned specifically an anonymous Frequently Asked Question (FAQ) Forum which had been set up within the virtual learning environment as providing quick and effective support on the module, with one student respondent suggesting it increased interaction ‘with the lecturer and the students from the other campus.’ This was an interesting response as it confirmed that the enhancement proposal to foster a collaborative community feel amongst the students through the use of ICT was successful and aligned with the University’s Strategy for Learning. The recurring theme to the responses when asked what was not going so well on the module was a timetabling issue. Of the 10 respondents, 2 chose not to answer this question, however, 100% of the remaining respondents were unhappy with either their 2-hour weekly delivery, or 2-day delivery every 4weeks. This issue is out-with the scope of this research and to that effect is disregarded.

When asked whether they felt they were progressing on the module, 9 felt they were and 1 respondent did not feel they were progressing, however, elaborated to say that they were devoting study time to another module they found more challenging. In terms of evaluating student engagement out-with mandatory attendance at taught classes, respondents were asked how often they accessed the VLE and/or consulted their notes/study for the module. Responses varied in that 3 chose not to answer, 50% accessed ‘a few times a week’ and the remaining 2 respondents were weekly, however, increased closer to submission deadlines. Again, interestingly, the correlation between engagement and graded assessment is admitted by the respondents who increase their interaction and engagement at assessment time. Next, respondents were asked whether they felt the use of technology and the ‘blended learning’ approach had aided their understanding of the module themes. Two chose not to answer, however, 100% of the remaining students, again specifically mentioned the FAQ forum as a beneficial tool to obtain answers to queries, whether they asked themselves or someone had already asked and had a response. One student mentioned that it provided a fair means of answering queries, in order that all students had the same answer and no one person was advantaged/disadvantaged by varying responses.
Two of the non-cognate students mentioned that the use of video simulations and voice over materials on power-points assisted in their studying and understanding of construction technology and the measurement themes respectively. Coincidentally, these materials have also assisted in ensuring materials are accessible by all.

**Module Evaluation Questionnaires**


![Figure 1: Glasgow Module Evaluation Questionnaire Quantitative Data](image)

Figure 1 presents data from the Glasgow cohort MEQs. In each of the three questions pertinent to the enhancement; staff making the subject interesting, effective use of learning technology and sufficient advice and guidance in their module, there has been consistent improvement over the past 3 academic sessions. In terms of staff making the subject interesting, an indicator of interactive materials, enthusiasm and student engagement there has been an increase from 36% to 78% of students agreeing with this statement. Similarly, effective use of learning technology to support learning has seen an increase of 47% from 36% to 83%. Although these results are encouraging, it must also be noted that the module team has changed since the 2016-2017 delivery, however, the same module team operated in the following two academic sessions and from 2017-2018 to when the enhancement was trialled in 2018-2019 there has been a consistent increase across all three questions.

![Figure 2: London Module Evaluation Questionnaire Quantitative Data](image)

Data is not available for the 2016-2017 session. The results for the London cohort are not consistent with that of the Glasgow cohort, however, there are items which have
had an effect on the data, the staff delivering the module between the academic
sessions changed and complications arose, it is believed this has compromised the
overall student experience and their quantitative responses. Figure 2 does show an
increase in the Learning Technology question and qualitative comments support this
with students stating ‘the Q&A forum was an excellent addition…quick
responses…seeing other students’ questions,’ ‘from a non-cog background I was able
to grasp the concepts well from the information on blackboard’ and one mentioning
‘engaging while making it interactive.’ These comments are supportive of the
enhancements.

CONCLUSIONS

Literature pertinent to diverse cohorts, blended learning techniques and the
practicalities of teaching measurement modules was undertaken to establish a suitable
enhancement proposal which was cognisant of the varying modes of delivery and the
diversity of the cohort. The enhancement proposal comprised of a blended learning
intervention focussed upon a Q&A forum and interactive video materials. A number
of considerations had to be made in order to confront this challenge which included
attitudes of colleagues to embracing change in respect of technology and both the time
and prevailing skill level available in which to implement changes amidst competing
work demands.

It is shown in the data that students found the Q&A forum an overwhelmingly
successful support tool, however, the interactive voice over materials have had less of
an impact on their learning. This is interesting as planning, preparing and creating the
interactive materials was far more time consuming and required a higher skill set, such
as assistance from a Learning Technologist. This could suggest that the benefit of
these materials is not currently sufficient to implement for further themes at this time
without revision or changing the implementation strategy or perhaps this cohort of
students have not appreciated the advantage of preliminary information prior to class
that other cohorts, challengingy, did not receive. The Q&A forum however, is
certainly a tool that staff will use again in modules and would like to encourage their
colleagues to also use within their modules as an efficient and helpful means of
answering student queries, particularly amongst the differing delivery modes and
volume of students within the Programmes. From the data it is also not strongly
shown that the social constructivist approach enabled the cognate and non-cognate
students to share their experience/knowledge, there was a suggestion the Q&A forum
assisted as they could see one another’s responses, however, they chose not to interact
with each other. This is an area that we would like to try to develop and facilitate
more in subsequent academic sessions in order to use a currently untapped opportunity
on the Programme of peer to peer learning and assisting students in reaching their
zone of proximal development without disadvantaging any particular group.

In this instance of a reasonably small response sample, blended learning was well
received by students, particularly the non-cognate students and has assisted in the
diverse cohort and individual students learning and understanding in the most
effective and equitable way aided by technologies. It is hoped this evidence supported
enhancement of utilising the virtual learning environment more effectively to support
students can assist in resolving the problems inherent in the teaching of, and in the
learning of, a diverse cohort consisting of both cognate and non-cognate students.
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MAKING SPACE FOR CONSTRUCTION PRODUCTIVITY STUDIES
THE IMPACT OF SKILLED LABOUR SHORTAGE ON CONSTRUCTION PROJECT PRODUCTIVITY

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Over the past decades, construction industry in many countries has experienced, at least in some regions and/or periods of time, a shortage of skilled/experienced craft labour. Craft workers are the major performers in executing the processes and activities in construction, hence the influence of skilled labour availability on construction productivity is substantial. Data from 97 construction projects completed in the United States and Canada were collected from two databases. The analysis shows that higher shortage of skilled labour in construction projects resulted in hiring higher percentage of less skilled/experienced craft workers and also higher percentage of extended overtime. These two factors contribute to the decline in project productivity. The analysis on two different databases demonstrate that there is a significant relationship between increased skilled labour shortage and decreased project productivity. The national and regional short-term and long-term workforce policies can provide fundamental solutions to the chronic problem of relatively lower productivity in construction projects.

Keywords: skilled labour shortage, productivity, skills gap, overtime

INTRODUCTION

Construction is a labour-intensive industry. Craft workers are the major performers in executing the processes and activities in construction, hence they have a significant influence on labour productivity (Maloney 1983). In addition, labour costs account for 30-50% of the total cost of a project (McTague and Jerges 2002) which highlights the critical role of craft workers to the overall construction productivity.

Over the past decades, construction industry in many countries has experienced, at least in some regions and/or periods of time, a shortage of skilled/experienced craft labour. The challenge has been discussed frequently in the past literature such as Goodrum (2004) and Taylor et al., (2016) in the US, Mackenzie et al., (2000) and Dainty et al., (2005) in the UK, Lobo (2008) in New Zealand, Shah and Burke (2005) in Australia. Projects encountering craft labour shortages endure difficulties in recruiting and retaining a required level of skills and/or quantity of craft labours. A productivity of a project executed under these conditions is highly likely to be affected adversely. The aim of this study is to identify how and to what extent the shortage of skilled labour can impact the construction project productivity.

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LITERATURE REVIEW

Craft Labor Shortage: Definition and Concept

U.S. Bureau of Labor Statistics defines craft shortage as the condition which “occur in a market economy when the demand for workers for a particular occupation is greater than the supply of workers who are qualified, available, and willing to do that job”. Shah and Burke (2005) believe that, in practices, there are different perspective on the concept of skilled labor shortage, hence, different definitions can be referred to this concept. They refer the aforementioned definition as the economics’ perspective on craft shortage. They stated that employer’s perspective is more about internal skills deficiency, skills gap or condition that employers need to react, in the short run, to the increase in production demand and they are unwilling to offer competitive wages.

When project managers express that they encountered skilled workers shortage, they have faced one or both of the quantity and quality issue. The quantity issue refers to the condition that a project cannot even meet the basic labour demand. Shah and Burke (2005) used the term “Hard-to-fill vacancies” and defined it as “the condition that employers are unable to fill or have considerable difficulty filling vacancies for an occupation at current level of remuneration and condition of employment and reasonable location after reasonable period”. They believe that this condition typically happens for highly skilled trades. The quality issue or skills gap occurs when existing craft workers lack the required qualification/experience. In this situation, a project usually is executed with less skilled/experienced craft workers. The decision on the qualification of workers can be made by tests performed by a company before hiring, the certificate of completing the training programs, or a number of years of experience (CII, 2015; Goodrum, 2004)

Causes of Craft Shortage in Construction Projects

The shortage of craft worker in a construction project can be emerged from two main reasons: 1) regional craft worker demographic and labor market of a region a project is executed, 2) project specific characteristics, planning and management strategies. A region’s labor market is mainly determined by socio-economic conditions, demographic trend and demand for construction projects in a region. Albattah et al., (2019) identified 15 reasons for workforce shortage which are related to the labour market and hence are beyond the control of project managers. On the other hand, a project planning and management strategy which is primarily influenced by project management team can also initiate a shortage of skilled labour in a project in a normal labour market. For instance, it is common for owners to require contractors to complete projects in less than the normal time frame of projects or to complete the additional work within the original schedule. The schedule compression is a prevalent solution for these conditions. Chang et al., (2007) demonstrate that implementing this strategy require additional man-hour per week due to generated inefficiency. In addition, this strategy can increase the labour demand particularly at peak. Chang et al., (2007) defined two variables of “actual peak/estimated peak” and “actual average manpower/estimated average manpower” as variables indicating the change in level of demand of craft labour in projects.
Impact of Skilled Labour Shortage on Productivity

The Impact of Skilled Labour Shortage on Productivity: Evidence from Previous Studies

The past literature identified construction productivity as a complex function of various factors. For instance, Dai et al., (2009), identified 83 factors affecting construction labour productivity. However, in the majority of past research which are mainly opinion-based studies, the contribution of availability of skilled labour on project productivity has been highlighted. Table 1 summarizes the research methods and findings of these studies.

Table 1: The evidence of the impact of craft labour availability on construction project productivity in previous studies

<table>
<thead>
<tr>
<th>Authors (Year)</th>
<th>Methodology</th>
<th>Summary of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homer et al., (1989)</td>
<td>Survey among British contractors about factors of labour productivity</td>
<td>Skill of labour ranked as the most influential factor and quality of supervision as the third factor among 13 identified factors.</td>
</tr>
<tr>
<td>Dai et al., (2009)</td>
<td>U.S. national-wide survey on 2000 craft workers to assess the impact of 83 identified factors on labour productivity</td>
<td>Ten groups of factors that represent the underlying structure of the productivity were identified. Four factors were related to labour issues: Training, Craft worker qualification, Superintendent competency, and Foreman competency.</td>
</tr>
<tr>
<td>Roja and Arunvareekul (2003)</td>
<td>Survey of U.S. based owners, consultants, general contractors to identify the relative importance of factors affecting labour productivity</td>
<td>The factor category of Manpower was ranked as the 2nd most influential on labour productivity among four factor categories. This factor includes experience, activity training, education, motivation, and seniority.</td>
</tr>
<tr>
<td>Liberda et al., (2003)</td>
<td>Interview with Canadian professionals to prioritize the productivity factors</td>
<td>“The worker experience and skills” was ranked the 2nd most critical factor among 51 identified factors influencing project productivity.</td>
</tr>
<tr>
<td>Lim and Alum (1995)</td>
<td>Survey among contractors in Singapore about factors of construction productivity</td>
<td>Difficulty in recruitment of supervisors and workers were the 1st and 2nd most important factors among 17 identified factors.</td>
</tr>
</tbody>
</table>

Projects experiencing a shortage of skilled workers may also have a tight scheduling in order to meet a project deadline. Overtime scheduling has become the prevalent option in this situation as it accelerates a project schedule and also an associated premium pay with overtime can attract the required workforce to complete the project (Hanna et al., 2005).

There is a general consistency in literature on the overall loss of efficiency due to the scheduled overtime. The loss in efficiency can be due to the fatigue and decrease in labour motivation (Halligan et al., 1994) or the inability to provide material, tools, equipment and information at an accelerated work (Randolph and Raynar, 1997). Hanna et al., (2005) developed a quantitative model that estimates a loss of work hours due to inefficiency caused by overtime.

Point of Departure

The past literature provides a wealth of information on the impact of skilled labour shortage on recruiting and retaining of labour in the context of construction projects. In addition, it provides strong qualitative support for the influence of skilled labour availability on construction productivity. This study attempts to quantitatively elucidate the mechanism of the loss of productivity when a project is executed under the shortage of skilled labour circumstance.
RESEARCH METHODS

Data Source

The data used in this research were obtained from two different databases. The first source was a primary data collection effort through a Construction Industry Institute (CII) Research Team 318 (RT-318) survey. This survey collected project performance and workforce demographic data on completed construction projects in the U.S. and Canada. All projects in this database were performed and completed between 2007 and 2014. The second data source was obtained through the Construction Industry Institute (CII) Benchmarking and Metrics (CII BM&M) database. The CII BM&M database was designed to capture comprehensive data of construction projects performed by CII member companies. For the purpose of this research, the projects in this database that reported data related to the availability of craft workers were selected. All projects in this database were performed and completed between 2001 and 2013. Table 2 shows the detailed information of these projects in both databases. Additional details of the survey effort were described by Taylor et al., (2016).

Table 2: Summary of projects size in RT-318 Survey and CII BM&M Database

<table>
<thead>
<tr>
<th>Database</th>
<th>Project Size</th>
<th>Average (Median)</th>
<th>Min, Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT-318 Survey (29 projects)</td>
<td>Actual Cost (SM)</td>
<td>455.15 (45)</td>
<td>3.6, 8549</td>
</tr>
<tr>
<td></td>
<td>Actual Schedule (Day)</td>
<td>554.65 (333)</td>
<td>134, 1648</td>
</tr>
<tr>
<td></td>
<td>Craft Work Hour (1000 hr.)</td>
<td>610.63 (321)</td>
<td>13.3, 3777.9</td>
</tr>
<tr>
<td>CII BM&amp;M (68 projects)</td>
<td>Actual Cost (SM)</td>
<td>142.49 (40.1)</td>
<td>0.5, 1799.3</td>
</tr>
<tr>
<td></td>
<td>Actual Schedule (Day)</td>
<td>1054.48 (678)</td>
<td>46, 3131</td>
</tr>
<tr>
<td></td>
<td>Craft Work Hour (1000 hr.)</td>
<td>732.5 (110)</td>
<td>2.5, 8870.6</td>
</tr>
</tbody>
</table>

Skilled Labour Availability Measurement

In both databases, an estimate of the level of craft shortage in projects relied on subjective evaluations of the project management team. In the RT-318 survey, the respondents were asked to indicate the level of craft staffing difficulty they experienced on their project for 13 main craft labour trades. There were five levels of staffing difficulty defined in the survey ranging from No Difficulty to Very Severe (Table 3).

Table 3: Levels of craft staffing difficulties in the RT-318 survey

<table>
<thead>
<tr>
<th>Level</th>
<th>Definition</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>No difficulty</td>
<td>There was no shortage. Able to staff the project with no delay on construction</td>
<td>0</td>
</tr>
<tr>
<td>Slight</td>
<td>Staffing difficulties led to consumption of schedule float and/or contingency</td>
<td>1</td>
</tr>
<tr>
<td>Moderate</td>
<td>Staffing difficulties led to delay of completing project activities on time</td>
<td>2</td>
</tr>
<tr>
<td>Severe</td>
<td>Staffing difficulties led to delay of completing project milestones</td>
<td>3</td>
</tr>
<tr>
<td>Very Severe</td>
<td>Staffing difficulties led to project delay</td>
<td>4</td>
</tr>
</tbody>
</table>

To provide an overall level of craft staffing difficulty for each project, the authors calculated an average score of craft staffing difficulty across these 13 trades for each project. In the CII BM&M database, the respondents indicated the level of availability of skilled labour across all trades compared to what had been specified during the planning stage of their project. These levels ranged from Extremely
Impact of Skilled Labour Shortage on Productivity

Negative (-5) (i.e. extreme shortage) to Extremely Positive (+5) (i.e. extreme surplus), and Zero represents an “As Planned” situation.

Quantitative Craft Staffing Variable

The RT-318 survey collected the quantitative staffing data of the estimated and actual number of peak crafts for each 13 trades. The variable of "Craft Peak Change" provides the quantitative measurement of the change in workforce demand in trades and can be calculated as follows:

\[
\text{Craft Peak Change} (\%) = \frac{\text{Actual number of peak craft} - \text{Estimated number of peak craft}}{\text{Estimated number of peak craft}} \times 100
\]

in which the “number of peak crafts” is defined as the maximum number of craft workers on site for a single day on a project.

Project Skills Level Measurement

To estimate an overall level of skill/experience of recruited craft workers, the RT-318 survey asked respondents to indicate the percentage of less skilled/experienced craft workers hired in each 13 trades in projects. These levels were defined as “Less skilled craft ratio” with the scores of between 0 to 5 which represents the percentage of less skilled/experienced craft workers ratio to the total craft recruited in each trade. The scores were defined as follow: (0) None, 0%; (1) To Some Degree, <25%; (2) Moderate, 25 to less than 50%; (3) Very Much, 50 to less than 75%; (4) Almost Completely, 75 to less than 100%; and (5) All, 100%.

Productivity Observations

For each project in the RT-318 survey database, the productivity Performance Factor (PF) was calculated as follows:

\[
\text{Performance Factor (PF)} = \frac{\text{Estimated Total Craft Work Hours}}{\text{Actual Total Craft Work Hours}}
\]

In the CII BM&M database, the respondents indicated the level of overall perceived construction productivity compared to what was expected at the planning stage of a project. These levels range from an “Extremely Negative” (-5) (i.e. very low level of productivity) to an “Extremely Positive” (+5) (i.e. very high level of productivity), and Zero represents an “As Planned” situation.

DATA ANALYSIS

The data analysis of this study comprises four sections. The first section examines the impact of variables of "Craft Peak Change" on craft staffing difficulty experienced in trades in projects. The second section examines the impact of craft shortage on level of competency and skill of recruited craft workers. The third section examines the relationship between craft shortage and overtime. The last section examines the influence of craft shortage on construction project productivity performance. In all sections, the regression analysis was performed to examine the hypothesis. The null hypothesis for each analysis is that there is no relationship exists between variables. The alternative hypothesis is that there is a significance relationship between variables, which was determined by obtaining the p-value of less than 0.05.

Impact of Craft Staffing Planning on Craft Shortage in Construction Projects

The first analysis was a multiple regression analysis conducted between craft staffing difficulty (dependent variable) and two variables of actual number of peak and peak
change in trades (predictor variables) in projects. As shown in Table 4, the analysis returned the regression model contains both two predictor variables. The p-value of the model was 0.011 which indicates the adequacy of the model. The $R^2$ value of the model is 0.16 with an adjusted $R^2$ of 0.13.

**Table 4: Regression analysis of impact of peak change on craft labour shortages (RT-318 survey)**

<table>
<thead>
<tr>
<th>No. Trades</th>
<th>Dependent Variable</th>
<th>Constant</th>
<th>Actual Number of Peak</th>
<th>Craft Peak Change (%)</th>
<th>F</th>
<th>P</th>
<th>R²</th>
<th>Adj. R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>Craft staffing difficulty</td>
<td>0.324*</td>
<td>0.003*</td>
<td>0.012**</td>
<td>4.95</td>
<td>0.011</td>
<td>0.16</td>
<td>0.13</td>
</tr>
</tbody>
</table>

* = t-statistics significant at 0.1, level; **= t-statistics significant at 0.05 level

The regression analysis between craft staffing difficulty and less skilled craft ratio elucidates how craft shortage influence the level of skill and competency of recruited craft workers. The total number of data points in this analysis was 125 trades. The analysis shows the linear association between increased craft staffing difficulty and increased less skilled craft ratio. The p-value of 0.000 affirms that there is a significant influence of craft labour shortage on skill/experience level of hired workers. The $R^2$ value of the equation is 0.67. Fig.1 illustrates the regression model.

![Fig 1: Regression analysis of craft staffing difficulty and skill level of workers (RT-318 survey)](image)

The next analysis examined whether projects with a higher level of skilled labour shortage tend to use more overtime. The total number of projects reporting overtime data in the CII BM&M database was 30 projects. The questionnaire defined overtime percentage hour as the ratio of work hours performed above 40 work hours per week to the total work hours.

The regression analysis returned a linear equation that demonstrated the lower level of availability in skilled labours was associated with a higher percentage of overtime hours in projects. The p-value of 0.034 indicates the significance of the association. The $R^2$ value of the equation is 0.16. The model can be seen in Fig 2.

The next regression analysis was performed to examine the relationship between craft staffing difficulty and project productivity in RT-318 Survey projects. The total number of data points in this analysis was 20 projects. The analysis shows the linear association between increased craft staffing difficulty and a decreased productivity factor. The p-value of 0.005 allowed us to conclude that there was a significant
impact of skilled labour shortage on productivity. The $R^2$ value of the equation is 0.36. Fig. 3 shows the regression model.

**Fig 2**: Regression analysis of Skilled Labour Availability and Overtime (CII BM&M database)

**Impact of Skilled Labour Availability on Construction Productivity**

The regression analysis also was performed between the skilled labour availability variable and the construction productivity factor in the BM&M database. The total
available data points for this analysis was 67 projects. The analysis shows that lower availability of skilled labour resulted in lower overall construction productivity. The p-value of the model was 0.000 which indicated the adequacy of the model. The $R^2$ value of the model was 0.43.

**Summary of the Result**
Fig. 5 illustrates the processes of the influence of skilled labour shortage on construction project productivity. The studies are those that demonstrate the impact empirically.

**DISCUSSION AND CONCLUSION**

The main purpose of this research was to quantitatively elucidate the processes of the influence of skilled labour shortage on construction project productivity. The craft shortage is mainly due to the labour market of a region that a project is executed. However, the planning and management strategy of project managers also can initiate the shortage in a project. The result of analysis shows that increase in number of required labours at peak plays a key role in experienced level of shortage in a project. The result also shows that when project managers encountered labour shortage, they hired higher number of less skilled labours. The higher $R^2$ in the analysis of skill level of labours (Fig. 4) compared to the one in the quantity issue analysis (Table 4) (0.67 vs. 0.16) implies the fact that skills gap is more substantial issue than “hard to fill vacancies” issue as it explains the variability of craft shortage better in projects executed under craft shortage circumstance. The result also indicate that project managers tend to use more overtime when they faced craft shortage. The low level of skill/experience of hired craft workers and also extended overtime contribute to the loss of efficiency in construction projects. The result in two different databases demonstrate that the higher level of shortage of skilled labour is associated with lower construction productivity. The study contributes to the body of knowledge by empirically elucidating the processes of the influence of skilled labour shortage on construction productivity. It supports and validates the previous qualitative studies that used opinion-based data to link the shortage of skilled labour to lower project productivity.

The study provides new realization for researchers and practitioners that the impact of skilled labour shortage on project productivity is significant and can be through hiring the less skilled labours and/or extended overtime. The study suggests industry leaders, decision makers and construction stakeholders that one of the fundamental solutions to the relatively lower productivity in construction industry is to invest on hiring, training and retaining of construction craft labours. The national and regional short-term and long-term workforce policies are required to address this challenge.
REFERENCES


Taylor, Karimi, Minooei and Goodrum


THE INFLUENCE OF PEOPLE-CENTRED MANAGEMENT ASPECTS ON CONSTRUCTION WORKERS' PRODUCTIVITY IN ZIMBABWE

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³ Department of Built Environment, Central University of Technology, Free State, Mangaung, 9300, South Africa

Low construction labour productivity is a challenge in developing countries. Among the factors contributing to low labour productivity, the lack of a people-centred approach to managing workers on sites has not been empirically interrogated in Zimbabwe. This paper reports on a study that sought to determine significant people-centred management aspects that lead to improved labour productivity. In addition, the study aimed at determining the existence of statistically significant differences due to the demographic variables of respondents. The design of the research follows a quantitative method strategy that enabled the collection of statistical data, through interviewer administered questionnaires, from on-site construction workers in Zimbabwe. The study obtained the perceptions of skilled and semi-skilled workers from six residential and seven commercial building projects in Harare, Bulawayo and Shurugwi. The selected trades were limited to bricklaying, carpentry and joinery, and painting as these are the most populated trades as well as being critical path activities. Descriptive and inferential statistics were used for data analysis. The results suggest that, though all people-management aspects considered were significant regarding improving labour productivity, their efficacy is most dependent on a progressive reward system within construction companies. Further to this, the responses indicate a statistically significant difference in respondents’ perceptions due to their educational levels, with those with no technical or vocational education requiring more attention. Interventions include incorporation of behavioural conditioning in people-centred values and the encouragement of Zimbabwean construction companies to implement people-centred management aspects within their construction sites. A recommendation from the study was fundamental instruction in people-centred management aspects that potentially promotes productivity enhancement prior to their entering and within the world of work.

Keywords: labour, productivity, projects, Zimbabwe

INTRODUCTION

Notwithstanding the performance of the construction industry being dependent on the performance of construction labour productivity (Nasirzadeh and Nojedehi 2013), Zimbabwe has for some time now suffered from suppressed economic growth emanating from low productivity (Zimbabwe National Employment Policy Framework, 2009). This has been characterised by time overruns and high labour costs on construction projects (Kazunga 2012). Inevitably, there has been an accumulation of costs associated with poor productivity which has resulted in production costs skyrocketing (Zimbabwe National Chamber of Commerce 2015).

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 Whilst management and manpower-related factors have been identified as being significant in enhancing construction labour productivity (Chigara and Moyo 2014), limited research regarding this determinant has been undertaken within the Zimbabwean context. This is despite the fact that Suliman and Abdelnaser (2009) emphasised that the improvement of working environment quality, opportunities for employee development and employment equity have become critical. The International Labour Organisation (2018) further concurs by highlighting the need for changing the organisation for production and work and the accompanying employment relationships. Anticipated gains include promoting respect and fair treatment of workers, enhancing and better protecting the natural environment, and increasing profitability and competitiveness (Smith and Pitt, 2011). Therefore, this study seeks to determine the most significant people-centred management aspect that improve labour productivity. Further to this, an examination into statistically significant differences due to construction skilled and semi-skilled workers’ demographics of age, gender, educational level and experience will be sought. Demographics play a key role in ascertaining the effectiveness of people-centred management aspects on construction sites. The variability of workers’ requirements is borne out in their demographic profile as shown in studies by Eliufoo (2007) in which the manifestation of gendered divisions on construction sites was acknowledged. However, Magwaro-Ndiweni (2016) lamented the gross gender imbalance within the Zimbabwean construction industry due to unequal opportunities and treatment. Burgess and Connell (2015) also concluded that workplace vulnerability is dependent on gender, level of skill, age and ethnic status and intervention methods are reliant on these demographic stratifications. Demographic considerations ensure a robust integration of people-centred management aspects for all skilled and semi-skilled construction workers to enable holistic targeted short- and long-term interventions.

**People-Centred Management**

Hasan, Baroudi, Elmualim and Rameezden (2018) confirm that the influence of different management approaches is paramount in productivity studies. Kocer (2014) reiterates that the idea of productivity can carry a dangerous seed of self-destruction if it is dissociated from societal concerns and if it is too mechanical. Whilst production-centred management is mechanical and still predominant, a deliberate attempt to focus on people-centred management as it relates societal concerns (Rekonen and Bjorklund, 2016) is essential. In addition, production-centred management approaches are primarily focused on increasing efficiency, whilst people-centred management approaches target people relationships and cooperation within organizations in order to achieve higher productivity (Hasan et al., 2018). Further to this, the people-centred management approach has been proffered as a suitable alternative (Kocer, 2014; Rekonen and Bjorklund, 2016; Hasan et al., 2018) owing to its advantages of solidifying co-operation, building trust, growing satisfaction and augmenting individual and team performance (Anzebgruber, et al., 2017). Despite this, people centred approaches can have greater cost implications due to the need to have a more strategic human resources function (Bainbridge, 2015) and lead to lessor management control which can have a detrimental effect on productivity (Feldman, Khademian and Quick, 2009). However, people-centred management aspects involve showing concern for the welfare of workers and appreciation of their efforts (Casimir and Ng 2010).
People-Centred Management Aspects

The various aspects are derived from significant factors that affected labour productivity as proffered by Chigara and Moyo (2014) and Kumar, Duhan and Haleem (2016) and key aspects of people management as proffered by Toor (2008). Low labour productivity factors included; poor management practices, poor relations between management and workers, lack of incentive schemes, lack of team work and lack of worker respect and recognition amongst others. Thus, derived aspects reviewed herein include adopting and implementing people-centred values and flexible management; motivating workers; encouraging teamwork; upholding workers’ rights; and practising inclusive and accessible management. Black and La Venture (2017) state that people-centred organisational cultures operate on the precepts that all people are important, that people shape an organisation, and that happy people working together perform at higher levels. Toor (2008) reiterates that the human resource remains a very important element and asserts that people-oriented factors have gained an incremental focus in project management compared to other aspects. Black and La Venture (2017) proffer primary drivers to people-centred organisations’ competitive advantage that include the belief that open communication increases productivity and profits, employees should be viewed as long-term investments and happy workers yield high returns. Toor (2008) proffers people-management factors as those that create best practice, enhance productivity and workforce satisfaction of working conditions, and create value through implementing incentives and awards schemes.

Certo (2008) supports teamwork in organisations owing to its ability to motivate employees, inspire enthusiasm and encourage responsibility. Teams have the advantage of increasing productivity and commitment from workers (Mathis and Jackson, 2011). Thus, employees exposed to teamwork have the advantage of being more productive and delivering high quality work (Certo 2008). However, Lussier and Hendon (2013) argue that the effectiveness of teamwork is largely based on the quality of on-site leadership on construction sites. Consequently, Bainbridge (2015) recommends the refining of job descriptions to reflect people-centred management responsibilities to promote accountability and consequent efficiency as a way of empowering employees and promoting inclusivity. Janicijevic (2013) avers that correcting, transforming and motivating employees’ behaviour is best achieved by having a robust reward system. However, a poorly designed and badly implemented reward system is worse than not having such a system at all (Lussier and Hendon 2013). Mathis and Jackson (2011) assert that reward systems are only plausible where the measurement of labour productivity is properly supported. This, however, is a challenge within the Zimbabwean construction industry where construction labour productivity has not been appropriately measured (Moyo, Mangore and Chigara 2014). Therefore, it is judicious that all the necessary structural adjustments be made for successful reward systems to be implemented within the Zimbabwean construction industry.

Feldman, Khademian and Quick (2009) promote inclusive management as a generative approach of engagement of employees. Related to this, Durdyev and Ismail (2016) posit flexible management as one of the most significant ways of raising productivity. However, they argue that flexibility should not be misconstrued as weakness by workers. Open communication within organisations equips employees through a people-centred culture and contributes towards encouraging commitment, interpersonal relationships, dialogue and persuasion (Black and La Venture 2017).
Whilst people-centred management aspects are not limited to those reviewed, important proponents of instilling people-centred values, teamwork, reward systems, flexible management, inclusive management and accessible management have been supported within the Zimbabwean context. In summation, Black and La Venture (2017) reiterate that leaders in people-centred organisations intentionally foster the belief that employees are important, their diverse opinions should be valued and people working together achieve more.

**METHODODOLOGY**

This study used the deductive approach and quantitative method to compile the results presented herein. The data was collected from skilled and semi-skilled workers on six (6) residential and seven (7) commercial construction sites in Harare, Bulawayo and Shurugwi through interviewer-administered questionnaires. Whilst perceptions from those in site management were also important, this study’s focus on skilled and semi-skilled workers allowed for contributions from those most vital to the labour productivity challenge. The questionnaire consisted of two sections. The first section dealt with demographic issues, namely age, gender, educational and experience. The second section dealt with people-centred management aspects extracted from the literature reviewed herein. A five-point Likert scale was used to collect quantitative data on the respondents’ insights on how the aspects would improve construction workers’ productivity on sites. Respondents were requested to rate within the parameters of 1- Insignificant, 2 - Little significance, 3 - Somewhat significant, 4 - Significant, 5 - Very significant, U - Unsure. The population for the study consisted of construction workers on construction sites which were purposively sought through the National Social Security Authority database. A total of 142 skilled workers and semi-skilled workers formed the total population on the 13 selected sites and from these a sample size of 104 was set at a confidence interval of 95%, with the margin of error of 5% (Gray 2009).

**Data Analysis**

The data was analysed through the Normality test, the Chi-squared test, Ranking, the Mann-Whitney U test and the Kruskal-Wallis test. For normality, Ghasemi and Zahediasl (2012) indicate that the Kolmogorov-Smirnov test and the Shapiro-Wilk test are used where a non-significant result (sig value > 0.05) indicates normality. The results for the two tests were p = 0.000, which was a significant result supporting the use of non-parametric tests; the Paerson Chi-squared test, the Mann-Whitney U test and the Kruskal-Wallis test. The Pearson Chi-squared test will be used for goodness of fit (Kothari 2009), with a significant level < 0.05, where significant people-centred management aspects that would improve workers' productivity were determined. Ranking is a product of data that has been collected through an ordinal scale where the respondents rate a response according to a number that represents their attitudes, opinions, perceptions or preferences (Naoum, 2013). Blumberg, Cooper and Schindler (2008) define the Mann-Whitney U test as a test for comparing the central tendency of two independent samples whilst Kothari (2009) describes the Kruskal-Wallis one-way analysis of variance as a test that is used to test the null hypothesis that more than two independent random samples come from identical universes against the alternative hypothesis that their means are not equal. The statistical significance level for both tests is based on a standard value of p < 0.05. A Cronbach alpha reliability test was undertaken for the fifteen people-centred management
aspects within the study with a computed value of 0.701, which was within the acceptable range of > 0.70 as suggested by George and Mallery (2003).

**FINDINGS AND DISCUSSION**

**Response rate**
The response rate for participation was 77.9% and this was satisfactory and acceptable. Baruch (1999) suggests a response rate of 60% with a standard deviation of 20% as a standard norm for populations of employees, managers or professionals.

**Profile of respondents**
The demographic distribution, from 81 valid responses, shows that generation X (52%) and generation Y (48%) were the represented age groups translating to ages of 24 to 51 years. Males consisted 85% of all the respondents and 15% were female. Though this may represent a skew in favour of males, it is a reflection of the representation in the construction industry which is male dominated (Magwaro-Ndiweni, 2016). Those with national trade certificates and with the minimum ordinary levels were skilled workers (46%) and semi-skilled workers (47%) respectively, thus these two educational levels are well represented in the study whilst those with no minimum ordinary levels were poorly represented. The majority of the respondents have more than 15 years of work experience (31%). While the least represented range of work experience is 11-15 years with 16% of the respondents. The other work experience ranges were represented as; 0-5 years (23%) and 6-10 years (30%). Whilst the minimum number of respondents required for statistical analysis is inconclusive, Field (2014) emphasises on the importance of calculating effect size as it is a standardized measure of the magnitude of the observed effect. Therefore, the following scale was utilized to measure the strength of the relationship of the variables: r= 0.10 (small effect); r=0.30 (medium effect); r= 0.50 (large effect).

**Significance of people-centred management aspects**
A Pearsin Chi-squared test was undertaken to ascertain significant people-centred management aspects that lead to improved construction labour productivity and all aspects were significant with significance level of < 0.01, which is < 0.05. This confirms the assertion by Rekonen and Bjorklund (2016), on the construction industry being dominated by production-centred management, which is too mechanical to consider the human resource perspectives. Therefore, respondents perceive that a holistic people-centred management approach would significantly improve productivity. This is in agreement with the need to associate manpower management with societal concerns (Kocer 2014). Improved productivity is the summation of these aspects inculcating confidence, motivation, increased employee involvement, encourage commitment, and interpersonal relationships.

**Ranking of people-centred management aspects**
The results in Table 1 show that respondents' perception on the people-centred management aspects towards improving construction labour productivity had a mean score range of 4.222 to 4.988 and an average of 4.516. The aspect of “Adopt a functioning reward culture for construction workers”, with a mean score of 4.988, has the highest mean. Workers perceive that incentives are the most fundamental aspect that would withdraw the most labour productivity benefit. Mathis and Jackson (2011) and Janicijevic (2013) support the construction companies’ implementation of reward systems as being essential towards transforming and motivating workers for improved productivity. However, the success of these systems is only enabled by having robust productivity measurement bias (Mathis and Jackson, 2011), which is absent within the
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Zimbabwean context (Moyo, Mangore and Chigara 2014). This supports the need for structural reform within the Zimbabwean construction industry that will support people-centred management approaches to achieve higher levels of productivity (Anzebgruber, Goetz, Nold and Woelfle 2017).

Table 1: Ranking of people-centred management aspects

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adopt a functioning reward culture for construction workers</td>
<td>4.988</td>
<td>1</td>
</tr>
<tr>
<td>Encourage teamwork through highlighting its benefits</td>
<td>4.654</td>
<td>2</td>
</tr>
<tr>
<td>Supervise the workers appropriately upholding their rights</td>
<td>4.605</td>
<td>3</td>
</tr>
<tr>
<td>Promote continuous improvement on construction methods whilst incentivising the workers</td>
<td>4.556</td>
<td>4</td>
</tr>
<tr>
<td>Inclusive management - include the workers and their views in task-related decisions</td>
<td>4.519</td>
<td>5</td>
</tr>
<tr>
<td>Build staff confidence in people-centred approaches</td>
<td>4.506</td>
<td>6</td>
</tr>
<tr>
<td>Train staff on people-centred principles to drive practice and implement on sites</td>
<td>4.482</td>
<td>7</td>
</tr>
<tr>
<td>Reflect best practice and industry standards always through construction methods</td>
<td>4.432</td>
<td>8</td>
</tr>
<tr>
<td>Promote a consistent approach to the adoption and implementation of people-centred values</td>
<td>4.407</td>
<td>9</td>
</tr>
<tr>
<td>Provide adequate resources on targets for person-centred approaches and suitable implementation strategies</td>
<td>4.395</td>
<td>10</td>
</tr>
<tr>
<td>Recognise and respect individual differences in the workplace and exploit the positives while proactively rectify the negatives</td>
<td>4.395</td>
<td>11</td>
</tr>
<tr>
<td>Invoke commitment in workers through cultivating a sense of belonging</td>
<td>4.383</td>
<td>12</td>
</tr>
<tr>
<td>Accessible management - management should cultivate an open-door policy where workers are able to raise their concerns and get adequate re-dress</td>
<td>4.370</td>
<td>13</td>
</tr>
<tr>
<td>Respect local cultures through having a flexible management structure</td>
<td>4.321</td>
<td>14</td>
</tr>
<tr>
<td>Improve consistency for workers and be flexible enough to allow for responsiveness to local differences</td>
<td>4.222</td>
<td>15</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>4.516</td>
<td></td>
</tr>
</tbody>
</table>

Statistically significant differences in responses due to demographics

The aspect “Promote a consistent approach to the adoption and implementation of people-centred values” shows a significant difference (p = 0.008) due to gender. The aspects "Build staff confidence in people-centred approaches" and "Train staff on people-centred principles to drive practice and implement on sites" showed a significant difference due to educational levels. The two aspects were, however, considered further as educational levels collectively showed a statistically significant difference with a p value = 0.03. To ascertain the nature of educational levels which show significant differences, a post-hoc Man-Whitney U test was undertaken on only the individual people-centred management aspects that had p values of < 0.05. Osei-kyesi and Chan (2017) support the use of the Mann-Whitney U test on the significant aspects using a re-calculated alpha value according to Bonferroni correction. For educational levels, the aspects of “Build staff confidence in people-centred approaches” and “Train staff on people-centred principles to drive practice and implement on sites” had p values of 0.005 and 0.042 respectively. Hence a post-hoc analysis was done for these two aspects and Table 2 shows a re-calculated p-value of 0.0167(0.05/3). Dividing by 3 relates to the number of groups that emanate from the 3 different educational levels (certificate, minimum ordinary levels, and those with no minimum ordinary levels).
From the selected significant results in Table 3, certificate holders and minimum ordinary level holders, and certificate holders and those with no ordinary levels showed significant differences for “Build staff confidence in people-centred approaches” with p values of 0.005 and 0.015 respectively being less than 0.0167 and medium size effect of 0.322 and 0.371 respectively.

Table 3 shows those with minimum ordinary levels and those with no minimum ordinary levels as having a much higher mean rank of 43.37 and 31.00 compared to certificate holders’ mean rank of 31.31 and 19.92 respectively. Field (2014) states that the Mann-Whitney U test interpretation relies on scores being ranked from lowest to highest; thus, the lowest mean rank is the group with the greatest number of lower scores. Certificate holders and minimum ordinary level holders showed significant differences for the aspect “Train staff on people-centred principles to drive practice and implement on sites” with p values of 0.011 and a low size effect of 0.293. As shown in Table 3, certificate holders have a mean rank of 31.86 compared to minimum ordinary level holders with a mean rank of 42.84.

Discussion on statistically significant differences due to gender and educational levels

Despite the fact that the collective people-centred management aspects for gender did not show any statistically significant difference, the aspect “Promote a consistent approach to the adoption and implementation of people-centred values” showed a
significant difference. Eliufoo (2007) confirms gendered divisions and these potentially stem from different needs. Although Casimir and Ng (2010) affirm the welfare of workers and showing appreciation for their efforts as key people-centred management aspects, it is the nature and extent of these welfare requirements that may differ according to gender. The collective people-centred management aspects showed a statistically significant difference due to educational levels. Further to this, the aspects “Build staff confidence in people-centred approaches” and “Train staff on people-centred principles to drive practice and implement on sites” showed a significant difference due to specific educational levels. Inevitably, a difference would exist between a vocationally trained skilled worker and one that has been trained on-the-job. This is consistent with Burgess and Connell (2015) when they recognise vulnerability of workers due differences in skills levels of workers on construction sites, which has a direct impact on productivity. People-centred management implementation by construction companies is crucial and this is consistent with studies by Toor (2008), Mathis and Jackson (2011), Rekonen and Bjorklund (2016) and Black and La Venture (2017), as all demographic variables under study positively contribute towards productivity improvement.

CONCLUSIONS

The low productivity challenge in Zimbabwe is best dealt with by interrogating the factors that affect it the most. Having identified manpower management as a key contributory factor to the challenge, it was prudent that an examination into its potential structural adjustments should be undertaken. Thus, a manpower management approach that enhances productivity and supports human resource sustenance was envisaged within the Zimbabwean construction industry. Construction workers in Zimbabwe perceived people-centred management to be fundamental towards resolving the low labour productivity challenge, with the adoption of a functioning reward culture being the most significant aspect that leads to improved construction workers’ productivity. Thus, construction companies are encouraged to implement people-centred management aspects within their sites so as to enhance productivity. In addition, a holistic adjustment in the type of management is proffered if continuous productivity gains are to be achieved and maintained. Cumulatively, a confident, motivated, involved, committed workforce has the inclination to produce at a higher level.

Further to this, a statistically significant difference due to educational levels is testament to aptitude differences to management aspects and their effects on productivity. Fundamental instruction in people-centred management aspects that promote productivity enhancement prior to their entering and within the world of work is encouraged. Thus, behavioural conditioning for the propagation of people-centred values, especially for semi-skilled workers, is supported as potentially improving labour productivity.

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The purpose of this paper is to use accounting data for eight European countries to establish whether lagging productivity of Sweden’s construction industry is an anomaly or if it is a pattern in the construction industry in many countries. The KLEMS data base is used to compare total factor, capital and labour productivity for both the construction industry and the economy as an aggregate for the 1996 to 2014 period for eight countries. Within this sample, the construction industry performs worse than their within-country peers represented by three ways to measure productivity within each of the countries. Moreover, the analysis does not provide indications of differences between the situation in large and small EU countries.

Keywords: Total Factor Productivity, country comparison

INTRODUCTION

This paper was triggered by governmental reports indicating that productivity in Sweden’s construction industry is lower than in other sectors of the economy; see for instance SOU 2012:39 and SOU 2015:105. Similar concerns over the industry's performance have been raised in for instance the US and UK, resulting in several studies of these countries, sometimes also including Japan and Germany. An extensive literature addresses the substantial difficulties to measure productivity in the construction industry, challenges that may be less severe in other sectors of the economy. This gives reason to question productivity measures that indicate a dismal performance. But even though there are challenges with measuring construction industry productivity, these complications should be generic and affect all countries in a similar way. While several papers address construction sector productivity in larger countries, less empirical work is reported about smaller countries. It is not obvious that productivity patterns in large and small countries coincide. Moreover, there may be geographical differences between a (small) central European country like Austria, or a small eastern European country like Czech Republic. Against this background, the purpose of this paper is to analyse whether the patterns of productivity in small countries' construction industry differ from that in larger EU countries. Consistent information across countries at the firm or even single contract level would provide the ideal platform for productivity analyses and comparisons. Since no data of this nature is available to an extent that makes a broader country comparison possible, this paper uses aggregated data on sector-level for European countries, collected by the EU KLEMS project. The European Commission funded this research in order to make comprehensive and harmonised national accounting data available on industry

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level. The data is open source and available at EU KLEMS official webpage, euklems.net. The paper begins with a short literature review. Following a brief introduction to the methodology, data are described, and an overview is given of characteristics of each country’s factor input statistics in the construction industry. Productivity estimates based on KLEMS data for the construction industry relative to other parts of the economy are presented for eight European countries. The last section concludes.

Lacklustre productivity in the construction sector has been a topic in the literature for decades (e.g. Allen 1985, Fulford and Standing 2014). Another observation is that the construction industry seems to be lagging behind other sectors with respect to the use of Information and Communication Technology (subsequently referred to as ICT; cf. Bankvall et al., 2010; Fulford and Standing 2014). In a review of the literature Naoum (2016) identifies some recurrent explanations of the industry's poor performance. This includes less investment in technology and innovation than in other sectors, recurrent errors in project design, poor experiences of project managers, inappropriate planning and procurement design as well as communication style of leadership. Except for output heterogeneity, Rødseth et al., (2019) discuss two additional risks for bias in productivity studies in a Norwegian context. One is that it is more difficult to include quality improvements in the design of price deflators than in other sectors; a better way to account for quality improvements over time would at least make performance less paltry. Another explanation is that the definition of the construction industry fails to include complementary industries in the analysis, which then may miss important productivity improvements.

There are many approaches to study productivity, but they all have seek to estimate the relationship between one or more inputs in the production of an output. The most common measure is labour productivity, defined as value added growth over hours worked. One result in the literature is that the construction industry's growth of average labour productivity in Germany and France is lower than in the US (Ive et al., 2004, and Mason et al., 2008). This study focuses Total Factor Productivity (TFP) which is the increase in output that cannot be explained by increasing inputs (Zhi et al., 2003). From a neo-classical perspective, TFP stems from technological progress. In empirical work, TFP may also be explained by scale economies, technical efficiency, mark-ups and organizational improvements (Ruddock and Ruddock 2011). Ive et al., (2004) and de Boer (2002) cannot establish a difference in UK labour productivity compared with Germany and France while TFP is relatively higher in UK than in the other countries. Ruddock and Ruddock (2011) evaluate trends in the construction industry for UK from the 1971 to 2007 using KLEMS data. One result is that TFP growth is higher in UK than in Germany during the period 2000-2007 while US is about the same. Another finding is that UK’s value added growth per worker is higher than Germany, US, Japan and the aggregated EU15.

Results from using aggregate data for international comparisons are ambiguous and sometimes contradictory. To overcome at least some challenges of this nature, Abdel-Wahab and Vogl (2011) compares the productivity development in the industry as an aggregate relative to construction between 1971-2005 in Europe, US and Japan. They show that the productivity growth was lower in the construction sector than in the total economy and suggest one reason to be lower technological development in construction. Making country comparisons of productivity is per se a challenge. Abdel-Wahab and Vogl (2014) points out that cross-country productivity analysis relies on data where definitions and coverage may differ between countries. Further,
they stress that cross-national comparisons are sensitive to the methods used to harmonize output to a common and comparable currency. Moreover, the heterogenous nature of construction projects makes aggregated studies less robust than comparisons of the manufacturing industry. One reason is that there are substantial differences between what is delivered by construction projects (i.e., bridges, roads, shopping malls, accommodations, etc.), which makes it more difficult to compare performance relative to manufacturing which is reasonably homogenous in different parts of the country as well as between countries. There are also substantial differences between building houses or bridges on the one hand and the repair and maintenance of physical assets on the other. Hence, the aggregation of data causes a loss of valuable variation about projects and may mean that likes are not compared with likes.

**CONCEPT AND METHODOLOGY**

Following Jorgenson et al. (1987), eq. (1) defines TFP assuming constant returns of scale, technical efficiency and competitive markets.

\[
\text{TFP} = \frac{Y}{f(L, K)} \quad (1)
\]

Further assumptions include that production functions are equal and full capital and labour utilization. The Cobb-Douglas production function in eq. (2) can be used to clarify how changes in output in country i at time t \( (Y_{i,t}) \) is described by changes in the volume of input and by the residual TFP; output as well as input volumes are expressed as log-transformation and first difference.

\[
\Delta \ln(Y_{i,t}) = \bar{v}^K_{i,t} \Delta \ln(K_{i,t}) + \bar{v}^L_{i,t} \Delta \ln(L_{i,t}) + \text{TFP}_{i,t} \quad (2)
\]

Eq. (3) defines the weights of input factor for labour and capital, respectively, and \( \bar{v}^K_{i,t} \) and \( \bar{v}^L_{i,t} \) in eq. (2) is the average of these factors over two periods.

\[
v^K_{i,t} = \frac{p^K_{i,t} K_{i,t}}{p^K_{i,t} K_{i,t} + p^L_{i,t} L_{i,t}} \quad \text{and} \quad v^L_{i,t} = \frac{p^L_{i,t} L_{i,t}}{p^K_{i,t} K_{i,t} + p^L_{i,t} L_{i,t}} \quad (3)
\]

Further, capital input can be decomposed into ICT and non-ICT capital where \( \delta^\text{ICT}_{i,t} \) and \( \delta^\text{N}_{i,t} \) is the share of total capital input that stems from ICT and non-ICT, respectively:

\[
\Delta \ln(K_{i,t}) = \delta^\text{ICT}_{i,t} \Delta \ln(K_{i,t}^\text{ICT}) + \delta^\text{N}_{i,t} \Delta \ln(K_{i,t}^\text{N}) \quad (4)
\]

Labour input can be decomposed into hours worked, \( H_{i,t} \), and labour composition \( L_{C,i,t} \). The second term in equation (5) is the sum of wage shares \( w_{l,i,t} \) for labour type l in country i at time t, and \( \frac{H_{i,t}}{H_{l,i,t}} \) is the share of worked hours by labour type l plus an expression for worked hours.

\[
\Delta \ln(L_{i,t}) = \sum w_{l,i,t} \Delta \ln \left( \frac{H_{i,t}}{H_{l,i,t}} \right) + \Delta \ln\left( H_{i,t} \right) = \Delta \ln\left( L_{C,i,t} \right) + \Delta \ln\left( H_{i,t} \right) \quad (5)
\]

Inserting equation (4) and (5) into (2) gives (6), which decomposes contributions to output volume growth into five components; ICT-Capital, non-ICT capital, labour composition, worked hours and TFP where all variables are in first difference log-transformation form.
\[
\Delta \ln(Y_{it}) = \frac{\psi^K_{it}}{\delta^K_{it}} \Delta \ln(K_{it}^{ICT}) + \frac{\psi^K_{it}}{\delta^K_{it}} \Delta \ln(K_{it}^{non-ICT}) + \frac{\psi^L_{it}}{\delta^L_{it}} \Delta \ln(L_{it}) + \frac{\psi^L_{it}}{\delta^L_{it}} \Delta \ln(TFP_{it})
\]

An inherent challenge for all cross-country comparisons is the appropriate handling of bias related to price level and exchange rate changes over time. Following Abdel-Wahab and Vogl (2011), our strategy is to use the rest of the economy in each country as a benchmark for comparison with the construction industry. This provides control for country-specific conditions that hold for other parts of the domestic economy than only construction. This design is, by construction, sensitive to sector-specific shock to the reference sectors, meaning that if the productivity goes down (up) in the reference-sector, construction’s productivity will appear as increasing (decreasing).\(^2\) One way to reduce this risk is to use three different sectors as benchmark. Total industries refer to basically all industries, the Market economy is the same as Total industries minus real estate activities, public administration and defence, compulsory social security, education, health and social work. Furthermore, compositional changes, i.e. changes in share of road constructions, residential construction and so on, are assumed to affect all countries in a similar way in the long run. To capture changes in the composition of the labour force, KLEMS make use of both employment data and labour force surveys. This makes it feasible to consider the possible consequences of the changes in the composition of the labour force. Information is thus available about gender, age (as a proxy for experience) and educational achievements\(^3\), which break down the labour force into \(2 \times 3 \times 3\) 18 employee categories.

**PRODUCTIVITY**

The comprehensive picture Table 1 corresponds to eq. 7 and show estimates for changes in value added and input contribution for all 15 countries in the material.

It is, however, obvious that the information covers different time periods. The rest of the analysis will therefore consider eight countries for which data is available for the same time period, i.e. 1996-2014.

Labour input

Figure 1 indicates that the input of construction labour has increased in Finland, Sweden and France while the input of labour is substantially lower in 2015 than in 1996 in Germany and the Czech Republic. All eight countries experience at least some reduction in the labour force as a result of the 2008 financial crises, but the reduction of the labour force seems to be structural in the latter two countries. Total

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\(^2\) Data for the construction industry is defined as category F, i.e. an aggregation of division 41-43 in the NACE rev.2 classification. For relative TFP measures are following aggregations used; Total industries, Market economy and Manufacturing. Total industries include all industries except from category T and U, where T is "Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use" and U is "Activities of extra-territorial organisations and bodies" Amt, S. (2008). Market economy is Total industries but excluding L, O, P and Q (L: Real estate activities, O: Public administration and defence, compulsory social security, P: Education, Q: Health and social work. Amt, S. (2008)). Manufacturing industry is an aggregation of division 10-33 (for a more details see Amt, S. (2008) or Jäger (2016))

\(^3\) Gender: male or female. Age groups (in years): 15-29, 30-49 and >50. Educational level: University graduates, Intermediate, no formal qualification.
number of hours can be decomposed into number of workers and number of hours worked by each.

Table 1 Annual growth of value added and input changes in the construction industry

<table>
<thead>
<tr>
<th>Country</th>
<th>Value Added</th>
<th>Hours Worked</th>
<th>Labour composition</th>
<th>ICT</th>
<th>Non-ICT</th>
<th>TFP</th>
<th>Start</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT</td>
<td>-0.4</td>
<td>0.1</td>
<td>0</td>
<td>0.1</td>
<td>0.3</td>
<td>-0.8</td>
<td>1996</td>
<td>2014</td>
</tr>
<tr>
<td>BE</td>
<td>2.5</td>
<td>0.4</td>
<td>0.2</td>
<td>0.2</td>
<td>1.4</td>
<td>0.4</td>
<td>2000</td>
<td>2014</td>
</tr>
<tr>
<td>CZ</td>
<td>-1.5</td>
<td>-1.1</td>
<td>0.7</td>
<td>0.1</td>
<td>1.3</td>
<td>-2.6</td>
<td>1996</td>
<td>2014</td>
</tr>
<tr>
<td>DE</td>
<td>-1.6</td>
<td>-1.7</td>
<td>0.2</td>
<td>0.1</td>
<td>0</td>
<td>-0.2</td>
<td>1996</td>
<td>2014</td>
</tr>
<tr>
<td>DK</td>
<td>0.8</td>
<td>0.3</td>
<td>0.7</td>
<td>0.1</td>
<td>0.2</td>
<td>-0.5</td>
<td>1996</td>
<td>2014</td>
</tr>
<tr>
<td>FI</td>
<td>0.3</td>
<td>1.3</td>
<td>-0.1</td>
<td>0</td>
<td>0.3</td>
<td>-1.2</td>
<td>1994</td>
<td>2014</td>
</tr>
<tr>
<td>FR</td>
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<td>0.5</td>
<td>0.2</td>
<td>0</td>
<td>0.2</td>
<td>-1</td>
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<tr>
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<td>0</td>
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<td>0</td>
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<td>1996</td>
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<td>1</td>
<td>0.2</td>
<td>0.8</td>
<td>-1.1</td>
<td>2009</td>
<td>2014</td>
</tr>
<tr>
<td>LV</td>
<td>-7.8</td>
<td>-6.4</td>
<td>0.6</td>
<td>0</td>
<td>-1</td>
<td>-0.9</td>
<td>2009</td>
<td>2014</td>
</tr>
<tr>
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<td>0.7</td>
<td>-0.1</td>
<td>0</td>
<td>-0.4</td>
<td>2001</td>
<td>2014</td>
</tr>
<tr>
<td>SE</td>
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<td>-0.4</td>
<td>0</td>
<td>1.2</td>
<td>-0.7</td>
<td>1994</td>
<td>2014</td>
</tr>
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<td>1.1</td>
<td>-0.1</td>
<td>-1.6</td>
<td>-6.4</td>
<td>2009</td>
<td>2013</td>
</tr>
<tr>
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<td>1.8</td>
<td>2005</td>
<td>2014</td>
</tr>
<tr>
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<td>-1.8</td>
<td>-0.6</td>
<td>0.2</td>
<td>0</td>
<td>0.3</td>
<td>-1.8</td>
<td>2001</td>
<td>2014</td>
</tr>
</tbody>
</table>

Numbers might not add up due to rounding.

Figure 1 Total working hours and number of persons engaged in construction (1996=100)

Figure 2 show how hours per worker has developed since 1996 in construction and in the three industries that are used as benchmarks. A first observation is that workers in the construction industry toil more hours per worker than in the other sectors in five of the eight countries.

Figure 2 Annual hours per worker in construction relative to three benchmarks.

Secondly, most countries have reduced the annual working hours per person for all sectors over this time period. This is most notable in Sweden where working hours in
construction has shrunk from almost 2000 hours (1997) to less than 1700 hours per worker from 2010 and onwards.

It is possible to demonstrate that construction have a larger share of labour input than many other industries. One reason is that output is heterogenous and varies from project to project, making it more complicated to standardize and automate production. Moreover, the manufacturing industry has been able to move labour intensive parts of the production to countries where labour is less costly. This is not feasible for the construction industry since the ultimate task is geographically locked to where the building or road will be placed.

The construction industry is also known to hire low-wage labour from other countries to cut costs. However, countries with strong unions and restrictive labour market policies can protect their members and their working conditions.

Capital input
The use of capital is measured as capital services and reported in ten categories which are aggregated using weights based on rental prices, depreciation, capital gains and nominal rate of return; for details see O’Mahony and Timmer (2009). The construction industry's capital stock primarily comprises heavy equipment and Figure 3 demonstrates that three non-ICT categories dominate; Other Machinery and Equipment, Transport Equipment and Total Non-residential investment. Other Capital is minor capital posts aggregated. For most countries, Non-residential Investments are the dominating capital category followed by Other Machinery and Equipment.

Value added growth
Value added (VA) is the production value net of inputs. Where $P$ is prices, $Q$ is quantities, and subscript $y$ is output, and input is input factors as labour and capital. Figure 4 show value added volume growth from 1996 to 2015. Trivially, negative VA statistics indicate that the industry is a burden on the economy at large.

---

4 Computing equipment, Communications equipment, Computer software and databases, Transport Equipment, Other Machinery and Equipment, Total Non-residential investment, Residential structures, cultivated assets, Research and development, Other IPP assets.

5 “The other machinery and equipment category of non-financial, produced, tangible fixed assets consist of machinery and equipment assets not classified as “transport equipment” - stats.oecd.org

6 “Transport equipment (assets) consists of equipment for moving people and objects, other than any such equipment acquired by households for final consumption” - stats.oecd.org

7 Capital such as commercial real estate, tools, machinery, and factories.

8 \[ VA = P_{VA} \times Q_{VA} = (P_y \times Q_y) - (P_{\text{input}} \times Q_{\text{input}}), \] where $P$ is prices, $Q$ is quantities, and subscript $y$ is output, and input is input factors as labour and capital.
From 1997 until the financial crisis, VA growth is generally positive. But there is a difference in how the countries recover. Austria, Denmark, Finland, Italy and Sweden are all having a large drop in VA growth 2009, one year after the Financial Crisis, with numbers between -8.2 to -10 percent. While most countries seem to have higher growth 2010, Denmark is falling further to 13.1 percent. During five years after the financial crisis, neither Austria nor Italy have positive VA growth. Growth in France is positive one out of five years, while Finland and Sweden have positive growth two of five years. Denmark recovers fastest with only negative growth 2009 and 2010 before growth turns positive.

**Total factor productivity**

Figure 5 confirms that TFP in manufacturing has the strongest development. Productivity development in the Market economy and in the Total economy is similar, although the first, which excludes non-competitive submarkets, is slightly stronger. The pattern for the construction industry is that TFP is lower than in the other industries and indeed consistently negative. The upper panel in Figure 6 show TFP estimates for construction. Excluding the Czech Republic, TFP was approximately constant until 2007 while it falls into negative numbers during and after the financial crisis.

Lower panels in Figure 6 relates TFP in construction to manufacturing, total industry and the market economy. The overall pattern is the same irrespective of which measure is used: Not only is construction’s TFP falling in absolute numbers (first
Nilsson, Nyström and Salomonsson

panel), it is also shrinking relative to the three alternative ways to measure the economy in total.

*Figure 5 TFP growth (1996=100)*

![Graph showing TFP growth for different countries]

*Figure 6 Relative TFP measures*

![Graph showing relative TFP measures for different countries]

It is not straightforward to interpret negative technological efficiency, which literally means that firms are using less efficient production methods over time. There are, however, many empirical studies that have shown negative results (e.g. Ruddock and Ruddock 2011; Abdel-Wahab and Vogl 2011; among others). One common explanation relates to problems with capturing quality improvements over time. On a tangible level, buildings and roads built today may last longer than those produced ten years ago, and this may not be captured by the data. Further, if the functional form of the production function is less accurate or if omitted variable bias is larger in construction. Another possible explanation is that shares of different types of constructions in the aggregate data are changing over time. One example could be that if the share of road construction goes up and house construction goes down, and one of them are more productive than the other, this will affect the registered change of productivity. Vogl and Abdel-Wahab (2015) provide a similar explanation in that the share of construction and repair and maintenance.
CONCLUSIONS

The relevance of this paper stems from a general perception that productivity performance is poor in the construction industry. The international debate has encouraged researchers to study productivity in construction, but most papers focus on large countries, e.g., US, UK, Germany and Japan. Our paper strives to generalise results by comparing construction with other sectors within each country and then compare relative TFP growth across countries. Moreover, the analysis includes both larger and smaller countries. The paper established that the development of TFP in construction is similar across the size of the economies and geographical location. TFP is on average negative for 12 of 15 countries, which is a challenge to interpret theoretically but is a common finding in empirical studies. When productivity in construction is compared to the same statistic for other sectors of the economy for eight countries with a consistent time series, the result is that TFP performs less well. Sweden is perhaps the country where the relative TFP is most sensible and crucial to what part of the economy the industry first is compared to (see lower panels in Figure 6). The homogenous TFP patterns indicate that there is a similar underlying structure valid for the construction as such, i.e. TFP is not as country dependent as believed beforehand. The credibility of productivity measures in the construction industry are widely debated due to the heterogenous nature of output, problems with accounting for quality. However, it is neither possible to control for quality of output or proportion of tasks within construction, with aggregated sector data. Instead, the standard assumption is that proportions of tasks changes with the same probability in all countries and will affect all countries in similar ways in the long run. Descriptive KLEMS information establishes that working hours and non-ICT capital are the main inputs in most country’s construction industries. This is not surprising since construction is a labour and machinery driven industry in contrast to the manufacturing industry which, at least until now, has had higher potential in automatize production and move labour intensive parts elsewhere. However, the descriptive statistics reveals that there are variations in capital and labour characteristics. Interestingly, Denmark had a significant increase of "other capital" (which in their case consisted of increasing investments in ICT-capital) during the financial crises. Another observation is that hours per worker has decreased in Sweden from 1950 to less than 1700 hours between 1996-2011. Decreasing hours per worker isn’t as clear pattern in other countries. The heterogenous nature of construction work might suggest that it has been more difficult to use new technology in the same way as repetitive tasks in for example the manufacturing industry. Another way to look at it, is that the construction industry might have a huge, not yet adopted, potential in new technology. This emphasizes the significance of further strengthen the understanding of TFP performance in the construction industry, not least as a means for an improved future development.

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MOBILE METHODS FOR MOBILE WORK? AN EXPLORATION OF HEAD-CAMS IN CONSTRUCTION RESEARCH

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Off-site methods of construction reconfigure how people and materials move to and around construction sites. An increasing amount of research has attended to how video-based data can help understand workplaces implicit in the overall delivery of construction projects. Little research has however attended to how video-based data may enhance understanding of the mobile nature of construction sites and explored how such understandings could be shared with overall project teams. Building on approaches to audio-visual data in construction and theories of mobile methods, this paper proposes head-cams as an aspect of ethnography that may be fruitful to understanding characteristics of projects that involve collaboration across multiple workplaces. Over the course of a year, on site observations, site tours, and interviews unpacked how integration between construction professionals occurred when constructing with off-site methods of construction. Head-cams made up a broader methodological approach that aimed to follow the construction of the homes from inception to completion. To attend to the potentially fruitful use of head-cams to enhance integration between construction professionals - such as site managers, timber-frame contractors, carpenters, and plumbers - we describe the mobile nature implicit in house building. Incorporating the benefits of using head-cams for researching inherently mobile practices the ‘trade off’ between filming and analytical engagement is argued to be adapted due to the hands-free potentialities that head-cams provide. This is argued as helping to understand the potentialities of supply chain integration in construction projects. The paper ends by speculating future avenues of incorporating mobile methods into construction research and by pointing to potential considerations to bear in mind when including head-cams in research designs.

Keywords: audio-visual, off-site, timber-frame, mobile, head-cams, house building

INTRODUCTION

Off-site methods of construction are increasingly deemed the most viable - while underused - way to build substantially more houses (Farmer, 2016). Off-site methods of house construction generally involve moving materials to ‘factories’ where they are assembled into elements such as walls, individual rooms, or whole homes. These elements are then transported to site, positioned and then accessed by installers and follow-on trades using scaffolding and/or cranes. With a potential to halve building times, open up innovative design opportunities, reduce carbon emissions, and be resilient to material and skill shortages, it is unsurprising that off-site methods of house construction are a tried and tested - yet underutilised - method of reducing shortages of adequate housing.

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Foregrounding mobility through audio-visual tools such as head-cams is put forward in this paper as a way of better understanding how new technologies such as off-site methods of construction are implemented. The paper begins by stating the importance of integration across the supply chain when implementing off-site methods of construction. Video-based methods of research are subsequently outlined before an overview of how mobile methods may contribute to understandings of integration in construction is provided.

LITERATURE REVIEW

Off-site methods of house production reconfigure tasks not only in terms of off-site methods of construction (OSM) but the supply chain in general. While attention is increasingly given to the potential of OSM to increase the number of houses built in the UK (DCLG, 2017) understandings often focus on how moving more of the construction process to a manufacturing setting may help to alleviate housing shortages (Farmer, 2016) rather than broader implications of supply chain arrangements that occur.

A growing interest in the potential for OSM to contribute to reducing the housing shortages has led to a necessity to understand how new technologies both impact construction professionals and co-evolve with the capacities of construction firms (Dowsett et al., 2019). OSM involves designing and assembling elements - walls, individual rooms or whole homes - which are incorporated into the overall build. With OSM processes of the overall buildout are adapted; relations are reshuffled between construction professionals - such as plumbers and electricians - as the materials and programs they work with include new materials and technologies. Construction - with or without off-site methods of construction - involves the integration of disparate organisations - which come together through projects of creating buildings.

Situated integration

In order to better understand how organisations, co-create buildings it is important to foreground how relations currently occur. The situated actions and interactions implicit in how co-creation takes place to create buildings is however only beginning to be explored (Pink et al., 2010). Broadening understanding of the ways in which integration between organisations plays out on site could enhance understandings of social relations between organisations involved in constructing buildings, and potentially increase the amount and quality of buildings created.

In drawing on long standing theories surrounding ethnographic methods, headway is being made through proposing fine-grained observations of how technologies and social relations shape each other (Pink et al., 2010). Deviating from emphasizing functional properties of technologies by attending to the co-evolution of social interaction and technologies, assumptions that technologies do exactly what they say on the tin is ousted. Replaced by a focus on the social interactions that participate in the design and installation of particular technologies, recognition is given to what happens on the ground as people and technologies intersect.

Video-based data is aiding understandings of social relations in the design phases of construction (Maftei et al., 2018) while little attention has been given to video-based ethnographies of sites themselves. This is surprising given the tactile nature of construction in which incorporating technologies and materials into socio-technical systems may be better understood with observations of sites.
Mobility studies and construction

Despite a long-standing consensus of the potential benefits of off-site methods of construction, a major challenge is the movement of materials and people to sites. Scholars across the globe have compiled lists of barriers of off-site methods of construction in specific countries and delays from traffic and access to sites often feature (see Goulding and Rahimian, 2019). Significant attention has also been given to mobility in terms of migrant labour (Tutt et al., 2017), and moving manufacturing nearer to construction sites (Young et al., 2015). Mobility here is however couched in terms of adaption to established processes of construction - accommodating a workforce of diverse ethnicities and languages or adapting build processes to speed up the installation. In focusing on strategies at particular stages of construction, the mobile nature of construction on sites has been left in the background, and in the process inherent aspects of mobility - and immobility - have been neglected.

Mobility studies have already gained traction to overcome tendencies of conceptualising work as static. Fundamental to the motilities turn is to focus not only on the creation of the routes themselves in terms of logistics or transport planning but to incorporate multiple scales of mobility including the interactions of materials and people (Sheller and Urry, 2006). For example, changes in work, business, leisure, and the environment have been positioned as intersecting with transport technologies and infrastructures (Cresswell, 2006).

The relationship between construction and mobility is however yet to be foregrounded. Framing mobility as being adapted in isolated companies or industries, as construction scholars often do, neglects the importance of how houses - and the materials that constitute them both come to sites and move around them during construction. Positioning construction sites as static - or working alongside - rather than being intricately linked to multiple workplaces neglects how construction relies on multiple mobilities. An off-site method of construction in this sense relies on intersecting mobile and innovative systems.

The integration of disparate organizations requires understandings of how fellow project-level colleagues’ work is mobile.

Video-based approaches are an underutilised aspect of construction research which has the potential to enhance understanding of mobilities and how these intersect. Head-mounted cameras seem also appropriate given the importance of being aware of one’s surroundings on construction sites in order to avoid unsafe situations. Pink puts forward ‘walking with’ as a method - whereby walking with participants while videoing - helps to enhance the communication of experiences of places and place making (2007). In studying the social worlds relating to mountain biking and walking with head-mounted video cameras, Brown et al., (2008) point to the benefit of using head-mounted videos for researching inherently mobile practices. Most importantly for our paper, both Pink (2007) and Brown et al., (2008) reinforce how videoing becomes embedded into the performance of activities, and as such reconfigures how events such as site visits are enacted.

Foregrounding mobility is put forward in this paper as a way of better understanding what fellow organisations do, which can aid understanding of how integration occurs on construction projects. Video-based methods of research have shown conceivable promise of attending to problematics of integration through focusing on how the implementation of technologies emerge through existing social relations. Mobilities studies help to reinforce the importance not only of multiple mobile systems but
inspire scholars to think though how these are enacted through social relations. The following outlines how head-cams made up a broader methodological approach to aid understanding of how mobile integration occurs on construction sites.

METHODS

This paper draws on research conducted to follow overall buildout of five houses in the South East of England UK. This focussed on the installation and fit-out of a small-scale timber frame housing development ‘Percy’s Yard’ to the point of the finished buildings. Over the course of a year key integration issues between onsite tradespersons and the timber frame were captured through interviews, observations, and audio-visual data collected using head-cams worn by interviewers during direct observations on site. The research followed the University of Reading ethics procedures regarding the participants’ informed consent and the confidentiality and data protection.

In line with principles of ethnographic and video-based research methods (e.g. Heath et al., 2010), the study accounted for ethical / methodological considerations around the influence of the video cameras on the participants’ behaviour and their reactions to being filmed. Achieving unobtrusiveness (as practically possible) of the video camera on the site is common challenge in video-based research methods. To enable the transition from gaining physical access to the observation site towards establishing trust and participation in the setting, we focussed on: familiarising the participants with the aims and scope of the research and with the researchers’ presence on site over a long period of time; explaining the advantages of using video for the analysis of the participants activities; ensuring the participants on the research compliance with the ethics procedures around confidentiality and data protection.

The research involved spending time in the site-office, having regular walks with the site-manager assistant manager, professionals employed by the timber-frame manufacturer, and subcontracted construction professionals such as electricians, brick layers, carpenters, and plumbers. As we got into the routine of walking around with head-cams, construction professionals on the construction site seemed less affected by the researchers’ presence on site. And while, despite being in agreement that critical points can be discerned when planning ethnographic informed research approaches (see Pink, 2010), gaining trust from all participants evolved over elongated periods of collaboration between researchers and participants.

Reflecting further on the influence of the video camera on the participants’ behaviour (and as illustrated below in this section), in this particular research case (some of) the participants were already familiar with using images and videos to communicate project issues across the firms involved in the supply chain and they rather embraced the use of the head-cams as a reinforcement of the audio visual already used by their firms.

The research took place over a year long period, while not all the time was spent on the site. Critical moments - such as the delivery and installation of the timber-frame - were targeted for long periods of observations and interviews on site. Two head cameras were used on site and one was completely on charge in the site office, which overtime became back stage for the research. That is not to say that spending time in the office did not contribute to the research. More so that through clear understanding regarding what would happen with the footage from the cameras - helped for us all to understand options for how supply chains collaborate.
RESULTS
Field notes, videos, and interviews with participants highlighted the initial intrigue and uncertainty regarding head-cams on site from site managers. It was the first time the firms had been involved in a research project with a university which seemed to heighten curiosity regarding how aspects of the research were needed. For example, when initially meeting the site manager Gary, immediately after gaining permission to take pictures and to wear the head-cam while spending time on the site he was unsure why videos were needed for a study of innovation. He asked “Really? Why?” The researcher explained that the video footage would help to analyse particular aspects of supply chain collaboration and that permission would also be asked from others that are visible or audible. Gary agreed and joked “maybe I’ll be on construction news” and the curiosity surrounding the ‘the point’ of the research remained - to different extents and in different forms - throughout the yearlong research.

The following vignettes (walkabouts) focus on particular ways in which incorporating a headcam into the ethnography revealed insights into both the role of the headcams in construction research and of insights into mobility more generally. The first focuses on a walk with the regional manager of the timber-frame supplier, the second on the site manager, and the final vignette draws on an interview with an electrician conducted while being shown around a house he was working on.

Walkabout 1: Embedding performance and interactions

If we’ve got any issues or any problems our fixers will take a photograph, a video, and they will send it immediately back to us …. It is great to have a visual. We can show the boys [in the manufacturing ‘setting’] what, exactly what we’re on about. (Dazla, regional manager of the timber-frame supplier)

Once the timber-frame has been installed, the regional managers, ‘Dazla’, conducts an inspection of the installation. The above quote was taken while walking around with Dazla during the routine snagging inspection post-installation with Brian, the Managing Director of the housebuilding firm. Dazla revealed how photographs and videos help to provide valuable feedback for improving the design and manufacture of the timber-frames. While prodding parts of the frame with an offcut picked from the floor, he pointed out problems and took pictures to inform actions to resolve issues on the site. He continued to explain how taking pictures on his phone helped “The designer gets a feel of it [the problem] … And it gets, if there’s an issue it gets resolved there and then”. The emphasis given to videos and photos as a means of enhancing clarity for improvements in the manufacture and installation of the timber frame continued throughout the inspection. This routine ‘walkabout’ gave Brian a better understanding of the quality control process undertaken by Dazla and his team.

Capturing this walkabout, and the interactions occurring throughout, using the headcam illustrates the importance of pointing out and fixing problems with particular organisations in the supply chain and alludes to the how particular problems occur with the implementation of new technologies. Integration of disparate organizations requires understandings of how fellow project-level colleagues work. This is of particular importance when implementing new technologies such as off-site methods of construction.
Walkabout 2: Oversight through insight

During elongated periods of observation on-site researchers were constantly ready to capture what was happening. On arrival into the site cabin in the morning researchers would ask what was happening that day and reinforce how they would be happy to be around when anything interesting was occurring. This approach often led to the site-manager often explaining what they were going to do and inviting the researcher to join them. On one occasion, in what could be described as jovial manner expecting the researcher to decline the offer, Gary explained how he was going to sweep up and asked, “do you want to come along?” To Gary’s surprise, the researcher accepted such offers and in doing so became aware how sweeping up enabled Gary to more than keep the site clean and tidy. As he walked around the site with a brush, conversations were instigated and continued with fellow construction professionals. Topics ranged from following up on conversations regarding previous enquiries - such as are the tolerances between the timber-frame and the traditional any better on that plot - to gaining advice on technologies he was thinking of procuring for future sites.

Far from structured assessments/inspections of whether the build out was ‘going to plan’, Gary meandered around the site picking up advice and misplaced items keeping an eye on how the build out was progressing. Regular ambles around the site are also testament to Gary’s approach to oversight through insight on Percy’s Yard. Far from walking aimlessly and/or following a predesignated route Gary’s ambles around site were open to detours and wrong turns.

Walkabout 3: Being put on show - active acknowledgments

In one ‘walk-round’ the electrician described the challenges he was experiencing working with the timber-frame building. The problem centred on the difficulty he was having running cabling for the first fix on the party wall side of the ground floor of one of the housing units. This task required running the cabling from where the sockets would be located up the wall and through the top-plate of the timber frame panel into the ceiling void. Issues arose because the structural beam resting on the top-plate in one room - of the two adjacent to the party wall - was flush with the panel and offset in the other. Chiefly what this meant for the electrician was drilling service
routes through the top-plate into the structural beam - not a problem in theory - but the significance of this in the context of timber-frame means navigating the regulations around drilling service routes through structural members. As the electrician put it:

*Bear in mind that I shouldn’t drill in the bottom of that joist, I’ve got to drill in the middle height of it ... I’ve got no idea what nails are in there or anything. So, what do I do? Drill ninety degrees that way, ninety degrees that way and hope it lines up, hope I don’t hit any nails. If I hit something that’s too heavy to cut through to with my wood drill, I end up drilling another hole, so you end up getting two or three holes there or whatever. So why is that timber there?*

*I could wire one point in the same time as I wire five others because of that [points to structural joist] and I can’t get through because there’s nails there.*

Inconvenient though this was what the use of the headcam afforded to the depth of the empirics captured was the electrician was able to talk through and walk-through the problem discussing it relation to the overall logics of the prefabrication process of the timber-frame. Trying to articulate the extent of these issues within an interview setting would have been very difficult given the nature of the problem and the expanse of space it stretched across. The researcher was immersed within the artistic/craft space of the electrician which made it easier for each to direct with literal movement around the space (Figure 1&2) - attention to the individual components that constituted the whole of the issue in discussion.

![Figure 2](image.jpg)

**Figure 2 Talking and walking through problems**

Any reference made to another aspect of the problem was readily to hand within that artistic/craft space. For instance, the researcher asked about the extent of detail on the drawings that the electrician had to work with. The electrician walked the researcher from one side of the building through to the other to flick through the drawings in a gesture to indicate the lack of structural details going on to point at the same joist (Figure 3) and say:

*I’ve got nothing that shows the detail of that and even in fact if I had it wouldn’t necessarily be like that anyway because when they put that up, they’ll do it however it works out.*

*[takes researcher over to the internal wall]*

*Because if you consider the depth of these timbers obviously, they’ve added a little bit on to bring it out (starts giggling)*
DISCUSSION AND CONCLUSIONS

As noted in Dowsett et al., (2019) - which drew on the same research - attention in the research project as a whole was given to the role of the entire construction team, including subcontractors. Our head-cam video-based approach helped to feedback into the phases of design and construction as they happened. More important for this paper at least, is how the role of the video helped to contest perceptions around scope of roles on sites, and perhaps emphasise the mobilities involved in resolving clashes between offsite and onsite activities.

Head-mounted cameras were implicit in the each of the vignettes while seemed to have different inferences depending on the organisation's role in the supply chain, and of previous experiences of walking around sites more generally. From this point of view construction is inherently mobile - people move around sites in the process of constructing building - and headcam ethnographies help to gain understandings of the different ways in which construction occurs. In this sense the walking around sites is part and parcel of construction and taking this on board when understanding how particular tasks are enacted is important. As Brown (2010) clearly puts forward, headcams can help researchers delve into the intricacies of workarounds in ways that static or handheld cameras may not.

In beginning to explore how mobile methods may be useful for mobile work, the three vignettes provided above helped to illustrate how walk arounds were both integral to the ‘roles’ of the different actors in the buildout of the houses on Percy’s Yard, and to social relations more broadly between these ‘roles’. The following attends to the former before more conclusive comments are made.

In taking on board the argument that videos have a material capacity that is enacted and performed through activities such as walking (Pink et al., 2010) we illustrated how walking around sites is already taking hold of the way in which construction occurs. When joining Dazla, the regional manager of the timber frame contracting firm, the headcam seemed to reinforce the role of audio-visual currently used by the firm. The headcam helped to illustrate how audio-visual data helped to reassure clients that potential problems were being looked into and that the firm more generally was dedicated to improving their products and services. The photos and videos that Dazla took were part of overall walk around which seemed well oiled in order to
reinforce how feedback from sites led to improvements on future plots which was all part of the package that the firm offered. The role of the camera was primarily used as means to problem-solve reactively and could have been embedded in the way of walking when inspecting sites with colleagues in the supply chain.

For Gary, walking around was a way of capturing information around the site and for future projects. In this sense Gary's walk around illustrates the ‘recognition’ of how subcontractors’ expertise plays out in the overall buildout, while at the same time attempting to gain trust by not monitoring them too closely.

In the example of the electrician the head-cam became a conduit through which he could explain, within his own craft-space, how the interaction between onsite and offsite activities play out on a day-to-day basis and the challenges subcontractors face. In an interview context the depth of detail is unlikely to have been achieved without the physical reference points for both the researcher and participant. Walking and talking through the challenges of implementing new technologies here stood out.

The paper consequently builds on recent developments in construction research that attends to how through walkabouts (Pink et al., 2010) help to provide fine grained detail on the experiences participants share with researchers, and through drawing on the concept of participatory-performance to explore how the camera shapes site visits and communication amongst construction professionals. This study highlights the relevance of using video as both methodological tool - supporting the research focus on how supply arrangements unfold - and as regulatory tool in configuring, reinforcing and contesting roles and relationships between construction professionals on site. Future work can dwell on and expand the focus on the potential of the video as elicitation technique (e.g. Jirotka and Luff 2006; Jewitt 2012) by using video alongside interviews or focus groups to encourage discussion, memory of past events, fostering reflection, or to cross check different participants' interpretation of the events. This would support integrating knowledge and expertise between different construction professionals could generate a repository of shared knowledge/ and experience.

Head-cams at present are an under-utilised approach to capturing the empirics of onsite activities that are inherently mobile in nature. Future potential for their use could relate to eliciting insights into how overcoming supply chain tensions, inter-firm relations, managerial practices, capturing what is happening on site more broadly, and finally perhaps capturing the broader power structures at play within projects and how different firms benefit from new technologies.

REFERENCES


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One of the complicated inputs to manage construction projects is the labour component. Labour cost constitutes a third of the total project cost and its performance intrinsic to the success of the construction endeavour. The measure of the success of construction projects is based on the performance of labour. However, an omission exists through measures used to measure labour productivity. Additionally, in quantifying or establishing a unit of measurement for labour performance, the degree of impact that contextual factors have on the performance of labour are not factored in the scales used in the measuring process. A notable gap identified in literature is that the extent through which contextual factors impact the performance of labour is not rigorously explored. Furthermore, there is limited research that examines the productivity of labour in the South African construction context. Therefore, this study explores the contextual factors that impact labour productivity in the construction industry, particularly on construction sites. Furthermore, the study aims to establish core factors that impact the productivity of labour on site. The aim of the study will be achieved through a systematic review of literature pertinent to contextual factors and labour productivity. The study objective will also be achieved through a quantitative analysis of data gathered through a structured questionnaire survey of contractors listed in Grade 2-9 of the cidb Register of Contractors. It emerged that Findings of the study show that inclement weather (rain/cold/heat), followed by change orders from the designers/consultants, fluctuations in materials/equipment prices, unexpected site ground conditions, lack of experience amongst workers, inspection delays from engineers, Economic changes (change in VAT, inflation and foreign exchange rates), delays in delivery of material, incomplete drawings, poorly designed projects and lack of experience of workers, are core factors that impact on the productivity of labour on construction sites in South Africa. These findings aim to inform and foster collaboration amongst management and on-site staff in the establishment of the expected level of productivity on site by considering the available resources and knowledge of probable contextual factors that might affect productivity. The study recommends an all-encompassing method for establishing the expected productivity and in the same light, consider the context in which a project is developed to understand the degree of impact of particular factors. Further studies that will examine the potential impact of productivity on time and cost of the final project is also recommended.

Keywords: change order, material delays, measurement, payments, productivity

INTRODUCTION

According to Barbosa et al., (2017), the level of labour productivity in the construction industry is stagnant and has reported a marginal growth in the past two decades (Barbosa et al., 2017). The stagnant productivity output is linked to the level...
of labour productivity experienced on construction projects. This level of labour productivity is varied when analysed by project types and sizes, and as a result, reports different outputs (Kaming et al., 1998; Park, 2006; Alinaitwe et al., 2007). This study aims to examine the contextual factors impacting labour productivity across construction projects. Within the South African context, one of the most significant contributors to Gross Domestic Product (GDP) and employment creation, is the construction industry (cidb, 2017; StatsSA, 2017). Additionally, the construction industry comprises multiple disciplines which simplistically, may be considered according to the different projects forming part thereof. These projects are infrastructure projects which address the core needs of the economy (Durdyev and Mbachu, 2011; Barbosa et al., 2017; cidb, 2017). Whereas building projects provide housing and infrastructure and basic shelter for either housing or commercial use for income generation (Tilt et al., 2009).

Scholars suggest that the productivity of labour on construction projects is affected by a variety of factors and this is varied from project to project (Love et al., 2002). Farnad and Pouya (2013) identified factors suggested to have both a positive or negative impact on the productivity of labour. However, other scholars argue ascribing positive and negative impact on the level of labour productivity, especially if the benchmark or standard of labour has not been set as the premise to measure the impact of the contextual factors (Park, 2006). Additionally, contradiction arises if one factor is assumed to yield the same type of effect on one project which may vary from another particularly given that each project presents with itself, varying levels of complexity (Xia and Chan, 2012). As a result, factors are grouped according to a specific section of the work that they emanate from and which they could potentially affect. These groups are site environmental factors, organisational factors, technical factors and social factors.

However, factors that impact the performance of labour on construction projects has been undertaken and Niazi and Painting (2017) asserts that delays in payment by owners, change orders by the clients are some of the core factors that impact the productivity of labour on site. Additionally, the delivery of material on site contributes significantly as the project success depends on the material and timely delivery thereof in order to execute the construction project (Jarkas, 2015). Durdyev and Mbachu (2011) in their evaluation of core factors hindering efficient productivity on site, postulate that lack of experience amongst workers, the level of skill and experience, inadequate experience of the managers and methods of construction are central to factors impacting productivity. Lastly, Kaliba et al., (2009) asserts that some of the factors to that affect labour productivity are inclement weather, variation orders, economic changes including inflation, poor designs of project. The foregoing studies are used as references to the south African context of analysis.

This study will examine the contextual factors that impact the productivity of labour on construction projects varied by the project type. The two types of projects that are to be compared in relation to what factors affect labour productivity are building and infrastructure projects. The results of this study are useful to estimators, planners and project managers in the identification of the factors that impact on the level of labour productivity before construction commences. Furthermore, it enables estimators to envisage the impact of the factors on labour productivity and adequately plan for and cost the construction activities.
RESEARCH METHODOLOGY

A systematic literature review of peer-reviewed journal articles was conducted for this study. The literature search was narrowed to focus on the objective of the study, and this was achieved using the keywords; labour, measurement, payment delays, productivity and supervision. A research questionnaire was designed from the literature and distributed via email through the SurveyMonkey web platform. The study population was limited to construction organisations graded between 2 - 9 on the cidb Register of Contractors. The questionnaire was distributed across 8400 contactors and the response rate was 164. After cleaning the responses received, a total of 117 questionnaires were found to be fully completed and useful for the purpose of the study. The questionnaire was divided into the section between contractors that specialise in building projects, road projects and infrastructure projects. The objective of the study is to evaluate the contextual factors perceived to impact labour productivity on site, it became imperative to ascertain the ranking of these factors in relation to their impact to project performance. In analysing the data, relative importance index (RII) is used as the method of analysis to rank factors perceived to have an impact on the level of labour productivity. Equation 1 below is used in calculating the RII (Doloi, 2008; Fugar and Agyakwah-Baah, 2010; Jarkas, 2015).

\[
\text{Relative Importance Index} = \frac{\sum_{i=1}^{n} W_i}{A \times N}
\]

Where \( W \) represents the aggregate weighting given to each attribute in the Likert scale assigned from 1 to 5 where 1 = very low, 2 = low, 3 = undecided, 4 = high and 5 = very high impact. \( A \) represents the highest weight that could be assigned to a factor on the Likert scale, and \( N \) represents the total number of respondents.

FINDINGS

Table 1 shows the results of the analysis and it can be established that across construction projects in South Africa, the 10 factors that affect the level of labour productivity on site are; inclement weather (rain/cold/heat) (RII = 0,662), followed by change orders from the designers/consultants (RII = 0,656), fluctuations in materials/equipment prices (RII = 0,648), unexpected site ground conditions (RII = 0,646), lack of experience amongst workers (RII = 0,646), inspection delays from engineers (RII = 0,644), Economic changes (change in VAT, inflation and foreign exchange rates) (RII = 0,641), delays in delivery of material (RII = 0,634), incomplete drawings (RII = 0,631), poorly designed projects (RII = 0,629) and lack of experience of workers ( RII = 0,629). According to the respondent's perceptions, these are the core factors that impact the labour productivity output on projects.

DISCUSSION OF THE FINDINGS

Table 1 details the ranking of the contextual factors and the discussion of the 10 top ranked factors is carried out below. Inclement weather (rain/cold/heat) (RII = 0,662) is affects the nature of construction as projects are carried outside (Park, 2006). This finding aligns with previous studies (Motwani et al., 1995; Chan and Kumaraswamy, 1997; Radosavljevic and Horner, 2002; Senthilkumar and Shafee, 2013; Jarkas, 2015; Naoum, 2016). Furthermore, the ranking of this factor aligns with this assertion as it can be seen that weather plays a pivotal role in the development of a project. In the event that a construction site is exposed to excessive rain, it is reported that labour
productivity will be diminished and as a result some of the construction work that is scheduled to take place, will be affected (Park, 2006).

Table 1: Perceptions of respondents regarding factors impacting labour productivity in construction projects.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Very low impact...Very high impact</th>
<th>Rank (R)</th>
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</thead>
<tbody>
<tr>
<td>1 Inclement weather (rain/cold/heat)</td>
<td>13 28 11 40 25 0.662 1</td>
<td></td>
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<tr>
<td>2 Change orders from the designers/consultants</td>
<td>21 19 17 26 34 0.656 2</td>
<td></td>
</tr>
<tr>
<td>3 Fluctuations in material/equipment prices</td>
<td>17 22 22 28 28 0.648 3</td>
<td></td>
</tr>
<tr>
<td>4 Unexpected site ground conditions</td>
<td>13 26 22 33 23 0.646 4</td>
<td></td>
</tr>
<tr>
<td>5 Lack of experience amongst workers</td>
<td>13 30 14 37 23 0.646 4</td>
<td></td>
</tr>
<tr>
<td>6 Inspection delays from engineers</td>
<td>20 23 16 27 31 0.644 6</td>
<td></td>
</tr>
<tr>
<td>7 Economic changes (change in VAT, inflation and foreign exchange rates)</td>
<td>21 25 15 21 35 0.641 7</td>
<td></td>
</tr>
<tr>
<td>8 Delays in delivery of material</td>
<td>17 32 12 26 30 0.634 8</td>
<td></td>
</tr>
<tr>
<td>9 Incomplete Drawings</td>
<td>22 25 14 25 31 0.631 9</td>
<td></td>
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<tr>
<td>10 Poorly designed project</td>
<td>21 23 18 28 27 0.629 10</td>
<td></td>
</tr>
<tr>
<td>11 Lack of experience of workers</td>
<td>21 25 12 34 25 0.629 10</td>
<td></td>
</tr>
<tr>
<td>12 Labour unrest/rioting</td>
<td>28 20 15 18 36 0.624 12</td>
<td></td>
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<tr>
<td>13 Site location/environment</td>
<td>13 33 17 37 17 0.621 13</td>
<td></td>
</tr>
<tr>
<td>14 Delays in payment of labour</td>
<td>33 17 6 28 33 0.619 14</td>
<td></td>
</tr>
<tr>
<td>15 Relationship between supervisors and labourers</td>
<td>17 30 14 38 18 0.617 15</td>
<td></td>
</tr>
<tr>
<td>16 Complexity of the project</td>
<td>21 22 24 31 19 0.609 16</td>
<td></td>
</tr>
<tr>
<td>17 Poor co-ordination/planning of activities</td>
<td>24 24 12 39 18 0.605 17</td>
<td></td>
</tr>
<tr>
<td>18 Non-payment of labour</td>
<td>38 14 8 22 35 0.603 18</td>
<td></td>
</tr>
<tr>
<td>19 Inexperienced supervisors</td>
<td>30 21 12 30 24 0.595 19</td>
<td></td>
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<tr>
<td>20 Uncertain job security</td>
<td>28 18 24 25 22 0.591 20</td>
<td></td>
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<tr>
<td>21 Change in government legislature/policy</td>
<td>26 26 16 26 23 0.590 21</td>
<td></td>
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<tr>
<td>22 Poor site supervision</td>
<td>24 34 9 26 24 0.586 22</td>
<td></td>
</tr>
<tr>
<td>23 Methods of construction (prefabrication vs onsite)</td>
<td>27 27 17 28 18 0.571 23</td>
<td></td>
</tr>
<tr>
<td>24 Mismanagement of resources on site</td>
<td>28 32 12 21 24 0.568 24</td>
<td></td>
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<tr>
<td>25 Rework due to poor quality</td>
<td>33 28 10 20 26 0.562 25</td>
<td></td>
</tr>
<tr>
<td>26 Personal problems</td>
<td>31 23 18 28 17 0.561 26</td>
<td></td>
</tr>
<tr>
<td>27 Shortage of labour/manpower</td>
<td>25 38 8 31 15 0.554 27</td>
<td></td>
</tr>
<tr>
<td>28 Buildability of the structure</td>
<td>31 24 20 29 13 0.547 28</td>
<td></td>
</tr>
<tr>
<td>29 Long commute periods to site</td>
<td>33 24 19 29 12 0.537 29</td>
<td></td>
</tr>
<tr>
<td>30 Lack of tools and equipment</td>
<td>31 37 9 19 21 0.535 30</td>
<td></td>
</tr>
<tr>
<td>31 Changes in management structure</td>
<td>30 31 21 20 15 0.530 31</td>
<td></td>
</tr>
<tr>
<td>32 Drug abuse</td>
<td>41 24 16 21 15 0.506 32</td>
<td></td>
</tr>
<tr>
<td>33 Alcohol abuse</td>
<td>38 33 10 23 13 0.497 33</td>
<td></td>
</tr>
</tbody>
</table>

This further result in the inability for the construction work to continue as the construction activities are interlinked (Love et al., 2002). Similarly, on construction projects where extreme cold weather are experienced, the productivity of labour can be
Factors That Impact Labour Productivity

affected and additionally, in extreme heat weathers, the level of labour productivity diminishes as the health of labourers will be susceptible to heat strokes and exhaustion (Love et al., 2002).

Change orders from designers/consultants (RII = 0.656) was also ranked highly with regards of being a core factor affecting the productivity of labour. There seems to be consensus across literature that purport that the variation orders or changes in designs and in some instances, errors on the drawings certified for the project significantly affect the productivity of labour (Kaming et al., 1997; Park, 2006; Jarkas, 2015; Naoum, 2016). Change orders not only impact the cost aspect of the construction project, but as can be seen from the ranking of this factor so high in the list, the performance of labour is directly affected by change orders as well. This assertion agrees with literature that also looked at the impact of the change and variation orders on the level of the productivity of labour on construction projects (Park, 2006). A link is drawn between the communication link and response time adequate to action a required change order between the consultants and the contractor in order to address the variation order by Love et al., (2002). Furthermore, the emergence of change orders from consultants, seldom consider the contractor’s program of works and as a result, any change in that program gives rise to labour being unproductive as the change in the programme requires an adjustment of the construction works (Doloi, 2008; Naoum, 2016).

Another factor ranked high is the fluctuations in material/equipment prices (RII = 0.648). Across the various projects analysed, this factor impacts not only the viability of the profitability of the project, but also the productivity the labour on site. Fugar and Agyakwah-Baah (2010) purports this finding in that the changes in the prices of both material, equipment and plant that is essential for the project execution, significantly affects the project delivery and subsequently, the productivity of labour on site. This assertion was inter-alia validated by Park (2006) in that the planning of acquiring material and equipment as well as their procurement, is necessary to ensuring that the productivity on a construction project is not halted and as a result, deemed unproductive due to poor projection of the changes in process and materials of the resources on site. According to the findings, it can be seen that this factor has the potential to affect the productivity if not considered well in advance in the execution of the construction process.

As part of the ranking, unexpected ground conditions (RII = 0.646) is ranked high to the level of its perceived impact on the level of labour productivity on construction project. The lack of knowledge of the geographical context of the soil as well as the geotechnical composition of the soil has been shown to have a detrimental impact on the productivity of labour and as a result, this finding is not in contention as it aligns with other studies (Gidado and Millar, 1992; Durdyev and Mbachu, 2011). The uncertainty in ground conditions is not limited to the soil composition but can also refer to the services and the municipal service pipes that pass through a particular erf where the development is happening. As a result, in the case that a service pipe is cut accidentally due to a lack of a clearly detailed service layout, this halts the construction work and inadvertently affect the labour productivity (Motwani et al., 1995; Durdyev and Mbachu, 2011).

Lack of experience amongst workers (RII = 0.646) and lack of experience of workers (RII = 0.629) are both ranked highly in the study across the projects and for the purposes of this research, lack of experience among workers include those that are in management and supervisory roles. These two factors are in consensus with the
Literature and additionally, literature is elaborate with regards to the impact of these factors on the level and output of labour productivity across construction project (Makulsawatudom et al., 2004; Alinaitwe et al., 2005; Alinaitw et al., 2007; Naoum, 2016). This factor is greatly cited and studies in this regard have been extensively engaged with and the findings of this research are in alignment with these results. Moreover, it has been established that the ranking of the inexperienced workers in the construction industry so high, is due to the multiple functions that both the workers and the management overseeing these workers bring to the execution of the project (Park, 2006). It is further argued that the lack of skilled supervisors and managers impeded the productivity of labourers in that they lack the proper planning skills essential for the execution of the project, additionally, they seldom possess the critical ability to manage both the material and labourers. As a consequence of this, the labour force on the ground or on site is not given the proper scope of work and material schedule that allows them to do their work (Park, 2006; Enshassi et al., 2007; Jarkas, 2015). Notwithstanding this, in South Africa particularly, some of the initiatives and skills development programmes implemented both by the government in order to develop the skills of labour, requires that the contractor absorb a certain portion of the working class on their projects in order to train them for specific trades (as a result, the workmanship of these apprentices on site on average brings the productivity of the construction teams down as it is not up to standard but rather a requirement of the contract (cidb, 2015; Barbosa et al., 2017; cidb, 2017). It can further be argued that the lack of proper monitoring of the construction industry is due to the fragmented nature of its operations, as a result, this is attributed to the lack of proper skill as there aren’t standardised measures of competency and skill employed on projects (Motwani et al., 1995; Fulford and Standing, 2014).

Inspection delays from engineers (RII = 0,644) is also ranked as being one of the core factors affecting the productivity of labour on construction projects. In the event that the engineers do not action a prompt response to the inspection request from the contractor, this delay impact negatively on the productivity of labour as it halts the works. The data from this study support earlier studies that reported this finding and the eminent impact on the productivity of labour (Doloi, 2008; Gündüz et al., 2012; Naoum, 2016). This factor affects both the sequential planning of the project activities as well as the labour involved in the project. The lack of proper communication in reasonable time to not deter the productivity of a project is imperative to both the success of a project which is reliant on the productivity of labour (Alinaitwe et al., 2005).

Another factor considered significant from a ranking perspective is the economic changes (change in VAT, inflation and foreign exchange rate (RII = 0,641). Whenever prices change, or legislature is passed for VAT to be changed, material prices change, and this subsequently means that the labour may remain idle while organisations restructure their supply chain or source new suppliers for their supply chain. In this regard, the productivity is impacted on projects.

Delays in the delivery of material (RII = 0,634) is also another factor ranked high from the perceptions of the respondents. Large part of the construction project is the transformation of material into tangible output which means that without material, labour will not be able to perform their function. Lack of material on a project is the major non-productive factor (Park, 2006). This finding is in alignment and consistent with previous studies (Hughes and Thorpe, 2014; Dzadaza and Crafford, 2015) as it has been found that the delay in the delivery of construction material gives rise to poop
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productivity and as a result, affect the project as a whole. Additionally, the programme of the construction activities and the morale of the labourers can be drastically affected in the event that material delivery is disrupted and further giving rise to idle labour and overhead costs relating to labour productivity being incurred without expended output (Enshassi et al., 2007). It is these studies that support the findings of the study in this regard and as a result, giving substantiation to the delay of material delivery as a highly ranked factor on the construction project to impact the productivity of labour.

Incomplete drawings (RII = 0.631) is another factor that is ranked as being core to the productivity of labour in the construction industry. The level of information and the scope of the construction project is largely carried by the drawings and the details of the design. It further follows that drawings that are not complete affect the productivity of labour as the findings suggest. Throughout literature, this finding is asserted and thus is valid (Alinaitwe et al., 2007).

The last factor ranked high across the various project types of projects as affecting the productivity of labour on construction projects, is the poorly designed projects (RII = 0.629). Similar to incomplete drawings, this factor is ranked high due to it being core to the information necessary to execute the work and give guide to the construction team and the labourers of their impending scope of work. It further means that poorly designed projects make the project susceptible to unforeseen complexities that affect productivity of labour from an execution point of view (Soekiman et al., 2011). The survey responses in the present study are in alignment with previous studies in that incomplete drawings is a significant factor to poor labour productivity (Moselhi and Khan, 2012).

CONCLUSION

The study aimed to establish core factors that impact on the level of labour productivity on across the construction industry. Findings of the study show that inclement weather (rain/cold/heat), followed by change orders from the designers/consultants, fluctuations in materials/equipment prices, unexpected site ground conditions, lack of experience amongst workers, inspection delays from engineers, Economic changes (change in VAT, inflation and foreign exchange rates), delays in delivery of material, incomplete drawings, poorly designed projects and lack of experience of workers are the fundamental factors that impact labour productivity on site. The integration and deliberate inclusion of these factors are paramount at the inception of the project as a remedial and cautionary measure in dealing with the potential impacts that may affect labour productivity. Furthermore, the endemic reputation that the construction industry has poor labour productivity output can be addressed by the project team's ability to diagnose and remedy issues that may arise during the construction project as pertinent factors that may give rise to reduced productivity. Moreover, the varying nature of the construction projects demands a thorough analysis of the project's expectation with regards to labour and the complexity of the development at hand. Lastly, in the South African construction industry, a dearth of literature exists that addresses the contextual factors that impact the productivity of labour and this study will form part of creating that body of knowledge.
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Factors That Impact Labour Productivity


CONTRACTS AND PROCUREMENT
ILLUSTRATING GAME PLAYING ON CONSTRUCTION CONTRACTS: THE NEGATIVE IMPACT OF PROCUREMENT STRATEGIES, A PROPOSAL FOR RESEARCH

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The normative construction procurement paradigm promotes robust tendering processes; project control; risk and schedule sharing; and trust-based partnering, but these theoretical solutions appear to lack impact in practice. This study examined the ‘lived experiences’ of construction contract managers through their stories about problematic contracts to review the current paradigm’s efficacy. The research aimed to develop alternative hypotheses to challenge the existing paradigm and explain the lack of progress in contract management and project delivery. N=30 experienced construction project managers were interviewed with unstructured open questions designed to encourage them to relate their ‘lived experience’ via the story telling of ‘critical incidents’. It has been possible to interpret a detailed ‘predictive narrative’ from the interview data, one that describes the construction project as an informal ‘asymmetric negotiation’. Contract managers and their teams appear to have employed the asymmetric negotiation techniques of blame apportionment to create leverage over the other. (a ‘asymmetric negotiation’ is a positional negotiation where the parties, or one party, withholds information from the other, using their hidden information to create advantage. Construction contractors are well placed to do this, as they control and report project progress). The ‘negotiation’ represents a hypothesis of how project uncertainties might be understood and resolved in modern construction contract practice. The primary data indicates that the approach identified might be common. The interview findings are presented as a ‘story’ of how a typical negotiation might unfold and offers this explanation as a general hypothesis. The client project manager might experience any asymmetric negotiation as ‘game playing’ by the contractor. However, rather than seeing this as the nefarious exploitation of one party by the contract, the paper hypothesizes that this ‘game playing’/’asymmetric negotiation’ is a consequence of the dominant structure of competitive procurement in UK construction, and represents an unspoken method for recovering underbid tenders. Understanding whether this is the case would seem important. It is recommended that the qualitative findings from this study are examined in follow-on studies that further examine, and test, the hypotheses developed here.

Keywords: conflict, contracting, negotiation, procurement

INTRODUCTION

Pursuing the question: “what can the lived experiences of contract managers in construction, tell us about the performance of construction procurement contracts?” This research aimed to: “Interpret the ‘lived experience’ of practicing contract/project

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Managers on construction contracts”. While the major challenge for projects is to manage the uncertainty of the investment, the assumption underpinning procurement contracts in construction is that the tendered contract will offer most of that certainty, by guaranteeing performance at a competitive market price. This assumption conforms to a neo-classical microeconomic theory. Although central to the current construction project paradigm, these assumptions were brought into question by the observed commentary of the sample group of contract managers to this study.

Hamilton (2001), Maylor (2010), Davis (2017), Coates and Heathcote (2017) highlighted the importance of the management of the uncertainty of the project’s capital investment. Capital investment exposure for clients forms a significant risk, the potential for variability in cost and time performance forms a central concern (Pryke and Smyth 2006). To manage this risk, projects and contract management employ techniques to control the possible variability of outturn. However, this assumes that the outturn costs of a contraction project can be accurately forecast. Several observed behaviours, and the dispositions of both contracted suppliers and clients in bidding and tendering show how this might be subject to further variance, and somewhat undermine efforts to control it.

The UK’s New Engineering Contract (NEC) suite of contracts, arising from Latham report (Latham 1994), sought to hand greater control to clients, by bringing about greater cooperation on UK contracts, post contract, through the sharing of risk (early warnings) and plan schedules. Egan (1998) took ‘partnering’ further proposing supply chain partnering that mimicked other industries where that was the norm. Making visible both dependencies between contractors in the supply chain and the client organisation (Eggleston 2006, Gould 2007) would alert to delays and cost overrun risks before they develop. Knowledge that this would happen in delivery might influence more caution in bidding. To control the problem of inaccurate and low bids (sometimes referred to as the ‘bidder’s curse’ (Mahmendier and Young 2011)), mitigating actions have been proposed, examples of which include: Waddle’s (2009) suggestion of how (mathematical) bid preparation techniques can assist contractors to avoid cost errors. Hiyassal (2001) had proposed an average bid method of selection to avoid the problems of accepting the lowest bid, which is more likely to represent and underbid. Hiyassal (2001) pointed out that lowest bids are typically associated with poor project performance in terms of quality and delay. This approach seems likely to fall foul of many procurement rules and law, particularly for public sector clients. Skitmore et al. (2002) proposed a method for identifying outliers in contract auctions, using distribution modelling to assist in better identification of credible bids by buyers. Sarjapur (2012) in reference to Californian construction contracts, considered the practice there of including “no damage, no delay” clauses which sought to transfer the total risk of underbidding to the contractor and to remove any mechanism to recover an underbid through claims for delay and cost, even where the cause of that delay might clearly come from the client organisation or others. This appears to be the ultimate risk transfer clause, but Sarjapur argues for its non-use, claiming, it was generally thought unenforceable by bidders, and was not reasonable either.

Supporting Sarjapur’s claim is Muaz et al’s (2016) assertion that the true cost of the project cannot be known until the contract work is complete and referred to the selection of an underestimated bid as ‘adverse selection’. Muaz et al., (2016) thought this adverse selection would be further compounded by multi-stage bid environment and recommended cooperative game theory as the possible source of any potential solution. Although much emphasis has been placed on creating more cooperative
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practice in U.K. construction engineering. Bresnen (2007) suggested that the presence of ‘partnering’ needed to be observed in practice, (as it often was presented as rhetoric only), and adversarial competitive behaviours remained dominant, between client and tier 1 contractor and between tier 1 contractor and the supply chain. Cheung et al., (2003) also saw partnering as being paid ‘lip-serve’ to, rather than enacted, with attitudes remaining adversarial. Related to this, Bennett and Peace (2006) described ‘bullying’ of [commercially] weaker sub-contractors as being a feature of U.K. construction. In many cases ‘partnering’ was limited to the relationship between the client and tier 1 contractor (Chan et al., 2006), with much of the work being completed by sub-contractors in the supply chain of the project, who were outside the arrangement, meaning the majority of the project continued in an adversarial way. McMeeken (2008); Gadde and Dubois (2010) and Morris et al., (2010) all saw partnering struggling in implementation. These interventions had sought to better equip the client investor with a more dependable outturn forecast. Actions to prevent adverse selection may not overcome other pressures on bidders. Muaz et al., (2016) point to the complexity of influences on bidders each bidder holding varying dispositions.

The varying degrees of preference and sensitivity of bidders identified by Muaz et al., (2016), brings an additional source of variability acting on the inaccuracy of contract bids. Oo et al., (2012) showed, in a statistically significant study, how contractor bidding behaviour, in a Hong Kong sample, was lower after a period of no-wins, and higher post-wins. Tang et al., (2008) showed how risk seeking tenderers are more likely to win contracts. Gkritza and Labi (2008), with data from Indiana contracts, showed that larger contracts were more likely to incur cost overruns and Mahmendier and Young (2011) demonstrated that 42% of auctions in their sample, exceed a simultaneous fixed price, this would equate to underbidding tendency on construction tenders, if this ‘bidders curse’ was mirrored there. These examples all point to the tendency for contracts to be underbid. Rather than this being a tendency limited to construction contracts, Kahneman and Tversky (1979) and Beuhler et al., (1994), had demonstrated in repeatable experiments that human beings possessed an embedded tendency to underestimate time and cost even when in possession of an immediate reference data that suggested otherwise. Kahneman and Tversky (1979) called this the ‘planning fallacy’. Investigating the over spend on public projects in Europe, separately Flyvbjerg et al., (2009), and Gray (2010) showed how the client business cases for projects tended to underestimate cost forecasts, which they both attributed to a desire for client project managers to achieve authorisation. This had the effect of creating pressures to arrive at a lower contract price.

This situation does indeed support the need, for contractors to ‘win’ work, and one way to do that is to underbid, and to seek to redress this is subsequent claims, for additional money and time as the work progresses and crucially, as the client is progressively more committed (Bresnen 2007). Perhaps contemporary developments fail to overcome the fundamentally adversarial nature of competitive bid. It is reasonable to assume that contractors will seek methods to reduce their own risk. Being very accurate in pricing might not be as available to bidders as it is assumed.

RESEARCH METHOD

This study looked to capture to the lived experiences of those managing construction contracts. Gabriel (1998) cited in Symon and Cassell (1998), showed how story telling might be used to gather qualitative data, and might be particularly applicable to
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research in and between organisations. Gabriel believed that ‘story telling’ “are valuable windows into .... the lives of organisations” and offer researchers a “powerful research instrument”. Gabriel (1998 in Symon and Cassell 1998, p135). Gabriel categorised story types for research, and included, amongst others the typologies of: “Tragic; Gripe and History” Gabriel (1998 in Symon and Cassell 1998, p136). These three would appear to best apply to the primary data gathered for this study. Storytelling allows for the ‘actual experience’ to be revealed and allows the professional processes and protocols to be set aside. In more formal inquiries, in this context, respondents might be more likely to recite the contracting protocols, that reflect the established paradigm. Organisational theorists and project management theorists regularly adopt cultural ‘paradigms’ in their disciplines thus connecting ‘stories’ as ways in which the paradigm is understood. (Meek 1988, Bowles 1989). The story telling approach is reminiscent of Flanagan’s (1954) ‘critical incident technique’ (CIT) with its focus on ‘lived experience’, although originally conceived for health-related studies has been employed in organisational and construction research (Kaulio 2008).

Chell (1998) cited in Symon and Cassell (1998) discuss how CIT can be applied to qualitative work in organisations and saw a focus on the practical learning can be extracted by asking questions that narrowed down on the problem. To support practical outcomes Flanagan (1954) suggested that: “..the incident must occur in a situation where the purpose or intent of the act seems fairly clear to the observer and where its consequences are sufficiently definite to leave little doubt concerning its effects” Flanagan (1954, p327). The qualitative data gathered in this study involved an opportunistic sample and arose from seminar interactions, and so lacked the structured rigour to make it clearly a CIT approach and attributions were formed later from the data gathered, not solicited as part of the CIT interview approach. The data however displayed a rich insight into the detailed stratagems employed in competitive tendering approaches and the ensuing relationship difficulties affecting people working on the project and the projects’ performance. For this reason, and unlike CIT which seeks to form practical recommendations, this study can only be regarded as a precursor to a more structured inquiry that might further refine or test the hypotheses raised here.

Unstructured interviews were conducted, (which were much less structured then the CIT approach would recommend), in which the experiences of these professionals in negotiating with clients and with contractors were related. The ‘telling’ was typically a little emotionally charged with the story often representing a level of frustration with the claims and the challenging of claims. The sample was drawn from those mature students who were able to comment on this phenomenon of contract management conflict, from their personal experience. Amongst sample respondents, the experience of contract management ranged from 5 to 20+ years. The sample included medium to large scale contracts and included client representative contract managers (or project managers) and contractor representatives at tier 1. There was n=30 respondents.

As with interviewing, and focus group research, ‘story - telling’ requires some interpretative effort on the part of the researcher (Saunders et al., 2007). Gabriel (1998) discusses how in story telling the researcher becomes involved in the ‘sense-making’ of the story being told. Researchers also use attributional coding to make sense of qualitative data gathered by interviews Silvester (1998 cited in Symon and Cassell 1998: 75). For this study, the researchers have interpreted the unstructured interview findings, and that forms a limitation.
Respondents’ comments had ‘sense made’ of the combined stories by the lecturer/researcher who had been present. The data has been interpreted to create a single predictive narrative of the course of ‘negotiations’ on contract engineering projects. This was made easier by the great deal of commonality in the stories being told of the contract managers’ ‘lived experience’ of tendered service contracts. This cumulative story/narrative is presented in the findings section.

**FINDINGS**

The cumulative sense-made of the interview data has been collated into a ‘story-line’; a ‘predictive narrative’ that explains how the ‘asymmetric negotiation’ will proceed on a competitively tendered contract. The ‘story is presented as a series of numbered short paragraphs in Table 1 but should be read as prose. The 72 points are separated as sub-hypotheses. It is this paper’s proposition that these separated, and related hypotheses should be tested in follow on studies. Text in italics in this section, are included for further explanation of the overarching hypothesis, and to maintain the narrative.

**Table 1: The summarised narrative of contract manager’s lived experiences of construction projects’ post award contract negotiations.**

<table>
<thead>
<tr>
<th><strong>UK contracting in construction related engineering has progressed to a highly refined form of negotiation. And it has done this to deal with a particular set of trying factors.</strong></th>
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<tbody>
<tr>
<td>1. Chief among these factors is the difficulty of accurately predicting the cost of a complex piece of work,</td>
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<tr>
<td>2. even when it's highly specified,</td>
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<tr>
<td>3. and especially when subject to some interpretation.</td>
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<tr>
<td>4. Also, construction engineering is highly volatile market, first to suffer the vagaries of an economic downturn. When that happens to maintain some Cash-flow and ride out the downturn, contractors may well bid very low</td>
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<td>5. or to knowing make a loss,</td>
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<td>6. just to get work coming in.</td>
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<tr>
<td>7. Further, as the upturn occurs tier one contractors can be left holding contracts priced when times were bad</td>
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<tr>
<td>8. and find their cheap supply chain tier 2 subcontractors have left to pursue more lucrative newer contracts.</td>
</tr>
<tr>
<td>9. This desire of the tender-bid process for deterministic predictions (cost certainty) in probabilistic realities might lie at the root of the problem.</td>
</tr>
<tr>
<td>Contributing to this is the fragmented nature of some supply chains (SC). But also, because much that SC can small businesses at tier 2 and 3, who do not use cost accounting but 'absorption accounting' (this is a method of estimating based on percentage uplifts from a base cost which typically will be the cost of materials).</td>
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<tr>
<td>10. Consequently, the price bid for work involves some guess work.</td>
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<td>11. Tier 2 subcontractors might allow as much as 40% margins to allow for this uncertainty</td>
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<td>12. ...Tier 1 buyers might well be aware of this</td>
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<td>13. ...and seek methods to reduce it.</td>
</tr>
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<td>14. So, when a tender-bid is made, the tier 1 uses the estimates from its supply chain to 'take a guess' at the cost of the work.</td>
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<tr>
<td>15. They take a risk,</td>
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<td>16. ...and they are then highly likely to spend the rest of the contract focussed on removing that risk.</td>
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<tr>
<td>Now what follows may represent either a conscious effort or an unconscious situation. I doubt it's written down anywhere as a matter of strategic ploy.</td>
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<td>17. The 'fixed' price offered for work is likely to be a misconception in the mind of the client.</td>
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<td>18. The contractor will be merely offering up a price-number that 'wins' their organisation the contract in a competitive bid situation.</td>
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<tr>
<td>19. ...Not a price that necessarily reflects reality.</td>
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<tr>
<td>20. Though it's also trying to be 'credible',</td>
</tr>
<tr>
<td>21. ...so would aim to be - not too low.</td>
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</table>
22. The rest of the contract becomes an ongoing measuring of the actual turn out cost,  
23. ...and an ongoing negotiation to arrive at a price with the client  
24. ...which can be reasonably justified  
25. ...and extracts as much profitability as possible.  
26. For the client this is frustrating.  
27. The contract price is a key factor in determining whether the project's business case stands up  
28. ...and supports the decision to go ahead with the project.  
29. Where the tier 1 contractor is involved in the feasibility work that looks at the viability of the  
   business case, then the contractor may likely support the natural optimism in any cost forecast  
   that encourages organisational approval.  
30. Once the contract starts the tier 1 contractor has a number of cards to play in the negotiation:  
   30.1. The client is not aware that a negotiation to improve the contract price  
   being prepared  
   for them;  
   30.2. The contractor prepares the programme of work, so they can disguise actual progress;  
   30.3. Much of the work is carried out by tier 2 sub-contractors (and tier 3), using absorption  
   costing so that they are unsure of their actual costs  
   30.4. ...and so are vulnerable to having their margins squeezed.  
   30.5. ...Or even removed completely;  
   30.6. A drip feed of claims for extension and additional costs can be fed to the client,  
   30.7. ...ideally faster than they can handle,  
   30.8. ...building up a back log.  
   30.9. The contractor has an advantage here because of point 30.2 (the programme report)  
   above.  
31. These claims will be mostly refuted by the client's project staff,  
32. ...but they'll be re-issued and  
33. ...never really go away.  
34. Eventually a large cumulative claim  
35. ...of great complexity is arrived at.  
36. It is increasingly presented to the client team as the contract nears completion.  
37. The approaching completion can then be delayed as a bargaining gambit.  
38. The project end is in sight,  
39. ...but commissioning is no longer guaranteed.  
40. ...And completion becomes a focus of client concerns.  
41. ...Tensions may increase now because of this uncertainty  
42. ...and because old refuted claims are re-made.  
43. (Pursuing any of this through formal legal routes like the courts, will seem expensive,  
44. ...and has the potential to attract unwanted publicity).  
45. So instead, when the timing is right the contractor's directors will cut out the client project  
   team and speak directly with the directors of the client organisation.  
46. All the refuted claims will be re-presented.  
47. ...Because the refuted claims look large (and have not yet been presented to the client directors,  
   by their own team, because they are not accepted as credible)  
48. ...and so, the client project team may well appear incompetent before their own directors.  
49. The project is likely to represent a highly visible capital investment for the client organisation,  
   failure to deliver it would be an embarrassment,  
50. ...doubts about the running of the contract/project by the client organisation are likely to be  
   personally damaging to the client's 'agents'  
51. ...so significant pressure to settle the claim has built up by this point.  
52. Directors (who are skilfully placed in a pally, lunching, flattered position)  
53. ...can then be set up to 'Rescue' the project  
54. ...by settling at much less than the full claim,  
55. ...say half.  
56. But this may still represent mostly un-defendable claims,  
57. and therefore profit,  
58. ... (or some recovery of an underbid tender) for the contractor.  
59. In this part of the negotiation the contractor is probing to find out what margin is left in the  
   business case for the client.  
60. ...This may be a critical time for the contractor.  
61. ... (Far from simply seeking to immorally profit from an unwitting client, the contractor may  
   well have found the project cost them more than they had estimated.
...They are seeking to reduce losses
...and perhaps create something of a margin.
...It's hard to be sure, unless you are on the inside).
Where the settlement is within the client's business case these can be readily agreed.
Where the price-bid is too low for this to be the case, there is more impetus for the client organisation to resist.
Then more legal means may be employed. Such as Adjudication.
(These however are expensive additions for the client too).
Many tier 1 contractors (in construction engineering especially) do not have much of anything in the way of engineering ability.
...All of it is sub-contracted out to the supply chain.
...So, tier 1s can focus on this negotiation game.
...Plus, they can play a similar game with the sub-contractors.
Who are focussed on the work task, not the negotiation, and so are also very vulnerable to being 'played' in this way?

DISCUSSION AND CONCLUSIONS

The findings allow for the summarised hypothesis that: H1 ‘The predictive narrative of the negotiation in the findings section, suggests that ‘game playing’ or ‘asymmetric negotiation’ that increases waste and risk to the client project, is common on construction contracts’.

H2 ‘That this ‘game playing’ or ‘asymmetric negotiation’ is a deliberate tactic’.

And that H3 ‘This approach is a consequence of price competition at tender’. The findings in table 1 set out the detailed set of sub-hypotheses to detail how this is achieved in practice. To explain; the competition places the emphasis on the need to both ‘win’ work, to reduce uncertainty for the contracting business, and to then maintain a reasonable profit margin. The approach can be used by contractors to either mitigate losses; or else maximise profit margin. Far from removing cost uncertainty for the client organisation, and transfer risk to the contractor, this ‘game’ increases it, and necessarily means that misinformation on progress is presented for much of the project.

Because each contract is 'bid' any reputational damage is reset at the start of each new project. Meaning the impetus to continue in adversarial game playing of asymmetric negotiation bluff is not moderated. One possibility is that this stratagem, is that it leads to blacklisting. But such blacklisting effects of a bad contract outcome have the potential to smear both parties. Clients tend not to have lots of repeat work meaning they have limited opportunities to make any blacklisting work. It should be noted that the sample group respondents included contract managers working on partnering frameworks.

New entrants are able to present attractive winning bids that are also unachievable, but once contracted, the contractor has created the opportunity to ‘make money’ from generating claims on project, that will bring them back up to an acceptable profit-making position. Similar circumstances occur in other markets with similar pressures. In effect the under-bidding contractor is offering a ‘loss leader’ to create a firm relationship with a client who can then be exploited.

Other sectors (notably auto-manufacturing) employ longer term partnerships with the tier 2 contract 'doers'. This largely allows for a focus on the work. And combined efforts to reduce costs through genuine efficiency over the period of more than one
contact. As in the case of a production run. This led Egan (1998) to propose ‘partnering’ for UK Construction. Arguably this has led to a change in rhetoric but not in behaviour. (Cheung et al., 2003).

It seems particularly important to say that this current state of affairs cannot be solely attributed to any imagined nefarious tendency of tier 1 contractors; this attribution was a feature of the respondents’ interpretations. However, it should be noted that the pressures to bid work and single project offers in a fragmented market that is subject to swings in the availability of work plus low barriers to new entrants are all significant structural factors creating this situation. It may even be a measure of the industry's ingenuity/innovation that the asymmetric negotiation solution, illustrated in table 1, has been arrived at.

The dominant feature for professionals working in construction engineering, tends to be that of contract management, rather than contract engineering. Somewhat illustrating the dominant nature of the risk transferring contract law paradigm in construction. Several alternative procurement approaches are available from other industries, where they are tried and tested. Egan (1998) made much of this and saw ‘supply chain management’ practices in other manufacturing industries as offering a ready solution. Its translation to in-situ construction can be said to have had limited effect (McMeeken 2008). It can be observed that ‘partnering’ has been corrupted to represent the traditional adversarial approach with a different rhetoric (Cheng et al., 2000, Chan et al., 2003, Chan et al., 2006). This was also evident in the respondent’s comments. The ‘stickiness’ of the current method of procurement may be partly because a professional structure also supports this culture.

By highlighting the ‘game playing’ ‘asymmetric negotiation’ approach that many projects and contracts, may think is the most available solution, it highlights how waste is created in the management of construction projects, but that it is done so with purpose. Removing that purpose might offer a route to future solutions. A follow-on study, to move towards the rejection of the null-hypotheses associated with this study’s findings, is recommended.

LIMITATIONS

The nature of the data collection meant that the researchers were collecting, rather than good news stories, when things went right but: Tragedies, Gripes and Histories, (Gabriel 1998) consequently the ‘stories’ might represent exaggerations of what really happened and also be influenced by the trauma and frustration of the memory, or because the respondent was in the middle of the scenario the respondent was describing. The follow-on study proposed will need to consider these potential biases and their potential skewing affects.

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CREATING STRATEGIC ALIGNMENT DURING THE DEVELOPMENT OF PROCUREMENT INSTRUMENTS

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Achieving strategic alignment is generally acknowledged as being key to procurement performance. However, the literature is unclear about how exactly alignment can be created on the operational level of procurement instruments. Furthermore, previous research indicates that procurement instruments are often developed intuitively and subjectively. In such circumstances it is questionable whether alignment will be achieved. A case study based on action research was conducted to examine how public clients can rationally and objectively create strategic alignment when developing new procurement instruments. The case concerned the development of a new procurement instrument by a major public construction client. The research was guided by a conceptual model that interprets the general concept of strategic alignment in the form of coherence in reasoning on multiple levels and dimensions of strategy. The results indicate that the rational and objective creation of strategic alignment requires the reasoning behind the design of procurement instruments to be explicated and linked with the reasoning behind higher level strategies and with the supply market. Elucidating the reasoning requires practitioners to articulate, share, discuss and combine their reasoning. The linking of reasoning can easily become complex and therefore requires the ability to use practical tools to define and complete hierarchical means-and-ends relationships.

Keywords: procurement, strategic alignment, tendering

INTRODUCTION

Public clients not only use existing procurement instruments, they also develop new ones. Instrument development can be justified if altering currently used instruments is no longer expected to result in an appropriate fit with the environment in which they are to be used. Such a misfit can occur if, for instance, new procurement strategies are introduced, or supply markets change significantly. Considering this from the perspective of fit, it would seem straightforward to assess newly developed procurement instruments on the basis of fit before they are put into use. It would be better still if this were to take place at those moments during the instrument development process when crucial design choices are made.

However, in reality, assessing the fit between procurement instruments and their environment does not seem to be straightforward. Previous research indicates that, in practice, designing procurement instruments may involve a highly intuitive and subjective process, involving few theoretical or empirical considerations (Ballesteros-Pérez et al., 2015). Further, when it comes to procurement instruments, the literature

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lacks operationalisations of the concept of 'fit', or 'strategic alignment'. In such circumstances, it is questionable whether the alignment between an instrument and, for example, the client's strategic goals can be properly assessed. Creating strategic alignment may then be more a matter of chance than of skill.

This paper explores how public clients could rationally and objectively create strategic alignment when developing new procurement instruments. It reports on an exploratory action research case study that was performed at the procurement department of a major public construction client. In this study, researchers and practitioners collaborated to achieve strategic alignment during the development of a new procurement instrument.

CONCEPTUAL APPROACH

Previous research has employed the term 'procurement instruments' to refer to the methods, systems and documents needed to run the procurement process (Plantinga et al., 2019). Contracts and contract award criteria are examples of such procurement instruments. As an alternative to applying standard procurement instruments (e.g. NEC3 contracts), public clients can also self-develop instruments (e.g. a tailor-made contract). This process of designing or modifying procurement instruments by a public client has been referred to as a 'development process' (Plantinga et al., 2019).

Previous research has recognized the relevance of creating strategic alignment in both private (Baier et al., 2008) and public procurement (Patrucco et al., 2017). The central proposition of strategic alignment is that the performance of an organization is determined by the alignment or fit between two or more factors such as strategy, structure, technology or environment (Spina et al., 2016). Patrucco et al., (2017) propose a framework that identifies alignment between public procurement strategies and four specific dimensions of the environment: broader political strategies; departmental strategies; the supply market; and the public organization's internal strategies.

Procurement instruments also need to be aligned with these four dimensions. Although Patrucco et al., (2017) discuss procurement strategies rather than instruments, it is reasonable to treat both in the same way since procurement instruments constitute the operational means to implement procurement strategies and therefore concern the same 'content of fit' (Venkatraman 1984). While the literature is clear about the need to create alignment, it is less clear as to what exactly constitutes this alignment. This study views strategic alignment in terms of logically valid relationships between the reasoning behind the design of procurement instruments on the one hand, and the reasoning behind the strategies present regarding Patrucco et al., (2017)'s four environmental dimensions on the other. Similar to the way in which a causal map may represent a strategic plan (Bryson et al., 2004), a procurement instrument can be considered as well-aligned if the corresponding reasoning forms clear and logically valid means-and-ends relationships with the reasoning on these four dimensions.

Explication of reasoning

Before the reasoning can be assessed, it needs to be clearly explicated. However, explication may be problematic if the procurement instrument development process has been highly intuitive and subjective. If the process can be typified as such, then the reasoning behind the procurement instruments (from here: Procurement Reasoning (PR)) is also probably intuitive. Further, the need to explicate PR has probably not
been recognized. In such cases, PR will likely remain implicit - that is, neither articulated and shared with colleagues, nor discussed and improved.

To conceptually approach the explication of reasoning, this study employs the general notions of tacit and explicit knowledge (Polanyi 1966). It has been argued that tacit and explicit knowledge form the two ends of a continuum (Nonaka and von Krogh 2009). While purely tacit knowledge cannot by definition be turned into explicit knowledge, lesser forms of tacit knowledge can be made explicit through articulation and externalization (Nonaka and von Krogh 2009). This study therefore assumes that some tacit forms of reasoning, such as intuitive practitioner knowledge on the effects of a procurement instrument, need to, and can be, turned into explicit reasoning before strategic alignment can be assessed. To create favourable conditions for this, the development process ideally needs a more rational approach.

**Conceptual model**

The conceptual approach elaborated above is summarized in the following model. A procurement instrument is considered highly strategically aligned if the PR forms logical and coherent chains of means-and-ends relationships with, ultimately, goals formulated on the four environmental dimensions: political, departmental and internal strategies plus the supply market. However, in an intuitively and subjectively run development process, the assessment of strategic alignment may be hampered by implicit reasoning. To enable assessment, this implicit reasoning needs first to be explicated. Figure 1 illustrates the study's conceptual model.

![Conceptual Model](image)

**Figure 1: Conceptual Model**

**RESEARCH APPROACH**

This research is set in the procurement department of a major public construction client in the Netherlands. The research was commissioned by the department manager in order to gain a tighter grip on the current practice in handling procurement instruments. The development of new procurement instruments was given particular attention. This focus was chosen because the development process seemed the least manageable of all the procurement instrument handling processes present in the department.

**Methods**

To explore how the development process was enacted in the department, an action research case study was undertaken on one of the more complex procurement instrument development processes going on at that time. Case research is appropriate for answering how and why questions that focus on contemporary events where there
is no control over behavioural events (Yin 2014). Action research is appropriate for addressing 'real-life' problems and bringing about change in specific contexts with the dual goals of improvement and of generating knowledge (Connaughton and Weller 2013). In the construction research community, action research has, one the one hand, been criticized in relation to its replicability, reliability, generalizability and objectivity but, on the other hand, it is also recognized for helping to close the gap between theory and practice and for improving the relevance and impact of academic research through its proactive nature (Connaughton and Weller 2013).

The present study utilized a five-step AR cycle: 1) diagnosing, 2) action planning, 3) action taking, 4) evaluating and 5) specifying learning (Azhar et al., 2010). Diagnosing amounts to identifying the primary research problem(s). Action planning establishes the target for, and approach to, change. In the action-taking step, researchers and practitioners collaboratively intervene in the practitioner's organization to cause certain changes. Evaluating involves determining whether the theoretical effects of the action were realized. Although, formally, specifying learning is the final step, in practice it is usually a step in an ongoing circular process (Azhar et al., 2010).

The research team consisted of four people: three researchers and the procurement officer responsible for running the development process. The latter is referred to in this paper as the Procurement Instrument Developer (PID). Given that the joint interpretation of results is held to provide validity (Connaughton and Weller 2013), the PID was actively involved in all five AR steps. Being responsible for development progress, the PID collected and created documentation, organized meetings and reported to management. The PID involved a group of about ten peer practitioners in the development process, mainly for discussion and validation purposes.

The researchers had the opportunity to join up with the PID in an early phase of the development process. The first author of this paper (from here: author1) attended meetings at the procurement department. Data were gathered by author1 in the form of interviews, external and internal client documents (reports, memos, emails) and meeting observations. These observations were documented in field notes. Practitioners were typically interviewed shortly after a development process meeting had taken place. The goal of these interviews was to question the meeting participants individually and compare their inputs. Interviews had a semi-structured format, using a fixed set of questions and taking the opportunity to inquire further when considered necessary. Questions primarily dealt with a participant's reasoning on the new procurement instrument and potential issues that impeded delivering such input. The interviews typically lasted one hour and were audio-recorded and later coded.

The second author took part in some of the development process meetings to gain a personal frame of reference for when discussing steps in each AR cycle. The third author did not take part in these meetings in order to safeguard objectivity during the AR cycles.

Since the AR intervened in an ongoing development process, and explication and linking of the reasoning was best observable during PR discussions in practitioner meetings, the AR cycles were defined by the extent to which interventions had achieved satisfactory results in later meetings. The AR cycles were therefore delineated by the meetings organized during the development process.
Case description

The development process in question concerns the development of a new qualification system (QS). The European Utilities Directive describes the QS as an option for particular types of public clients. A QS offers the opportunity to select potential suppliers for a period of time and a certain scope of work, rather than having them re-qualify for each tendering procedure (article 77, directive 2014/25/EU).

In our case organization, the PID was assigned to develop a vision for a new QS. The QS concept was not new to the client as it had initially set up a QS more than 20 years ago. Over time, this QS had undergone some considerable changes but, recently, department management had decided that the current QS design should be fundamentally reconsidered. The PID was selected because of his extensive knowledge of the current QS.

Vision creation was the first stage of the procurement instrument development process. After management approval, the next stages would involve detailing the vision and implementing it in practice. The action research was initiated some considerable time after the management assignment, but in time for author1 to participate in the first internal practitioner meeting arranged by the PID.

The results section below summarizes the research into the AR steps undertaken in each AR cycle. In the past, AR papers have been criticized for not being entirely clear as to what 'interventions' (actions) were being introduced, observed, reflected upon and used as a basis for a further AR cycle (Connaughton and Weller 2013). To address these concerns, we summarize the individual steps to provide the reader with clarity with regard to these interventions.

RESULTS

In total, three AR cycles were completed before strategic alignment in the sense described in the previous section was achieved. The main findings from the AR cycles are that:

1. Disentangling PR from other development process aspects is needed in order to recognize PR explication as a separate activity (AR cycle 1).
2. The subjective and fragmented nature of the PR generated impedes rational assessment of strategic alignment (AR cycle 2).
3. Revising an instrument's causal map during the procurement instrument development process provides a rational way to create strategic alignment (AR cycle 3).

AR cycle 1: Disentangling PR

The first AR cycle was triggered by research observations in a two-hour meeting in which the PID presented his first ideas regarding the new QS to a small group of colleagues. Author1 attended this meeting and then organized five separate one-hour interviews.

Diagnosing - Conversations during the trial meeting barely touched on PR. Most of the meeting was spent clarifying issues that the researchers later categorized as development process issues. In total, the researchers identified nine such issues that led to time-consuming discussions.

One category of issues concerned ambiguity in the assignment to create a vision. It was observed in the meeting and in subsequent interviews that the assignment lacked
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clarity. Questions were raised with regards to what exactly the development process should deliver (issue 1: what is a ‘vision’ anyway?), what triggered the assignment (issue 2: why a new vision?), what is the current state (issue 3: what exactly is our current vision, is it documented?), which problems should be solved (issue 4: on precisely which aspects is the current QS supposedly lacking?), how urgent is the assignment (issue 5: when to deliver, what are the consequences if delivery is late?).

Another category of issues related to ambiguity in the organization of the development process. This regarded current process design (issue 6: how is the process designed, what are the next steps, who is involved?), and alternative ideas for running such a process (issue 7: benchmark international QS designs?).

The final category of issues concerned practitioners’ understanding of the current QS. Questions were raised about demarcation (issue 8: what exactly is part of the QS?) and performance measurement (issue 9: how is the current QS's performance assessed, how should it be assessed?).

Action planning - We initially hypothesized that a clear conceptual identification of PR and its role in the development process was needed. This would help to move development process ambiguities to one side, and thus create time and focus attention on PR. Author1 presented a detailed, process proposal in which the role of PR was distinguished from other development process aspects and activities.

Action taking - Author1 developed a proposal for a generic procurement instrument development process. This was discussed in a workshop with the PID, members of the management team and the researchers. The proposal was approved.

Evaluating - After the workshop, the PID and the first two authors evaluated the action. Overall it was concluded that the process proposal was an improvement on current practice because it distinguishes PR-related activities from other process activities. This enables the PID to focus on PR explication.

Specifying learning - The development process and PR can be intertwined in an ambiguous manner. Therefore, disentangling PR from other development process aspects is needed in order to recognize PR explication as a separate activity.

AR cycle 2: Explicating PR

The second cycle was started after a two-hour try-out session organized by the PID. Having substantially elaborated on his original ideas, his aim was now to present these as 'the vision' for the new QS and find out whether the attendants would support this vision. The PID's PR was incorporated in the presentation. Three experienced category managers and author1 were invited to this try-out session. Within the two weeks following this meeting, author1 interviewed each of these category managers. The separate one-hour interviews were intended to evaluate the meeting in general and particularly to explore each person’s personal PR on the QS.

Diagnosing - The PID felt he was not receiving sufficient feedback in the form of PR. As in AR cycle 1, discussions on other issues were consuming the meeting time. Six additional issues were identified. These were categorized as either development process issues (issue 10: more time needed to process all the information before confirming one's support of the new vision; issue 11: changed motivation for creating a new vision; issue 12: lack of clarity about extent of personal involvement in the development process) or PR process issues (issue 13: reinvention of PR; issue 14: difficulties in articulating PR; issue 15: insufficient opportunity to develop PR).
Action planning - Author1 and the PID agreed to invite the category managers for a second two-hour meeting but, this time, they would be restricted to talking only about PR in the sense of the presumed effects of the new QS design in their respective procurement categories. To illustrate the desired PR, quotes from each of the earlier interviews would be presented as examples of PR. In this way, the category managers would be shown which parts of their own words should be understood as PR.

Action taking - In the second meeting, both the PID and the authors intervened several times to urge the category managers to explicate their PR. This resulted in pieces of PR for each procurement category, such as 'I expect the new QS will decrease our supply market'. Why? 'In my category, some types of contractors will doubt whether the relatively limited amount of expected future work outweighs the investment needed to become qualified.' In turn, this gave rise to a discussion on the desired number of competitors for that particular type of contract and the expected increase in quality delivered.

Evaluating - This time, each of the category managers had expressed their PR about the vision’s presumed effects. Further, the PR was deepened through discussion. While it was clearly not always easy to explicate one's PR, the relevance of explication became clear in this meeting. However, the generated PR came across as rather incomplete and subjectively prioritized lines of argument. Relationships with higher level procurement strategies, and ultimately the public client’s strategic goals (safety, reliability, punctuality and sustainability of the rail infrastructure) were unclear or missing.

Specifying learning - While it is certainly helpful that practitioners now acknowledge the role of PR in the development process, and that time has been devoted to PR, the subjective and fragmented nature of the generated PR impedes rational assessment of alignment.

AR cycle 3: Creating strategic alignment

The third AR cycle was initiated after a meeting with the procurement department's management team. Having finalized his vision on the new QS, the PID's next step was to obtain management approval. To this end, a two-hour session with management representatives, some category managers and some experts on the current QS was organized. The first two authors also attended this meeting.

Diagnosing - The new vision's presumed impact was seen as referring to an overly complicated environment that would make it impossible to swiftly inform the management team. It was diagnosed that the PR generated to date needed more structuring and that the relationship between PR and goals needed to be more clearly established.

Action planning - It was hypothesized that causal mapping would be a helpful tool to structure the PR and establish relationships with goals. Since both the PID and the researchers were inexperienced with causal mapping, it was decided to try it out with only the PID initially, using only the PR generated so far. Author1 was to make himself familiar with the causal mapping literature so that he could guide this process.

Action taking - Author1 organized a two-hour session with the PID to use causal mapping as a means to assess strategic alignment. In this session, the PR behind the new vision was linked to a mix of top-level organizational goals (e.g. safety), lower level category goals (e.g. competition), inter-organizational goals (as described in the client's concession granted by government) and to some supply market features.
Evaluation - For a complex system such as the QS, causal mapping was seen as a useful tool to structure PR and relate it to higher level goals and strategies. The causal map for the new QS provided a practical means to place PR in a logical hierarchy. Similar to the causal mapping of process descriptions, going back and forth between the hierarchy of reasoning resulted in adjusted relationships, and additions and reformulations of reasoning. As such, the process of creating this map also involved an assessment of the level of alignment. Such hierarchically linked reasoning can be validated on the logic of presumed cause-and-effect relationships. Incomplete parts of the map point towards potential misalignments.

Reflection - Causal mapping provides a practical tool to support the creation of strategic alignment by structuring and improving the PR so far generated, linking PR with other reasoning and goals, and complementing the hierarchies of reasoning. The process of revising an instrument's causal map along with the development of a procurement instrument provides a rational way to create strategic alignment.

Since this reflection answers this study’s research question, no more AR cycles were required. Table 1 summarizes how the AR cycles resulted in an answer to the research question.

Table 1: Summary of AR cycles

<table>
<thead>
<tr>
<th></th>
<th>Diagnosis</th>
<th>Action planning</th>
<th>Action taking</th>
<th>Evaluation</th>
<th>Reflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>AR cycle 1</td>
<td>Development process issues impede discussion of PR</td>
<td>Detail role of PR throughout development process</td>
<td>New process proposal written as concrete activities</td>
<td>Role description of PR is helpful but insufficient to explicate PR</td>
<td>Development process and PR are ambiguously intertwined</td>
</tr>
<tr>
<td>AR cycle 2</td>
<td>Explication of PR needs to be organized</td>
<td>Dedicate meeting to PR only and illustrate concept of PR</td>
<td>PR stimulated in practitioner meeting</td>
<td>Method needed to structure and relate fragmented PR</td>
<td>Generating PR requires deliberate organizing effort</td>
</tr>
<tr>
<td>AR cycle 3</td>
<td>Difficulty to relate PR to higher level goals or strategy</td>
<td>Use causal mapping method</td>
<td>Workshop organized for linking PR to alignment dimensions</td>
<td>Causal mapping helps to explicate, link, discuss and complete PR</td>
<td>Alignment can be rationally created by frequently revising the causal map</td>
</tr>
</tbody>
</table>

DISCUSSION

This study set out to explore how public clients could create strategic alignment during the procurement instrument development process. Previous research posited that procurement instrument development can be an intuitive and subjective process (Ballesteros-Pérez et al., 2015). This characterization was also valid here even though that research particularly concerned the formulation of economic scoring rules. Here, the development process was both started and shaped in an implicit manner. This gave space for many issues to arise, for discussions to become blurred and for participants to contribute in intuitive and fragmented ways. Most significantly, it impeded the rational creation of strategic alignment.

One key problem is that while the explication of PR is necessary to create strategic alignment, this in itself is already difficult to achieve. Explication requires not only time to be dedicated to PR in meetings, it also requires the willingness and ability of practitioners to collectively articulate, share, discuss and combine their PR.

Another key problem is that the PR present needs to be linked with reasoning, and ultimately with goals, on the four environmental dimensions. Causal mapping has
been shown to be a helpful and practical tool to facilitate this. In addition, causal mapping helps to explicate PR as well as stimulating practitioners to address incomplete or illogical parts of their PR. Overall, it appears that PIDs should either have the ability or avail themselves of the capability to effectively chair meetings dedicated to explicating and linking PR.

In answer to the research question, this study indicates that the creation of strategic alignment requires the PID to deliberately organize the explication and linking of PR as a recurring activity in the development process. Organizing other process aspects in a more explicit and rational manner is helpful in avoiding spending meeting time on clarifying process issues instead of PR.

This paper contributes to the literature in two ways. First, the literature shows a lack of research that seeks to operationalize the concept of strategic alignment in construction procurement. Although many methods have been proposed for selecting the best procurement approach (Love et al., 2012), the use of the strategic alignment concept is quite scarce in that setting. This paper's conceptual framework and the recommendations on how to rationally create strategic alignment offers a means to achieve this alignment. On a note of caution, this paper's conceptual framework and recommendations for achieving strategic alignment are based on a single case study, and different client organization contexts, procurement instruments and other factors may lead to different recommendations. Nevertheless, the core problems of explicating and linking PR will probably be relevant in many other cases since these are rooted in generally acknowledged difficulties inherent to tacit knowledge and knowledge conversion (Nonaka and von Krogh 2009).

Second, while individual procurement instruments have been addressed in the literature (e.g. Ballesteros-Pérez et al., 2015), research on the development of new instruments is very limited. This paper elaborates several aspects where the procurement instrument development process can be characterized as intuitive and subjective. Although this inventory is again based on a single case, and future research may identify additional issues, creating awareness of these aspects will help to rationalize and manage the development process.

CONCLUSIONS

Rationally and objectively creating strategic alignment during the process of procurement instrument development can be achieved by explicating and linking the reasoning behind the design of procurement instruments with the reasoning behind higher level strategies and approaches to the supply market. Unless the process is deliberately organized and managed, it is unlikely that alignment will be achieved. Explication of reasoning requires practitioners to articulate, share, discuss and combine their reasoning. The linking of reasoning can easily become complex and this therefore requires the ability to use practical tools to compose and complete hierarchical means-and-ends relationships. An intuitively and subjectively run development process complicates the creation of strategic alignment as this can lead to discussions on issues that, although relevant, distract attention from the focal issue and consume valuable meeting time.

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HOW CAN DIGITAL TECHNOLOGY IMPROVE PRODUCTIVITY IN RETROFITTING WORKS WITHIN THE UK SOCIAL HOUSING SECTOR?

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The UK Government advocates undertaking retrofitting works to the existing housing stock to assist in meeting the carbon reduction targets set out in the Climate Change Act 2008. Over 4 million dwellings within the current stock are managed and maintained by social housing registered providers and a significant number of these properties require retrofitting works in order for the registered providers to deliver low-carbon, energy-efficient dwellings. However, the social housing sector is facing a number of financial challenges which means that registered providers are seeking more streamlined and efficient ways of working to improve productivity in retrofitting contracts. The Government’s industrial strategy supports the adoption of Digital Technology [DT] to enable effective and collaborative ways of working throughout the construction supply chain. This research sets out to establish whether the innovative use of DT has, to date, been accepted within the UK social housing sector with respect to retrofitting works and endeavours to identify new areas and roles where DT may contribute to improving the productivity of retrofitting works. The research methodology collected data from senior professionals working within the social housing retrofit supply chain, using semi-structured interviews. Thematic analysis was used to identify ideas and patterns within the resulting datasets. The findings indicate that DT could be employed throughout the whole-life of a retrofitted property, from the initial design and construction stages through to playing a pivotal role in the management of the asset. This could include the utilisation of smart data and encourage collaborative engagement with all stakeholders including end users. However, for the diffusion of DT within the social housing sector to be successful a change in the perception of DT by actors within the sector is required.

Keywords: carbon reduction, digital technology, retrofitting

INTRODUCTION

Social Housing is the provision of accommodation let on a secure basis at affordable rents to people on low incomes. In the UK, Registered Providers [RPs] are bodies that own and manage social housing and are, predominantly, not-for-profit organisations such as local authorities and housing associations (Shelter 2017). Between 4 and 5 million dwellings are maintained and managed in the social housing sector (SHS) (Smith and Abbott 2017). A significant number of these homes will need retrofit works to improve the thermal comfort and to replace building components at the end of their economic life (Brown et al., 2018).

In the context of this paper “retrofit” will focus on the “fabric first approach” which optimises the fabric design of dwellings to minimise energy consumption over the life

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of the building. There are a number of definitions of fabric-first principles including those put forward by the BRE (Stenlund 2016) and Passivhaus (2018) which have the common features for meeting advanced energy efficiency requirements by using; the thermal mass of the building fabric, super high insulation, maximising airtightness, thermal bridging, and optimising natural ventilation.

Prima facie, RPs of social housing should be ideally placed to deliver retrofit contracts as they, together with their approved contractors, can (i) offer a volume scale of efficient operations via their existing reinvestment programmes (Loosemore 2016) and (ii) have the technical skill and customer-facing experience gained in delivering large scale improvement programmes (IET 2018). Nevertheless, the SHS is, currently, facing financial challenges such as cuts in development funding subsidies (Marsh 2018), reduction in rental income due to welfare reforms (MHCLG 2016) and the withdrawal of some banks from long-term lending resulting in more risk prone investments with other institutional lenders (PIC 2016). To overcome these difficulties, RPs are seeking more productive ways of working.

Intrinsic problems with productivity and how to improve value in the UK construction sector have been recognized over many decades, with the Chartered Institute of Building (CIOB) branding productivity as a “thorn in the side” of the industry in its report “Productivity in Construction” (CIOB 2016 p. 5). It is acknowledged that current productivity challenges in the UK construction sector focus around a mix of human, cultural and economic factors such as an ageing workforce, the poor image of construction, the ubiquitous Brexit issue, an inability to deliver projects on-time and within budget et al., Manifestly, there is no one panacea for these problems but the UK Government’s 2018 Industrial Strategy “Building a Britain Fit for the Future ” sets out to improve productivity by utilising digital technology with a focus on investment in digital skills, infrastructure and innovation. In addition to this the government has contributed £170 million to the “Transforming Construction” challenge which supports industry to adopt new technologies and help buildings to be constructed 50% faster, 33% cheaper and with half the lifetime carbon emissions (UK Research and Innovation 2019).

There have been several reports which suggest how digital technology will assist in improving productivity (ICE 2015, Mckinsey 2017, Accenture 2018). These reports have focused on the following digital technologies; (i) Building Information Modelling [BIM], (ii) Unmanned Ariel Vehicles (UAV’s)/drones and associated technologies such as laser scanning and photogrammetry, (iii) Smart technology including artificial intelligence and algorithms and (iv) virtual and augmented reality. These areas are the core focus of the literature review which assesses how each technology is currently being used with respect to retrofitting works within the UK construction industry.

LITERATURE REVIEW

BIM is a way of working in a team environment. The 3D model, the intelligent data that it contains and the simulations of the 'design-build-operate' process facilitate informed decision-making. This results in the reduction of risk and uncertainty, improved collaboration and communication in a common data environment (CDE) and, ultimately, increased efficiency (UK BIM Task Group 2017). There are four dimensions of BIM which refer to the linkage of specific data to a shared 3D BIM model. 4D BIM connects associated time schedules including visualisations to the model. 5D BIM adds accurate cost information based on the 3D model. 6D BIM
provides whole life cycle cost information and data to support the ongoing management of the asset using the Asset Information Model (AIM). 6D BIM is sometimes known as 'integrated BIM' or 'iBIM'. The Government commissioned report into the current skills shortage in the UK construction industry, "Modernise or Die", places BIM at the heart of the road map to collaboration and high efficiency and states that “BIM should be embraced by industry-the private sector moving to BIM adoption as a business norm” (Farmer 2016, p.69).

In general, the academic literature around BIM addresses its use on new-build construction projects, though research with respect to retrofit projects has made a case for the implementation of BIM to minimise disruption to tenants in housing retrofits (Kemmer et al., 2016) and improve stakeholders understanding of the retrofit process (Chaves et al., 2016). However, the application of BIM to retrofit existing buildings raises challenges in the production of a 3D pre-retrofit model which may be due to the wide array of technological components that are required to ensure the optimal exchange of information during the collaborative design process (Khaddaj and Srour 2016).

A possible future role of BIM in improving productivity is provided by a Dutch concept known as “Energiesprong” (literally translated as “energy leap”). This is a radical retrofit approach that involves enveloping an existing dwelling with customised cladding optimised for off-site manufacture, to deliver a highly insulated, low maintenance house with an assured net zero energy performance (Smith and Abbot 2017). Energiesprong UK Ltd claim that BIM plays a central role in the off-site manufacturing process as the properties are scanned using 3-D lasers and BIM produces working drawings that are sent to a flexible factory to produce the package of prefabricated panels (Energiesprong 2016). The creation of an accurate pre-retrofit model could, potentially, benefit from the use of a combination of photogrammetric and laser scanner systems to overcome the problems of resolution, accuracy and operational requirements.

The laser scanning (or Light Detection and Ranging [LiDAR]) of existing buildings to produce digital documentation has become popular in the construction industry due to its speed and accuracy of measurement. This process can capture complex geometry and small details but the limitations of using multiple point clouds to transform the 3D survey points collected is acknowledged (Laefer and Truong-Hong 2017). Similarly, photogrammetry extracts input data from 2D photo images to map them onto a 3D space and as the models are made up of photographs, they have highly textured detail that cannot be obtained using laser scanning. But environmental and site conditions such as lighting can affect the accuracy of the image processing (Omar and Nehdi 2016).

Over the last few years both laser scanning and photogrammetry have been used in conjunction with UAV’s and drones for the aerial surveying of buildings as they provide a very cost-effective alternative to hiring a plane. High mega pixel cameras are being combined with the latest GPS drone technology to create UAV photogrammetry which, potentially, is quicker than laser scanning especially when used in, say, the retrofitting of the external facades of tower blocks or inaccessible roof areas (Scanair 2019). A process to combine all these digital technologies to enable BIM to be implemented and improve productivity in retrofitting contracts has already been theoretically devised (Scherer and Katranushkov 2018).
Retrofitting of existing buildings using smart technology is currently being used to reduce energy consumption and improve the lives of the building end users. It is anticipated that smart technology will offer a number of functions ranging from recording how much energy is being used to reporting a broken light bulb. A number of smart thermostats such as Switchee have been retrofitted into social housing stock with the combined aim of reducing resident's energy consumption by up to 15% and providing RPs with analytics to optimise their ability to allocate energy efficiency retrofit budgets (SSEIR 2017). These systems contain sensors that pass readings to a secure cloud which, using algorithms based on historical data, produce an occupancy profile for each dwelling and controls the temperature and humidity levels within the properties. It is reasonably foreseeable that by using the external weather sensor data that exist on the Internet and comparing it with the data held in a secure cloud, real time control for heating and humidity in individual properties by smart thermostats could be achieved (Scaysbrook 2016).

Virtual Reality technologies have been used in construction for a number of years primarily for design review, end-user training and marketing. Despite the benefits of VR, it has not been widely adopted in retrofit contracts as the industry still lacks a general understanding of the technology in addition to a lack of expertise in the use of VR tools and display systems (Liu et al., 2014).

**RESEARCH AIM AND METHODOLOGY**

The overarching aim of the research was to establish if the innovative use of DT has, to date, been accepted within the UK social housing sector with respect to retrofitting works. It also endeavoured to identify new areas and roles where DT may contribute to improving the productivity of retrofitting works.

The research methodology collected data from senior professionals working within the social housing retrofit supply chain using semi-structured interviews. Thematic analysis was used to analyse the resulting datasets.

The research took the position that if DT is to be adopted within the SHS then the first step is for it to be procured by organisations within the SHS retrofitting supply chain. The research focused on actors who, prima facie, could be influential in the decision-making process to procure DT for use in retrofitting projects. The 10 interviewees were selected on a purposive sampling basis using the criteria that they were representative of experienced senior professionals within the SHS supply chain. The sample included; the director of a RP, a senior manager within a different RP, a geomatics specialist, a chief engineer of a residential development company, a software developer and a senior construction consultant. All of them were decision-makers within their own organisations, i.e. working at either board or executive management level and had the knowledge to supply perceptive and useful comments on some or all of the research topics. The interviewees had a broad range of experience and expertise and were members of independent bodies including the UK Government BIM Task Group, UK Housing Forum, Green Building Council, and the AEC (UK) BIM Protocols Committee.

TA was used to examine themes and identify ideas within and across datasets. It is acknowledged that reliability with this method can sometimes be a concern because of the wide variety of interpretations of the themes and the potential to miss nuanced data. The written records of the interviews were analysed using Braun and Clarke’s (2006) six-phase TA process which comprises: a) immersion in the data, b) generating
initial codes c) probing for themes, d) reviewing themes e) naming themes and f) final analysis and production of a written report. The main themes were derived using Patton’s (1990) dual criteria which states that themes must be clear and distinct from each other and the data contained within the themes must be cohesive and meaningful. The two themes established were; Construction Innovation and Digital Inclusion.

**RESEARCH FINDINGS**

**Theme One: Construction Innovation**

Though BIM is already used for retrofitting projects in a very limited way the general consensus was that there was no real client requirement for BIM to be introduced as the concept of BIM is not readily understood. Many actors in the SHS supply chain are satisfied with their existing design software. Nor was BIM always seen to be currently compatible with the sector’s culture. The senior construction consultant held the view that;

> A couple of years ago everybody was talking about BIM but now nobody is talking about it… BIM has to become part of the social housing culture before it becomes effective.

Several respondents expressed views on how perceptions could be changed so that BIM and associated DTs could be adopted for retrofitting in the SHS. Several of the interviewees foresee the BIM database being ideally placed to assist in health and safety compliance issues, notably, fire risk assessments, gas safety checks etc and clients would be able to see the cost benefits of purchasing the software. The ability to store photogrammetric data and geotagged photographs also allows BIM to build up a visual record of the condition of the subject property over the lifetime of the asset. The software developer commented on this issue:

> The future following Grenfell …council’s kind of thought contractors were keeping an eye on it, evidently now they will want to have that insight themselves.

A number of the respondents highlighted the issue that a good quality pre-retrofit BIM model can help to reduce waste and generate savings for clients and that laser scanning could be used to produce an accurate pre-retrofit model. The geomatics specialist stated that;

> it’s fairly easy to scan a building.” “you need a good quality base model and laser scanning will provide it

However, the difficulties with the use of the technology around laser scanning for retrofit models was also acknowledged. The interview with the chief engineer revealed that the use of point clouds to store the spatial data generated by laser scanning of houses is not trouble-free;

> there were some trials with laser scanning but it kind of died a death because of some of the challenges [encountered] and everything has gone back to being measured now

> the point cloud straightened up all the co-ordinates, it was the right size house, but it turned out as a square house when in fact it wasn’t perfectly square… the contractor would have ended up with the wrong shaped components…

Both the geomatics specialist and the software developer agreed that the use of UAV’s would become more prevalent for retrofit works and that they would be used in more innovative ways such as obtaining real time data to monitor the progress of both internal and external construction works on site. The software developer mooted the point that;
perhaps Grenfell could have been avoided if the data obtained from drone images taken from multiple locations and point clouds could have been used to view and analyse the construction details that were employed as the cladding was installed?

**Theme Two: Digital Inclusion**

The general response was that there is not a widespread use or adoption of digital technologies within the SHS. The senior construction consultant’s experience was that;

> At the moment, my Clients (mainly Housing Associations and Local Authorities) have hundreds of thousands of properties and no digital records. Even those new building that have digital records, are not referred to, as, generally, there is no effective filing system to recover the files when needed.

The utilisation of smart data may help to change the perception of DTs in the SHS. Though the use of smart technology is very much a nascent process it is anticipated that it will probably become an integral part of the daily lives of many social housing tenants. The RP director was very supportive of this idea as it can be used not only to monitor energy use but also to assist in dealing with vulnerable residents;

> We are currently trialling a scheme known as “Switchee” which is a remote monitor and sensor with a SIM card so that it can be remotely accessed…It has been a success with respect to controlling the environment within our tenanted properties and also acts as a warning detector for vulnerable tenants who are at risk.

The use of smart sensors means that energy consumption can be optimised with a consequential reduction in fuel bills to assist in mitigating fuel poverty. The Software Developer advised that RPs are also using smart technology on communal heating systems in order to reduce their fuel bills;

> They are using smart technology diagnostically have already saved about £50,000 per year, so [potentially] we think the savings could be huge

Apart from the software developer most of the interviewees were sceptical about tenants using BIM models and VR with it being described as “gimmicky” and a “novelty” but his contrary view was that users can engage with a 3D model via applications on smartphones or tablets using simple VR viewers for wayfinding purposes;

> “That games engine technology has developed so quickly that software can now link into existing user tracking interfaces to provide real-time refreshing of the users view, with the ability for the user to interrogate data directly from the BIM model”

**CONCLUSIONS**

The overarching view was that, currently, there is a negative perception regarding the use of digital technologies within the SHS. However, since the tragedy at Grenfell and the publication of the Hackitt Report, the SHS is beginning to realise the importance of digital data to record and store the “golden thread of information” proposed by Dame Hackitt. The use of BIM as an Asset Information Model could, potentially, act as the single repository for this information, from initial design through construction and for all subsequent changes during the use of a building.

The utilisation of BIM in conjunction with other developing technologies such as the use of drones and laser scanning, or photogrammetry can be used to produce an accurate pre-retrofit 3D BIM model. This also affords the industry the opportunity to explore the possibility of increasing productivity by implementing new service
delivery models such as “Energiesprong” to deliver volume retrofitting of zero carbon homes.

In addition to this, an accurate pre-retrofit BIM model could lead to the production of enhanced construction drawings which can be printed out on-site to address specific tasks. This could include detailing at materials joints to eliminate or reduce the occurrence of thermal bridging within retrofit projects which, consequently, should increase operational on-site productivity.

The benefits of the installation of smart thermostats such as Switchee are acknowledged in reducing carbon emissions across a housing portfolio and remotely monitoring its thermal performance. In addition, they can increase resident wellbeing through alerts for vulnerable residents, pre-emptive repairs and lower energy bills. This has synergy with the holistic viewpoint put forward by the CIOB that construction and the built environment can possibly have major direct impacts on the productivity within the wider economy by making people “happier, safer and wealthier”.

Advances around interoperability of file formats could allow smart meters to interrogate the intelligent data held in BIM models and compare it with external smart-city data. This gives rise to the possibility that the AIM could play a role in the real-time optimisation of internal temperature and humidity levels within retrofitted social housing dwellings, reducing energy consumption and resulting in lower fuel bills.

The use of virtual reality and augmented reality to access a retrofit BIM model has a potential role in allowing social housing tenants to monitor the progress of works. They could report any quality issues with workmanship via the model though, clearly, they would not be able to make any amendments to the model itself. Given the common usage of VR and AR outside the construction industry together with technical advancements in gaming technology this type of visual collaboration using laptops, tablets or even smartphones to interact with the 3D BIM model could, potentially, become a standard method of interacting with residents within the foreseeable future. This has a strong implication in terms of productivity, given that many retrofit projects are undertaken with tenants still residing within the properties.

RPs understand the importance of tenant engagement in the successful and timeous delivery of retrofit projects.

The findings, of this research, indicate that DT could be employed throughout the whole-life of a retrofitted property from the initial design and construction stages through to playing a pivotal role in the management of the asset. This could include the utilisation of smart data and encouraging collaborative engagement with all stakeholders including end users. However, for the diffusion of DT within the social housing sector to be successful a change in the perception of DT by actors within the sector is required.

The limitations of the research are also acknowledged in so far as the interviewees represent only one specific section of the SHS supply chain which may have given rise to narrow or restricted views in the semi-structured interviews. It is suggested that further research could be undertaken taking a more holistic approach which seeks the views and ideas of a more widespread sample of actors within the SHS supply chain such as stakeholders including end-users, digital technology operatives etc as this may produce a different or more varied set of results.
REFERENCES


ENVIRONMENTAL
Sustainable or green buildings are found successfully in a large number of published cases; however, they are questioned about success in many studies - mainly due to the cost premium, higher financial risk, and longer payback time. Therefore, this paper aims to understand the overall relationship between the three core pillars of sustainability and the current project success (with criteria of scope, time, cost, quality, and stakeholder's satisfaction). For this purpose, following an extensive review on sustainability in construction, a comprehensive measurement model was developed to hypothesise direct and supportive impacts of economic, environmental, and social sustainability on the project success. Questionnaires were carried out with the participation of 144 experienced professionals working in the building projects across the UK. By using the structural equation modelling technique, all the hypotheses in the model were tested. The research findings show that the achievement of economic and social sustainability targets has a significant impact on enhancing the satisfaction of the selected project success criteria. On the other hand, environmental sustainability was not proven as a supportive variable to the achievement of the traditional golden triangle and meeting stakeholder satisfaction.

Keywords: sustainability, project success, golden triangle, stakeholder satisfaction

INTRODUCTION

Under the common target of sustainability, construction buildings are expected to have an ecological design that reduces resources consumption, waste, and greenhouse gases emissions. They should also bring higher quality and affordability to occupants living condition. Sustainable buildings (with some other names as green buildings, high-performance buildings, or low/zero/negative/net carbon buildings) are found successfully in a large number of case studies, but there is also a question about the meaning of sustainability outcomes to project success by stakeholders, especially clients and investors.

On the one hand, sustainable buildings are found with economic, social, and environmental benefits to all stakeholders. They can reduce the bill of energy, which helps to cut down the running cost of buildings (Newsham, Mancini and Birt, 2009; Windapo, 2014). Fowler et al., (2011) found an average reduction of 19% in aggregate operational cost in their study, and some cases reached a reduction rate of 40-50%. In addition, sustainable buildings are able to increase employee productivity and achieve higher rentals/capitals (Kubba, 2010; RSMeans, 2011). Recent studies on post-occupancy evaluation show that sustainable buildings support a higher indoor environmental quality for occupants (USGBC, 2003; Fowler et al., 2011), which is proven by a higher satisfaction rate than traditional buildings from clients and end-

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Does Sustainability Support Project Success?

users. Furthermore, sustainable buildings are designed to limit detrimental damages to the natural environment and conserve natural resources with the use of more environmental-friendly materials and renewable energy. With all these benefits mentioned above, the achievement of sustainability in building projects should be in line with the accreditation of a successful project.

On the other hand, the achievement of sustainability is questioned against conventional project success criteria. For instance, sustainability solutions generally lead to an increase in initial costs (Dobson et al., 2013). The cost premium to adopt sustainability brought to higher financial risk and longer payback time for the investment. Besides, Hwang and Ng (2013) identified that green/sustainable design solutions could lead to a lengthy approval process, and it could bear a higher risk of project delay. For these reasons, the projects net-present value would become negative or less attractive than other alternative options under the eyes of investors. Clients with a lack of knowledge on sustainability see sustainability as a complex issue and uncertain value. Therefore, they tend to trade off sustainability with a reduction of cost and/or time for completion of projects, which is known as core criteria for the success of almost projects.

To answer the paradoxical thinking on whether sustainability in the same line with or contradict the achievement of project success in overall, this paper aims to hypothesis the relationships between them. In this study, sustainability construct was broken down to three variables as in the triple-bottom-line. The paper starts with an intensive review of earlier publications on project success and sustainability in construction projects. A conceptual model is then developed with the acceptance of 24 indicators as measurement units for the four variables of economic sustainability (EcS), environmental sustainability (EnS), social sustainability (SoS), and project success (PS). The paper then presents the testing of hypotheses developed between these variables and discussion of results, which is then followed with the conclusion and further recommendations.

Research Background

Project Success

The concept of project success has changed in the last twenty years (see Figure 1), moving from the traditional thought of the "golden triangle" (process criteria) to the modern thinking with consideration of outcome criteria after the completion of construction stage such as stakeholder satisfaction. This concept is now turning to "sustainable project success" with more embedded criteria of sustainability.

In the 1990s, the traditional project success included only "process" criteria, which was the meeting project constraints (i.e., time, cost and quality requirements) or the "golden triangle" (Wang and Huang, 2006; Lam, Chan and Chan, 2008). This understanding was still dominant in the early 2000s with the PMBOK Guide in 2004, which still highlighted the achievement of the triple constraints.

However, many flagship projects that had exceeded their time and cost targets in the past were generally considered successful, such as the Thames Barriers or Sydney Opera House (Lim and Mohamed, 1999). Project success was no longer assessed at the time of construction completion; outcome-criteria of projects were getting more attention. Therefore, the current or most widely accepted concept of project success does not only pay attention to the achievement of the golden triangle, but also to the meeting of project outcome criteria, for example, satisfaction of stakeholders,
functionality or performance of building (Müller and Turner, 2007; Serrador and Turner, 2015; Songer, Molenaar and Robinson, 2015).

Besides aspects of project performance (i.e., the meeting of time/budget/quality constraints) and stakeholders' satisfaction, the next evolution of thought in project success concept has integrated sustainability into the list of required criteria. For instance, Al-Tmeemy, Abdul-Rahman, and Harun (2011) introduced a model of success criteria for building projects, which considered the economic sustainability of buildings with criteria of "market success" (including revenue and profit, market share, reputation, and competitive advantage). Shenhar, Dvir, Levey and Maltz (2001) had a similar opinion when assessing the success of projects with dimensions of "business success" and "preparation for the future". Chan, Scott and Lam (2002) and Salminen (2005) had environmental sustainability as key criteria for assessing project success in their research. In addition, a model of "sustainable project management star" with five key criteria (economic, social, environmental, quality, and time) was introduced by Grevelman and Kluiwstra (2010) as one of the first models that merged the iron triangle and three pillars of sustainability.

**Figure 1: Different schools of thought in the concept of Project Success**

**Sustainability in the Construction Industry**

Sustainability is considered as one of the most urgent issues that require to meet "the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987). This definition of sustainability is expanded further by the Triple-Bottom-Line concept, which focuses on the balance of three pillars: environmental (conservation), economic (growth), and social (equity) sustainability.

In the construction industry, sustainability is related to the efficiency of resources use and ecological design (Kibert, 2013). The understanding of "resources" covers not only life-cycle energy consumption of construction products but also all other types of resources, which should be used smartly to prevent depletion. Besides, natural capital and bio-diversity surrounding construction buildings and cites need to be conserved; and the project should lead to safety and healthy indoor environment for users (Bourdeau, 1999). Yami and Price (2006) also explained other aspects of sustainability in construction projects, that it should ensure the quality, adaptability, constructability, durability, affordability, and whole-life-costing.

**Economic Sustainability**

Economic sustainability focuses on stable economic growth within the capacity of the natural environment (OGC, 2007). To achieve economic sustainability, not only
short-term profitability for investors should be ensured, but also long-term benefits of all related stakeholders are important (Silvius et al., 2012). Some strategic criteria could be listed as cost-efficiency over time, affordability, job creations, or benefits to the local economy (Bennett and James, 1999), building functionality during its life cycle, and the ability that building can support clients and users to face with future challenges (Shenhar et al., 2001). Moreover, the further development of project team helps to minimise waste, prevent risks, improve performance, and have a better adaption with client's expectation for the following project; therefore, this factor brings a straight and positive impact on the economic aspect of buildings.

**Environmental Sustainability**

Environmental sustainability is concerned with protecting and conserving the natural environment. In this study, six aspects used to represent for environmental sustainability are selected: minimisation of energy consumption; reduce/reuse/recycle of waste, usage of environmental-friendly (green) materials, minimisation of carbon footprint; conservation of biodiversity of surrounding areas, and reduction of pollution (Berardi, 2012; Kibert, 2013).

**Social Sustainability**

Social sustainability considers the problem of improving the health, safety, and well-being for both current and future generations (OGC, 2007). In construction, this concept was translated as ensuring high living-quality for occupants, healthy and safe construction site, well-being for employees (fair salary, no use of child labour, no forced labour, or adequate working hour), and the priority use of local employment (Hopkinson et al., 2005; Al-Yami and Price, 2006). In addition, Dong and Ng (2015) found that "public commitment to sustainability" (which requires for obligation on public sustainability reporting) is an essential criterion in assessing social sustainability of building projects.

**Conceptual Model and Research Hypotheses**

This research aims to understand the relationship between sustainability and the current/modern project success. From the findings of the literature review, 16 indicators are selected as measurement units for the three pillars of sustainability in building projects, and 8 indicators are chosen to reflect the concept of project success. Project success is defined as the achievement of project performance and stakeholder satisfaction. Project performance is measured with the meeting of scope, time, budget and quality constraints, and the target of meeting requirements of clients, end-users, project team and external stakeholders (such as local community or authority). These criteria were selected on the ground of their popularity in the literature review to ensure that the construct can reflect the current and most accepted-understanding of project success in the construction industry. The full list of these 24 indicators and the structure of the conceptual model are demonstrated in Figure 2.

Given the background on various components of the model, the following hypotheses are stated to be tested in this study:

- **h1 (EcS --> PS):** The achievement of economic sustainability has a positive and supportive impact on the achievement of project success;
- **h2 (EnS --> PS):** The achievement of environmental sustainability has a positive and supportive impact on the achievement of project success;
- **h3 (SoS --> PS):** The achievement of social sustainability has a positive and supportive impact on the achievement of project success;
METHODOLOGY

To test the hypotheses, data were collected using an online questionnaire, which required participants to evaluate the process, outcome, and sustainability criteria of project success. A 5-point Likert-scale was used to elicit the level of agreement (1 = strongly disagree/very low and 5 = strongly agree/very high) with the statements provided in each question. The open-ended questions gave a chance for participants to give comments about their project's performance and outcomes.

Partial-least-square structural equation modelling (PLS-SEM) is chosen for data analysis. PLS-SEM is a multivariate method of analysing the cause-effect relationships between latent variables. This statistical method aims to maximise the explained variance of the latent variables, and then the results can help to predict the relationship between them (Hair et al., 2017). The study selected PLS-SEM as the most suitable option as it is powerful with small sample sizes, and it can run with non-normal data (Afthanorhan, 2013).

Targeted participants for the research were project managers or members of the project management team with more than two years of working experience in building projects in the UK. These participants were approached through the LinkedIn network, where 83% of professionals in the construction industry chosen as social media for careers development (Trendence research, 2017). This network also allows researchers to see published profiles of potential participants; and then, invitations were sent to the potential participants that satisfied all requirements. The survey also included questions to double check the suitability of participants.

The research obtained 144 qualified answers. All the participants were experienced in directing and managing building projects. 86.2% of respondents had more than five years of experience in project management and execution.

RESULTS AND DISCUSSION

PLS-SEM used a bootstrapping procedure to randomly draw 5000 samples from the observed data with replacement. The standard errors for the path coefficients were derived from these subsamples. After that, t-values were calculated to assess this estimates significance; and the p-values were found as the probability of obtaining the empirical t-values at least as extreme as the observed ones (Hair et al., 2017). P-values were then used to evaluate the significance of the path coefficients between
variables when comparing with an accepted significant level. All hypotheses were tested at a significance level of $\alpha=5\%$.

Table 1 presents the result of hypotheses testing and the significance of path-coefficient. A higher value of path-coefficient identifies a stronger association between the two variables. The results presented in Table 1 show that the achievement of economic sustainability and social sustainability support the current assessment and accreditation of project success (h1 and h3 were fully supported at a significance level of 5%). However, h2, the supportive relationship between environmental to project success was not proven in this study.

Table 1: Results of hypotheses testing

<table>
<thead>
<tr>
<th>Hypotheses</th>
<th>Path coefficient</th>
<th>T-value</th>
<th>P-value</th>
<th>Inference</th>
</tr>
</thead>
<tbody>
<tr>
<td>h1: EcS $\rightarrow$ PS</td>
<td>0.484</td>
<td>4.424</td>
<td>0.000</td>
<td>Supported</td>
</tr>
<tr>
<td>h2: EnS $\rightarrow$ PS</td>
<td>-0.038</td>
<td>0.443</td>
<td>0.658</td>
<td>Not proven</td>
</tr>
<tr>
<td>h3: SoS $\rightarrow$ PS</td>
<td>0.313</td>
<td>2.438</td>
<td>0.015</td>
<td>Supported</td>
</tr>
</tbody>
</table>

**Economic Sustainability and Project Success (H1)**

The findings from the hypotheses testing show that economic sustainability has a medium and positive impact ($p=0.484$) to the achievement of project success. This result supports that life-cycle thinking has been embedded at a certain level in the current projects. Therefore, more long-term benefits of the project can be recognized when initiating, delivering, and evaluating the success of the project. In other words, such economic benefits like cost-effectiveness, reduction of running cost in the operational stage (which lead to the saving bills of energy consumption) are getting more attention of clients. The raising awareness on life-cycle energy consumption can promote the use of energy control system, renewable energy, the ecological design that prevent heat loss, and the use of smart electrical equipment. This target is in line with UK government goals to lead the construction industry toward sustainability, such as the target of upgrading building energy performance EPC to band C by 2030 (BEIS, 2018).

In addition to the energy saving, the client might be interested in investing in sustainability as an opportunity to boost sales with higher rental income, or by increasing competitive advantages (Rodriguez-Melo and Mansouri, 2011; Windapo, 2014). Research participants indicated in the survey that their clients were interested in achieving green-building certifications such as Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design Standards (LEEDS), Living Building Challenge (LBC), or Passivhaus. A sustainability medal on the wall can help clients boost up their company image to the community and attract more potential users; therefore, it is seen as an intangible benefit to clients. Moreover, the target of these green and high-performance building certification also supports the saving of energy consumption, and hence reduce the energy costs during the use of buildings. For example, LEEDS platinum building can reduce energy down to 32 kBTU/st/yr and one LBC building can reach to 16 kBTU/st/year, compared with an average level of 72 kBTU/st/year in conventional buildings (Kibert, 2013, p. 122).

**Environmental Sustainability and Project Success (H2)**

The data collected does not support a significant relationship between environmental sustainability and project success. There are several potential reasons for this finding.
First, it could be blamed on the higher price of green or environmental-friendly materials/components than the traditional products they replace, which results to the increase in the initial investment. Unfortunately, the use of green materials is not guaranteed for a straight monetary value to clients. The cost premium to adopt this type of materials is accompanied by higher financial risk and longer payback time for the investment but does not return a clear and monetary-quantified benefit. Secondly, sustainable buildings might need to use new technologies to reduce its impacts to the environment; however, these technologies could lead to difficulties and complications in the approval process and a higher level of risk due to the unfamiliarity of the project team (Zhang, Platten and Shen, 2011).

A report by the Department for Environment, Food, and Rural Affairs (DEFRA, 2015) in the UK can be a supporting document on how environmental sustainability might be not in line with project success. The construction industry produced the most significant amount of waste with an annual average of 100 million tons or 40% of total waste generated. Contrary to the waste reduction trend observed in other sectors, the amount of waste in construction remained relatively stable during the period from 2004 to 2012. Moreover, the quantity of hazardous waste in the construction sector increased from 4.6% of total hazardous waste in 2004 to 7.4% in 2006 and approximately 18.5% in the period 2008-2012.

The unsupportive relationship between the two variables could be the reason why governments tend to introduce more strict rules and standards on protecting the environment rather than the social and economic aspect. This approach seems to be appropriate as legislative force is the most critical driver to support sustainable development. However, many scholars, like Persson and Gronkvist (2014), believe that many building regulations "are too easy to achieve"; therefore, they have no practical impact.

**Social Sustainability and Project Success (H3)**

Research results also support a remarkable and significant impact (p=0.313) of social sustainability to the achievement of project success. Currently, the social aspect of sustainability in construction has a strong focus on the achievement of higher living quality for occupants. Therefore, this supportive relationship can be explained that the investor and project team have a focal point on satisfying end-users. What is more, a remarkable number of end-users follow sustainability behaviour; then living or working in a sustainable building gives them an extra value of satisfaction. For instance, numerous post-occupant evaluation reports showed that high-performance green buildings are also high in increasing users working productivity, in enhancing occupants' comfort, health and well-being (to name a few: USGBC, 2003; Newsham et al., 2013; Bonde and Ramirez, 2015). These reports pointed out the higher satisfaction rate from occupants of sustainable buildings than conventional ones. Besides the requirement of indoor environmental quality, social sustainability might support the success of the project through an intensive focus on the employees of the project. The use of local employment could help the project. The guarantee of wellbeing, health, and safety on the construction site creates a stable working environment in which employees can work more effectively in a comfortable environment. Furthermore, all projects would try to avoid occupational accidents as they could lead to the delay of project completion, reduce the productivity of workers, and might damage the image of the project under the eyes of local community and
government. Finally, the use of public sustainability reporting can help the project to better engage supportive stakeholders, which potentially leads to success.

CONCLUSION

The paper contributes to project management knowledge with an overall understanding of the impacts economic, environmental, and social sustainability on the achievement of generally-accepted project success. The research findings show that the achievement of economic and social sustainability targets has a significant impact on the satisfaction of project success. However, environmental sustainability was not proven as a supportive construct to the achievement of project constraints and meeting stakeholder satisfaction.

The findings can be further elaborated as, if the project is driven by the existing criteria of project success (i.e., the golden triangle and stakeholders satisfaction), only the achievement of economic and social sustainability can be promoted. The achievement of environmental sustainability, which does not have a clear impact on the conventional success of projects, might easily be traded-off with "cost saving". However, sustainability is the balance of the three pillars. Therefore, the project motivation toward current project success criteria does not lead to sustainable construction buildings, due to the lack of awareness and commitment to environmental sustainability. To overcome the problem, a consideration of "sustainable project success" (which requires a high awareness and commitment from clients) should be highly encouraged in the conceptual/initial phases of projects. Finally, in the macro point of view, a proper and stricter legislative force on buildings, especially in environmental issues, is critical to change and direct the current project approach towards truly sustainable development. In the micro viewpoint, project management guidance on how to achieve sustainable project success is necessary. Additional studies are needed to further establish such a guideline for the project management team.

REFERENCES


Does Sustainability Support Project Success?


EQUALITY, DIVERSITY AND INCLUSIVENESS
GENDER INEQUALITY IN AN ‘EQUAL’ ENVIRONMENT

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This paper examines the position of women within the Lithuanian architecture profession - an environment where principles of equality are firmly embedded in the history and culture of the country. Drawing on semi-structured in-depth interviews with Lithuanian women architects, our research explores how and why women are unable to advance their careers against the backdrop of equality. However, evidence shows us that while women are present in numbers equal to men their opportunities for career development are limited despite the legacy of women’s equal participation in the workplace and more recently, the adoption of EU-founded policies on gender equality and becoming the home of the European Institute of Gender Equality (EIGE). Lithuania provides us with a particularly interesting context to investigate gender inequality because of the focus on parity in both politics and the workplace as a key principle of the communist system under the Soviet regime from 1940 to 1990. Women played an equal role in economic production as it was a constitutional expectation that all citizens had both a right and an obligation to work. Consequently, at the time of independence the levels of participation of women in the workplace including at managerial and professional levels were much higher than other western European countries. However, this equality of activity in the workplace did not transfer into all aspects of economic activity, in particular the construction industry where women occupy lower levels. In architecture the profession has achieved parity in terms of numbers with the Architects’ Council of Europe reporting that 50% of architects in Lithuania being women however our data shows that career advancement opportunities are very limited despite the egalitarian nature of the labour market.

Keywords: architects, equality, gender, inequality, Lithuania, women

INTRODUCTION

Women account for 48% of the 1400 registered architects in Lithuania which although slightly down from 50% in 2016 still shows a favourable representation of women in the profession compared to Europe overall (ACE 2018). The Nordic states of Finland, Sweden and Norway have a higher proportion of women at 52%, 58% and 53% respectively and gender is not questioned in the architectural profession (Findal 2016), but generally across Europe the figure is much less (ACE 2018). The aim of this paper is to assess whether as a result of this critical mass of women, there is actually gender parity in terms of status and equal treatment within the profession in Lithuania. The research forms part of a larger cross-national project conducted by the authors

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and is among the firsts to look at the position of women in a specific profession in a former Soviet country. Indeed, Estonia is the only other former Soviet Socialist Republic (that we are aware of) where women architects have been studied (Ruudi 2017). As Lakštauskienė (2015) points out, there has been no analysis carried out of women's contribution to architectural education, professional development and creative development of Lithuania.

We begin with an overview of women in the workplace in Lithuania giving a brief historical background and identifying how this has impacted on and influenced their position today. The discussion then turns to gender equality before focussing on women in architecture. The research method of semi-structured interviews carried out in the qualitative paradigm is explored and the sample of 31 women interviewees is detailed. We then present the themes which have emerged from the interviews before drawing together the strands of the discussion and identifying our conclusions.

WOMEN, WORK AND THE ARCHITECTURE PROFESSION IN LITHUANIA

Women and Work in Lithuania

Following the breakup of the former Soviet Union and declarations of independence in the early 1990s there was a flurry of interest in the various labour markets because of the different social and political systems in place and curiosity as to how these former command economies would adapt to capitalism. Lithuania is of particular interest because of a long history of attempts to implement equality for women dating from the end of the 19th century (Birmontiene and Jureniene 2009). In the early 20th century, prior to Soviet occupation, equal pay, longer maternity leave and state support for housework were mooted although none became law. Equality in employment was a central tenet of Soviet socialism and all adult citizens were required to work (Jureniene 2008, Lafont 2001). However, the requirement to work coupled with the ideological condemnation of unemployed women (including housewives) and the declared equality did not lead to true equity due to the persistence of horizontal and vertical segregation.

The focus on parity in both politics and the workplace was a key principle of the communist system under the Soviet regime from 1940 to 1990. Women played an equal role in economic production as it was a constitutional expectation that all citizens had both a right and an obligation to work and ‘allegiance to the state was placed above that of the family and the family was seen as an economic unit supporting state objectives’ (Metcalf and Afanassieva 2005: 398). At this time, the economy was based on labour-intensive industries and it was difficult to support a family on one income, which coupled with the ideology led to a significant increase in women’s activity in the workplace (Lafont 2001). Consequently, at the time of independence the levels of participation of women in the workplace including managerial and professional levels, were much higher than other western European countries (Standing 1994, cited by Metcalfe and Afanassieva 2005). Indeed, women account for over 70% of those employed in professions (Bierman et al., 2013) capitalising on their easy access to higher education during the Soviet period.

According to Eurostat employment statistics, Lithuanian women's employment rate has been constantly higher than the EU28 average since 2002 (EUROSTAT 2019). In 2018 it stands at 76.7% (as % of the female population aged 20 to 64). And women and men are almost equally represented in the labour market (Stanikuniene and
Gender Inequality in an ‘Equal’ Environment

Kvedaraitė 2015). Furthermore, there is a high proportion of mothers in the labour market standing at 78% (Bierman et al., 2011) despite there being little in the way of childcare for under 3s due in part to generous parental leave provision. Parental leave is 100 weeks with the first year paid at 100% of the parent's wage and the second year at 85%. In addition, there is a very low incidence of female part-time working -8.7% in 2018 compared to 30.8% of EU average (EUROSTAT 2019), and as Bierman et al., (2011) go on to say, part-time working is not related to the number of children. Instead it tends to be involuntary and is related to poor job market opportunities.

However, this equality in the workplace did not transfer into the home and women still have the burden of caring for the home and family (Metcalfe and Afanassieva 2005). As Pollert (2005: 220) asserts ‘Women’s strong representation among professionals and associated occupations reflects their educational gains during communism, but they failed to advance further up the occupational hierarchy’. Men dominated the higher levels of professions and while ‘women do have a stronger presence in ‘male’ industries, as is to be expected from post-war communist industrialization policy … there are smaller proportions of women in the top occupations (Pollert 2005:227). Following independence in 1990, more than 100 women's groups, clubs and associations were established to promote the interests of women and Lithuania became home of the European Institute of Gender Equality (EIGE). However due to the post-communist revival of traditional values (Razzu, 2016) and a long history of patriarchy, Pavilionienė (2015) argues that gender inequality is persistent and unlikely to be overcome.

Gender Equality in the Lithuanian Context

In the early 20th century, prior to Sovietisation, there were significant moves to attempt to improve the position for women in Lithuania via legislation promoting equal pay, longer maternity leave and to recognise housework as equal to paid work thus attracting a wage, but these did not become law (Jureniene, 2008). The Soviet era brought 'equality' gains in that all people had to work and, as we mention above, it was not possible to support a family on a single wage. However, while this 'equality' existed, the system of patriarchy operating under the Soviet regime prevented any tangible improvements in the position of women as women's movements were strongly discouraged or banned (Bingham 2017).

Accession to the European Union where equality of opportunity is a fundamental principle means that each country must enact EU gender equality policy. However, it is down to each Member State as to how this is implemented, Lithuania has incorporated equality into its constitution but has also implemented 'hard' laws (Office of Equal Opportunities Ombudsman, Lithuania, Pollert (2005) points out though that while Lithuania has implemented EU gender-equality policies, most training programmes target the unemployed rather than women. She found no evidence of any positive action being put into place to encourage women to achieve equality of opportunity via training or recruitment. She goes on to argue:

"Neither men nor women appear concerned with sex equality… Trade unions are weak, and few are concerned with women’s issues. In this context, it is not surprising that equality legislation is flagrantly violated. Employers are either unaware of the law or disregard it, while workers are also often unaware, or frightened of victimization and are more concerned to keep their jobs rather than to protect their rights' (Pollert 2005: 228)."
Currently, there is still a clear relationship between both Soviet Union and the European Union in terms of gender equality policy although Kublickiene and Zvinkliene (2018) argue that gender equality policy has been reconstructed following independence and in line with the United Nations and EU requirements with a gender mainstreaming approach being adopted. Since applying for EU membership in 1995 and implementing laws on Equal Opportunities (1998) and Equal Treatment (2003), Lithuania has retained its position as leader of gender equality in the Baltic states bolstered by a 'bottom up' political mobility aimed at integrating equal opportunity processes but without challenging policy models. However, Kublickiene and Zvinkliene (2018) point out this has been weakened by a lack of understanding of gender relations and a shortage of experts to provide training in gender issues. In addition, Chiva (2018) suggests that negative legacies of 'forced participation' and issues of patriarchy remain serving to deter women from taking action to improve their position. Thus, we have a locus whereby due to the existence of asymmetric institutionalism where certain areas of political activity are prioritised over others and serve to reinforce male dominance.

Equal opportunities and equal treatment are enshrined in Article 29 of the Constitution of the Republic of Lithuania and is supported by the Law on Equal Opportunities for Women and Men enacted in 1998. This law creates a legal obligation on organisations, whether public or private, to implement gender equality principles in all areas of activity (Office of Equal Opportunities Ombudsman, 2018).

Gender equality is promoted by four separate mechanisms, namely the Parliamentary Commission for Family and Child Affairs, Women Parliamentarians Group, Parliamentary Human Rights Commission and the Office of Equal Opportunities Ombudsman (OEOO) which was created in 1999. The OEOO is an independent state institution which reports directly to Parliament and has overall responsibility for the supervision and implementation of equal opportunities. In addition, there are various social partners and non-governmental organisations such as Women’s Councils within trade unions. Their role is mainly in raising awareness and promoting women’s rights in both employment and education. The Lithuanian approach is largely Government-led and structured; however, such a method is not without its limitations as the various institutions have responsibility for separate areas of the equal opportunities policy and must rely on cooperation in order to be effective. In addition, most of the actions are based in and around the capital Vilnius and no structural units exist for the monitoring of equality principles outside of the capital (OEOO 2018).

Gruzevskis and Kanopiene (2016) argue, that despite these initiatives and the long history of women's active participation in the labour market, patriarchal attitudes and existing gender stereotypes are still strong in the country and influence social and economic relationships thus contributing to the perpetuation of sex discrimination.

**Women in Architecture**

The professional activity of architecture in Lithuania was first recorded in the 14th century with those practising having obtained their qualifications in Italy, the Netherlands and Germany (Lakštauskienė 2015). The first mention of architecture being taught in Lithuania comes in the 16th century where it was included as general education at Vilnius University. However, according to Leišyte et al., (2018) on closure of the university in 1831 for almost a century, architectural education ceased until the creation of the first dedicated School of Architecture in Kaunas in 1922. S.
Mitkovskaite was the first woman to qualify and she defended her diploma work in 1930 (Lakštauskienė 2015).

During the post-World War II until the 1970s women entered the architectural profession in both Lithuania and Eastern Europe in much greater numbers and were accorded more opportunities to design large-scale public buildings than their female counterparts in Western Europe (Pepechinski and Simon 2017, Bartosova 2018). The urgent demand for rebuilding in the post-war era along with the socialist commitment to equality, as well as day-care facilities for children and subsidised work place facilities all contributed to their relative success in the profession in Eastern Europe. During the Soviet occupation, architecture was considered a very prestigious profession with intense competition for the limited number of places in the Schools of Architecture, but despite the focus on equality the majority of applicants were men. Hence men dominated the profession from 1947 until 1965. However, from 1968 onwards the number of women entrants has equalled and exceeded the number of men (Lakštauskienė 2015). Despite this development of a 'critical mass' of women, glass ceilings have remained and gender-based divisions and stereotypes continued to influence careers and personal lives (McLeod 2017).

There is a high level of attrition with women leaving the profession after qualification. For example, according to available data from Vilnius Gediminas Technical University (leader in numbers of architecture students in Lithuania), in 2018 women accounted for 70% of bachelor's students and 72% of master's (Kairienė 2019). Yet, they account for around 48% of practising architects (down from 50% in 2016) (Source: ACE, 2018). The structure of the profession is that the majority of architects are salaried in practice (43%), sole practitioners account for 21%, partners and directors are 12%, freelance 14% and the remainder are employed largely in the public sector (Source: ACE 2018). However, figures do not exist to give us the gender breakdown against each of the employment options.

METHODOLOGY

The research comprises both semi-structured in-depth interviews carried out within the qualitative paradigm and a semi-structured survey with 31 Lithuanian women architects in total. Ideally, we would have preferred only interviews as the means of data collection but time and travel constraints on the part of several respondents meant we had to accept written responses which we received anonymously. We feel that we managed to get sufficiently in-depth responses from the surveys despite not being able to ask follow-up questions or to probe deeper.

Rather than formal questions, we used topic areas as the basis for discussion. These areas included factors which made them decide to pursue a career in architecture, how their careers had developed, what the difficulties were and what were the rewards. For reasons of both data security and to ensure sense-making throughout, all the interviews were conducted by a native speaker co-author who also transcribed and translated them and the surveys.

The interviews and surveys were analysed using thematic analysis whereby initially responses were matched back to the areas under discussion; then a second layer of analysis was conducted whereby we identified themes which emerged from the dialogues.

Their ages ranged from 24 to 74 -19 participants were under 40, 5 between 40 and 50 and 7 over 50 - thus we were able to collect data from those who had worked under
the former Soviet regime as well as from those who had worked only since independence. In total, 8 interviewees graduated and worked under the Soviet regime; 12 grew up during the regime but qualified post-independence; while 11 were raised and qualified entirely following independence. The eldest respondent was retired while the others were active in a range of areas from being salaried in practice; self-employed; practice principals; university associate professors including 2 vice deans; and, the public sector; 7 had senior management experience. All had carried out their studies in Lithuania but four had spent time abroad in other European countries as part of their studies.

Equality for Women in the Lithuanian Architecture Profession

"I feel equal"

While we didn't ask specifically about issues of discrimination, we did ask about factors which had helped or hindered the women's career development and twenty of the thirty-one interviewed mentioned gender. Some mentioned that the economic 'boom' years of the early 2000s had helped their careers and helped them to become established and gain a strong reputation for their work. In part, the boom years helped them to challenge the prevalence of patriarchy and gender stereotyping while showing their competence and skill as a professional architect. We were told that in the early 2000s “there was a big demand for architects, so the customers had to get used to women architects” #9.

Both were among the younger interviewees aged in their 30s so part of the ‘new generation’ thus not having been so exposed to traditional attitudes and one (#12) had studied in Denmark and worked in Ireland and Germany. Following qualification, she had worked for a German firm which won a contract in the Middle East so “I began to appreciate in what good times and a good place I am living in, where experts are valued according to their experience and qualifications not on race or gender”.

Neither felt there were gender differences saying “I don’t feel any gender differences … both genders are equally good” #9 and “I don’t feel discrimination based on sex” #12. Interviewees mentioned that no aspect of architectural work is gender-specific and can be carried out equally well be either men or women.

Other women reported more negative experiences saying, "Discrimination exists". Some women told us of unsafe working environments in an emotional sense where bullying and discrimination exists “There exists inequality between men and women” #13.

There were gendered stereotypes about what is considered appropriate work for women and there appears to be a perception among men that interiors are women’s work but “women are better at solving problems with clients” #13 “contractors appeared to be less afraid of asking them for explanations or advice regarding the design and construction details”.

Women reported receiving derogatory comments with one reporting "look, ‘meat’ has started to talk" (#22) from a male student when she offered an opinion in her university class and another woman told us of her professor quoted as saying “the woman to the kitchen, the man to enact works” (#14). These kinds of offensive comments were commonplace with another saying that male colleagues refer to her work as “The Molly did it” #13. This shows that the stereotypes from Soviet times continue to impact on the careers of women who grew up and qualified post-independence possibly remaining as a legacy within architectural education.
Exclusionary mechanisms exist
The majority of women cited the burden of bureaucracy, constantly changing regulations and heavy workloads as sources of dissatisfaction with their careers. They felt that men had in place better support mechanisms to help them cope. There were many instances of 'the old boys' network' where male contacts and acquaintances helped each other and overtly excluded the women "And the men go to smoke, they go for a drink and to discuss deals" #14, although #21 explained that "A lot of men architects become alcoholics due to big tension in their work".

Many of the women who were mothers felt they were excluded because they could not spend long hours at work or carry out networking in their own time, whereas others felt they were invisible. “They [women] do all the hard work and nobody knows about them” #21, as they were not allowed to carry out site visits instead having to do the menial detailing work in the office.

One woman told us of how she overcame the problem of being excluded saying "Men usually do not allow women to go for the higher positions but my attentiveness [to] and helpfulness for men has helped me somehow unnoticeably [to them] to achieve a high level in my career. When they noticed, it was too late. My diplomacy has helped me" #23

Proving themselves
Many of the women, especially the younger ones, said that they had to work harder and be better than their male counterparts in order to prove themselves as capable:

I must put in much more work and effort to prove my competence #14
Women must know ten times more than men #21
The builders don’t listen to my observations and suggestions because I am a woman … it is very difficult to be an authority (#4)

The impact of family
While the majority of our interviewees cited bureaucracy and ever-changing regulations as being the main cause of stress and hindering their careers; a smaller number mentioned family and children having a hindering effect on their careers. While women spend time away from work to raise children changes occur in IT programs, regulatory and design information. Therefore, so women suffer knowledge gaps and lag behind in their professional development so "it becomes hard to restart a working life" #13 following time out for children. Others mentioned the lack of self-confidence as a consequence of a career break.

Two women mentioned returning to work within weeks of giving birth instead of taking the 2-year period of maternity leave available. "I had to return to work from maternity leave very soon - after 4 months. Nobody can afford to [both in a professional experience or financial sense] and can’t wait long until you will return to work [as] you are at risk to disappear from the labour market." #23.

Another likens maternity leave and family commitments to becoming invisible as there is no time to attend any networking events and so "male architects are more visible in society." #14. Others reflected on gender stereotyping by men who assume a woman cannot be successful in her work or be able to combine work and a family. Traditional attitudes are very apparent here as one woman pointed out "My children were born during my studies period. But here [in architecture field] you can’t do breaks"#21. Notably, it was mainly the older women who mentioned children and maternity leave as being problematic in terms of their careers but two of the younger
ones who have not yet started families mentioned perceived difficulties in taking a career break. Patriarchy is also very apparent with women commenting that men do not believe they can compete in an equal sense and are somewhat less committed because they have family commitments.

An interesting observation made by one woman was that having children occupies mind-space which inhibits the design process with "Design, it is a very long creative process … having no children means you work without stops, till late at night, at weekends, have a few free hours for creative thinking, but having children, you can't. You need time for creation and with kids you have a lack of time" #24.

**DISCUSSION AND CONCLUSIONS**

In contrast to the other countries which have been part of this wider research project, the striking difference is that women architects in Lithuania predominantly work full-time. Part time working is rare mainly due to financial pressures but also due to there not being a strong tradition of alternative working arrangements. However, aside from this the position of women in the profession reflects that of several other European countries (Authors citation removed). Employment is a cross a range of sectors from central Government to sole practitioners which equally reflects the comparative studies.

Overt discrimination is much more apparent in Lithuania with women reporting derogatory comments particularly while studying from both fellow students and their professors. This surprised us given the backdrop of women's longstanding involvement in the workplace. It was sadly not surprising to hear of exclusionary behaviours by their male colleagues and needing to prove themselves to a much greater extent as this reflects findings from our earlier work (AUTHORS citation removed).

It is evident that the dominance of patriarchy under the Soviet regime has been replaced with an equally powerful force since independence. It is also apparent that women are still responsible for running their homes and caring for their families, ie the 'double shift,' despite their involvement in full-time work leaving them little or no time to engage with any women's support groups to try to improve their position. Women also are part of the 'reserve army of labour' in that during periods of economic stability and growth, they are able to find jobs easily but are more likely to experience unemployment and layoffs when there is economic uncertainty. Our interview evidence indicates there is currently an over-supply of architects in Lithuania leading to intense competition and lowering of fees, and in addition there are instances of graduates working for no pay just to gain experience.

While on the face of it, the generous parental leave provision would be enviable in many other national contexts, the reality is that it serves to hinder career development with women losing their contacts, dropping out of their networks and their skills becoming outdated. Capitalism supports advantage and personal gain through exploitation of personal resources and social capital, all of which are damaged by extended periods away from the workplace.

Thus, we draw two key conclusions from this research. There exists a paradoxical situation of economic freedoms preventing the move towards gender equality but also that without EU policies there would be no protection at all. Also, despite the presence of EU, national level and industry level policies, legislation and other soft law initiatives designed to promote gender equality, they clearly are not achieving
their aims. Our central theme and question is why is this the case? Why do these inequalities persist despite policy measures existing to eliminate them? We argue that more research needs to be done into where the fracture points between policy and practice occur and how these can be addressed.

Secondly, despite the existence of the legislation in place in Lithuania it is not succeeding in changing masculine attitudes and this is where, we argue, that real change needs to emanate from. Without there being a determined drive to challenge these dominant preconceptions and stereotypes then genuine equality cannot become a reality and we support Pavilionienė's (2015) assertion that gender inequality is persistent and unlikely to be overcome.

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PERCEPTIONS OF MANAGEMENT OF CIVIL ENGINEERING COMPANIES ON MANAGING DIVERSITY: A STUDY OF ROAD CONSTRUCTION COMPANIES IN GHANA

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Discrimination, equality, inclusion and other related workforce issues are increasingly important issues that need to be considered by management of construction companies. These issues are intertwined with the broader concept of diversity. Whilst these issues are relevant and have received much attention in developed nations, large civil engineering projects in developing countries require many actors in which diversity cannot be ignored. The aim of this study is to examine the perceptions of management of civil engineering construction businesses on challenges to managing diversity. A cross-sectional survey design was adopted for the study. Questionnaires were administered to site engineers and managing directors of sixty (60) road construction companies registered with the Association of Road Contractors of Ghana (ASROC) in Ashanti Region. A total of 208 questionnaires were administered and a response rate of 49% achieved. The findings of the study suggest that management of the companies studied viewed diversity as an important issue in their companies although they barely formulated any policies bordering on diversity. The key challenges to managing diversity included; lack of managerial skills needed to manage diversity, cost of managing diversity, and according low priority to diversity compared other pressing but interrelated business goals. The findings of the study have implication for pedagogical training of construction managers and content of training workshops organised by contractors’ associations.

Keywords: diversity, construction business, management, Ghana

INTRODUCTION

It is generally acknowledged there is a human side of teamwork (Gardenswartz and Rowe 2008). This is of particular importance to construction where work is carried by teams and crews or gangs of site operatives who characteristically are different from one another. Undeniably, achieving common goal by construction teams could impact positively on quality, time and cost including the safety of site activities. It can be argued that since construction team and gang members are of varied characteristics (background and experience), issues arising as result of diverse work force have to be overcome as they could impact negatively on the execution of site activities. Building on common ground, appreciating and capitalising on differences are for the astute site manager, a tool for accomplishing project objectives.

Construction projects are characterised by diverse workforce in both developed and developing countries. For instance, the construction projects in the US and Australia
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involve people of different nationalities and backgrounds (Loosemore 2012; Al-Bayati et al., 2017). In developing countries, many important projects are carried out by foreign contractors. Foreign participation is partly as result of procurement structures and weak construction industry. For instance, the Public Procurement Act, 2003 (Act 663) of Ghana provides for works whose contract value exceeds a certain threshold must be procured through international competitive tendering.

Ethical issues such as discrimination, equality and inclusion have partially fuelled research on diversity in the construction industry. However, much of academic research on diversity in the construction industry is focused on cultural dimension of diversity and developed countries (Loosemore et al., 2012; Ochieng and Price 2010; Al-Bayati et al., 2017; Clarke and Gribling 2008). Few, if any, consider diversity in the construction industry of developing countries. The aim of the study was therefore to examine the perceptions of management of civil engineering construction businesses on challenges to managing diversity.

Concept of Diversity

Diversity is a complex social phenomenon because of the multitude of dimensions and theoretical perspectives that characterise it. Mazur (2010) considers diversity as a subjective phenomenon created by group members which has, as its core, similarities and differences between groups. The differences and similarities are based on characteristics or simply put dimensions such as age, gender, beliefs, physical ability, ethnicity and socioeconomic status. Thus, groups may be described as being homogenous or heterogeneous depending of on the degree of similarity or difference ascribed to them. Notably, these characteristics associated with individuals or groups lead to issues of tolerance, discrimination and acceptance which need to be understood and managed within organisations to minimise or prevent any negative consequences on the organisations while embracing any advantages heterogeneous work groups may bring to the organisational milieu.

Dimensions and Effects of Diversity

Diversity has multiple dimensions which may be classified along primary, secondary, tertiary dimensions and perhaps beyond. The dimensions possess the quality of being dynamic and malleable with some for instance, character trait being infinitely expandable while others may be dominant than others depending on the context (Mazur 2010). Several models have been proposed to help explain the dimensions of diversity. For instance, the iceberg model by Hall considers easily observable dimensions such as race, ethnicity, clothing, food, disability, ethnicity, gender, age etc as being analogous to the small, visible portion of an iceberg. Other dimensions such as religion, political orientations and culture which are less noticeable represent the large portion of the iceberg below water. The seemingly endless dimensions of diversity are also well depicted by Gardenswartz and Rowe’s (1994) four-layered model of diversity.

Milliken and Martins (1996) cited by Mazur (2010) suggest that diversity can affect organisational functioning through four mediating variables; affective consequences, cognitive outcomes, symbolic effects and communication effects. Affective consequences refer to lessening commitment and satisfaction resulting from peoples' preference to interact with similar groups. Cognitive outcomes refer to enhancement of creativity and innovation in diverse work environments and symbolic effects refer to symbol of equality that relate to organisation's reputation in respect of diversity practices. Communication effects refer to the implications that diversity has for
communication processes within organisations. Diversity within work groups can result in difficulties in communication (Dulaiim and Hariz 2011; Ochieng and Price 2010).

**Challenges to Managing Diversity**

According to Patrick and Kumar (2012) common barriers to managing diversity include; discrimination, prejudice, ethnocentrism, blaming the victim, stereotypes, and harassment. Also, implementing and managing diversity brings about change and problems that should be solved. Edewor and Aluko (2007) note that individuals in organisations may resist change and those with strong prejudice against others may perceive the implementation of diversity as a threat. Some challenges are specific to national context. For instance, enabling institutional and legislative frameworks are lacking in Ghana as the existing legal frameworks for implementing diversity are in their early stages and evolving. The Constitution of Ghana and the labour laws provide the legal framework for managing diversity. These laws prohibit discrimination on the basis of race, sex, ethnic origin, creed, colour, religion, social, or economic status. Part VI of the Labour Act ensures protection of working women and Part V protects workers with disabilities. Section 68 specifies that every worker shall receive equal pay for equal work without distinction of any kind. Section 46 offers special incentives for the employment of persons with disabilities, and section 53 places special emphasis in training and retraining to enable the worker to cope with any aspect of the job. The Labour Act introduces the offence of sexual harassment. Section 175 defines sexual harassment as “any unwelcome, offensive or inopportune sexual advances or request made by an employer or superior officer or a co-worker to a worker, whether the worker is a man or a woman” (ILO, 2006).

**National Context of Diversity**

National policies, institutions, laws, culture and values that characterize nations have tremendous influence on the social identity of people whether as a group or at the individual level (Terrence 2004; Brown 2006; Macedo and Gounari 2006). In this regard, the national context may be argued to be important in understanding diversity since it contributes in shaping political viewpoints, behaviours, lifestyles and values as dimensions of diversity. These dimensions can be further argued to moderate relationships within teams in an organization or project environment in construction. The importance of the national context of diversity has been emphasised by researchers in the management discipline (Pringle and Ryan 2015; Akobo and Damisah 2018).

Ghana is multi-ethnic, multi-cultural and multi-religious with over 90 ethnic groups and many religious denominations (Gyimah-Boadi). The hub of social life revolves around the family and extended family value systems. Thus, people tend to relate strongly along family, extended family and ethnic lines. Diversity in Ghana may be thought to focus on social identities (Atta-Asamoah, 2012; Mengisteab, 2011) cited by Akobo and Damisah. The constitution of Ghana including state policies and institutions directly affect areas of diversity issues such as gender inequality, cultural norms of discrimination, disability exclusion and religious prejudice (Abdulai 2000). However, the efforts at the national level to addresses these issues are seriously undermined by challenges confronting the nation as acknowledged in the forgoing section.
METHODS

The target population for the study comprised senior (most experience in terms of number years of working in the construction industry) site engineers and managing directors of civil engineering contractors registered with the Association of Road Contractors of Ghana (ASROC) and foreign civil engineering contractors operating in the country. A draft of the questionnaires was discussed with experts in human resource management in construction and diversity management (DM) (selected by snowball sampling) and the updated version piloted in the field setting with five construction businesses. The final questionnaire developed and used in the study comprised closed ended questions. The questionnaires were divided into two main parts; thus Part 1 and Part 2. Part 1 covered the demographic profile of the respondents and characteristics of respondents' firms. Part 2 covered items on challenges to DM. The form of questionnaire items involved the Likert scale format with ratings ranging from Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4) and Strongly Agree (5). The questionnaires were pretested and Cronbach’s Alpha (α) was used measure the internal consistency of the measurement scales. The questionnaires were personally administered to the respondents during regional meetings of the Association of Road Contractors and through visits.

RESULTS

Demographic Profile

One hundred and eighty-seven (187) questionnaires were distributed to 42 civil engineering construction businesses. A total of one hundred and two (102) questionnaires were returned. The response rate from the site engineers was 49 questionnaires representing 26% of the total questionnaires distributed and 53 questionnaires representing 28% from the managing directors. The overall response rate was 55% which is relatively high compared with studies in similar settings (Kheni et al., 2008; Eyiah et al., 2018).

Four per cent (4%) representing 4 of the respondents were belonged to the age category of 30-39 years while 33% representing 34 of respondents were within age bracket of 40-49 years. A total of 64 representing 63% of the respondents were above 50 years or above. On the ages of the managing directors, 9% were in the age bracket of 40-49 years and 91% were above 50 years. For the site engineers, 8% were between the ages of 30-39 years, 59% were between the ages of 40-49, whilst 33% of them were above 50 years or above. Ferguson and Mulwafu (2004) suggest that age cohorts of workers play a significant part in the success of construction projects. Since, workers of different age cohorts have different strength and perceptions towards activities performed, varied perspectives are likely to be presented.

When asked about their educational qualification, 64 respondents constituting 63% indicated they have Diploma and 38 of them representing 37% have a Bachelor's degree. Amongst the managing directors, 81% were holding Diploma, whilst 19% were Bachelor's degree holders. Forty-three per cent (43%) of the Site engineers had obtained Diploma and 57% of them first degree. Respondents with higher levels of education are likely to be competent in their fields of specialisation compared to those with low levels of education and this is likely to translate into respondents’ understanding of issues relating to DM.

Responses on the particulars of respondents' businesses showed that 3 businesses representing 7% were foreign and 5 representing 12% were foreign subsidiaries.
operating in Ghana. The responses also revealed that 9 businesses representing 21% were businesses whose directors were foreign nationals. The rest of the 25 businesses were domestic civil engineering businesses whose directors were Ghanaians. At the time of data collection, over half of the businesses were undertaking road and housing projects (29) while the rest were involved in projects such as railways (4), port (3), dam (5) and market redevelopment (3). Two of the businesses were undertaking more than one kind of project.

**Challenges to the Management of Diversity**

The results obtained are ranked in descending order as shown in Table 1. The challenges were measured by mean and standard deviations and the significant mean level was pegged at 3.0. Any mean score above the 3.0 threshold is considered as a strong factor and those factors below the cut-off point are considered as a weak challenge.

It can be observed from the study results that there are no experienced experts employed by the businesses for managing diversity. This statement was ranked 1st with a mean score of 3.75 and a standard deviation of .999. Also, the respondents rated cost of DM as challenge in managing workforce diversity. This is supported by a mean of 3.34 and a standard deviation of 1.278. With a mean score of 3.30 and a standard deviation of 1.280, the respondents accepted that DM is not seen as an organizational priority. The respondents also affirmed that their organisations had no well-developed policies for handling workforce diversity issues (mean score 3.18, standard deviation 1.230). The respondents further rated workforce resistance to change as a challenge to DM (mean score, 3.13, standard deviation 1.376, ranked 5th).

The respondents rated bureaucracy within their organisations (x=2.49, SD=1.032), lack of enabling legal framework for implementing diversity (x=2.15, SD=.894), employees’ mistrust for management (x=1.85, SD=1.028), procurement method employed does not encourage employee to work as a team (x=1.75, SD=.571), cultural differences in itself is a barrier to managing diversity effectively (x=1.49, SD=.754), people often adopt the attitude of blaming the victim (x=1.35, SD=1.545), stereotyping is an obstacle to diversity (x=1.32, SD=.332), harassment of work mates (x=1.25, SD=.771), ethnocentric attitude and behaviours is an obstacle to managing diversity (x=1.215, SD=.671) and workers believing that efforts to manage diversity would be to their disadvantage (x=1.717, SD=1.871) as a challenges to managing diversity. These statements were ranked 6th, 7th, 8th, 9th, 10th, 11th, 12th, 13th, 14th and 15th respectively.

**DISCUSSION**

Challenges to managing diversity such as; bureaucracy or red tape, mistrust of management by employees, cultural differences, attitude of blaming victims, stereotyping, harassment of workmates, ethnocentric attitude and workers' perception about managing diversity were generally perceived by the respondents as weak challenges to managing diversity. This may be as a result of the characteristics or nature of labour employed by the companies. These challenges border on the beliefs, attitudes and behaviours of employees of the construction companies in the study. Over half of the respondents were employed by domestic Ghanaian-owned companies which have labour mix that could influence the perceptions of managers about challenges to DM. Many domestic construction companies are family businesses and
employing family relations, extended family members and friends is a common practice.

Table 1: Responses on challenges to managing diversity

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Challenges</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Rank</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>There are no experienced experts for managing diversity</td>
<td>3.75</td>
<td>.999</td>
<td>1st</td>
<td>Severe challenge</td>
</tr>
<tr>
<td>2</td>
<td>Cost of Diversity Management</td>
<td>3.34</td>
<td>1.278</td>
<td>2nd</td>
<td>Severe challenge</td>
</tr>
<tr>
<td>3</td>
<td>Diversity management is not seen as an organizational priority</td>
<td>3.30</td>
<td>1.280</td>
<td>3rd</td>
<td>Severe challenge</td>
</tr>
<tr>
<td>4</td>
<td>There is no well-developed policies for handling diversity challenges</td>
<td>3.18</td>
<td>1.230</td>
<td>4th</td>
<td>Severe challenge</td>
</tr>
<tr>
<td>5</td>
<td>Resistance to change</td>
<td>3.13</td>
<td>1.376</td>
<td>5th</td>
<td>Severe challenge</td>
</tr>
<tr>
<td>6</td>
<td>Bureaucracy within my organisation</td>
<td>2.49</td>
<td>1.032</td>
<td>6th</td>
<td>Weak challenge</td>
</tr>
<tr>
<td>7</td>
<td>Lack of enabling legal framework for implementing diversity</td>
<td>2.15</td>
<td>.894</td>
<td>7th</td>
<td>Weak challenge</td>
</tr>
<tr>
<td>8</td>
<td>Employees’ mistrust for management</td>
<td>1.85</td>
<td>1.028</td>
<td>8th</td>
<td>Weak challenge</td>
</tr>
<tr>
<td>9</td>
<td>Procurement method employed does not encourage employee to work as a team</td>
<td>1.75</td>
<td>.571</td>
<td>9th</td>
<td>Weak challenge</td>
</tr>
<tr>
<td>10</td>
<td>Cultural differences is in itself a barrier to managing diversity effectively</td>
<td>1.49</td>
<td>.754</td>
<td>10th</td>
<td>Weak challenge</td>
</tr>
<tr>
<td>11</td>
<td>People often adopt the attitude of blaming the victim</td>
<td>1.35</td>
<td>1.545</td>
<td>11th</td>
<td>Weak challenge</td>
</tr>
<tr>
<td>12</td>
<td>Stereotyping is an obstacle to diversity</td>
<td>1.32</td>
<td>.332</td>
<td>12th</td>
<td>Weak challenge</td>
</tr>
<tr>
<td>13</td>
<td>Harassment of work mates</td>
<td>1.25</td>
<td>.771</td>
<td>13th</td>
<td>Weak challenge</td>
</tr>
<tr>
<td>14</td>
<td>Ethnocentric attitude and behaviours is an obstacle to managing diversity</td>
<td>1.215</td>
<td>.671</td>
<td>14th</td>
<td>Weak challenge</td>
</tr>
<tr>
<td>15</td>
<td>Workers believing that efforts to manage diversity is to their disadvantage</td>
<td>1.717</td>
<td>1.871</td>
<td>15th</td>
<td>Weak challenge</td>
</tr>
</tbody>
</table>

It is likely that these companies (with such labour) will be characterised by cooperation of workers with management and the existence of stronger bond between workers due to the extended family value systems and communality of belief systems. Consequently, managers of such work environment are unlikely to rate the stated challenges as severe and worthy of consideration by them. The disproportionately small number of foreign firms means that overall these challenges will be rated as weak challenges to managing diversity.

Bureaucracy within construction companies and procurement methods were also perceived by the managers as a weak challenge to managing diversity. The management structure of construction companies is relatively simple and without bureaucratic bottlenecks partly because they are predominantly small and medium-sized businesses (SMEs). Notably, none of the companies in the study had a management structure with regional branches in Ghana. Procurement of public projects is guided by the Public Procurement Act, 2003 (Act 663) and the Public
Procurement (Amendment) Act, 2016 (Act 914). These acts do not influence matters relating to contractors' labour management although the process of procurement is required to be non-discriminatory and transparent. The results suggest the rest of five challenges as important to managing diversity namely; lack of experienced experts for managing diversity, high cost of DM, lack of priority attached to DM, lack of well-developed policies for handling diversity challenges and resistance. According to Kreitner (2001), managing a diverse workforce comes with potential challenges that mentors and leaders must overcome. To overcome challenges there is the need for training and building a knowledge base that will enable practitioners to handle issues on diversity. High cost of DM perceived as a severe challenge accords with Jain and Verma’s (1996) finding the need to increase job satisfaction, DM could sometimes be very costly. Cost of DM training programmes can prove to be substantial financial burden to overcome.

The results showed that lack well-developed policies for handling diversity is a challenge and this is in accord with the study by Wambui, et al., (2013). Commitment to effective DM is key factor in developing formal policies to guide implementation and achieving objectives of DM. Many of the respondents’ companies being SMEs operate through relatively simple structures and are unlikely to develop formal policies and guidelines to drive the implementation of DM. Managers face formidable challenges in building a multicultural organization that truly values diversity. To be successful, managers need to “unlearn practices rooted in an old mind set, change the ways organizations operate, shift organizational culture, revamp policies, create new structures, and redesign human resource systems (White, 1999). Managing diversity will involve doing away with old ways of managing issues and embracing a change in which new approaches will be adopted to solve problems. Resistance to change is bound to arise as people resist change for reasons such as fear of failure, mistrust and peer pressure (Kreitner, 2001). Notwithstanding the numerous challenges that may confront management, overcoming challenges to diversity by according it high level priority will enhance the health of the business.

It is necessary to draw a caution that management of companies are likely to prioritize issues relating to productivity and firm performance over others as levels of productivity performance directly affect company profits. Thus, managers' views on diversity are likely to be nurtured and expressed based on productivity and performance perspectives. However, diversity may be managed as part of corporate social responsibility (CSR) and other broader societal issues (Starostka-Patyk et al., 2015). This perspective of managing diversity may not have benefited from the design of the study and this limitation of the study is acknowledged. The results and discussion therefore exclude this view of DM and further research incorporating this aspect of DM will present a comprehensive picture.

CONCLUSION
The findings suggest contextual factors such as family as a social unit and extended family value systems may affect and thus shape management view of challenges to DM on the one hand. On the other hand, the findings of the study revealed lack of experienced experts for managing diversity, cost of DM, not prioritising DM, lack well-developed policies for handling diversity challenges, and resistance to change as key challenges to managing diversity. Based on the findings it is recommended construction businesses come up with policies that are geared towards managing diverse workforce in the firms and managers should be prepared to embrace changes
that involve the adoption of new approaches that are well suited to diverse work environment.

**REFERENCES**


HEALTH AND SAFETY
AN EXPLORATORY STUDY OF BUILT ENVIRONMENT ACADEMICS’ RESILIENCE AND MENTAL HEALTH

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Emerging research in other disciplines suggests that academics experience higher levels of stress and mental health issues than most other professions. However, little is known about the wellbeing of Built Environment (BE) academics. As much of the extant research lacks a theoretical underpinning, this study adopts the lens of resilience theory. In an exploratory study of this issue in the BE disciplines, a sample of 56 attendees at the 2018 ARCOM Conference in Belfast completed a paper survey to assess their resilience and mental health (depression, anxiety, stress and burnout). The results show that younger academics experience higher levels of burnout, more anxiety and lower levels of resilience than older academics, a finding that reflects the protective benefits of age and experience reported in studies of the general population. For all academics, longer working hours are associated with higher levels of anxiety. Resilience theory explains positive mental health in the higher education environment. The ability to maintain perspective (a resilience sub-factor) is a major predictor of good mental health. The findings of this study suggest the value of securing a larger sample as well as conducting in-depth interviews to deepen our understanding of the resilience of BE academics and their mental health needs.

Keywords: built environment, academics, mental health, PhD researchers, resilience

INTRODUCTION

While studying at university can cause a deterioration of student mental health (Larcombe et al., 2016; Scott-Young et al., 2018), evidence is beginning to demonstrate that the university environment exerts similar deleterious effects upon educators (Kinman and Wray, 2013; Shin and Jung, 2014) and PhD researchers alike (Levecque et al., 2017; Tsai and Muindi, 2016). Emerging research suggests that university academics and researchers experience higher levels of stress and mental health issues than most other professions (Guthrie et al., 2018). Little is known however, about the mental health of academics who teach and research in the Built Environment (BE) disciplines. At recent BE conferences, researchers have expressed a growing interest in their own resilience and wellbeing; recognizing the importance of a better understanding to address and prevent the mental health issues that they and their colleagues may experience. This exploratory study responds to that expressed need.

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Incidence of Mental Health Issues in the General Population

Over the past two decades, levels of mental health have been declining globally across all age groups, causing personal hardship and costing the world economy an estimated $1 trillion in lost productivity per annum (World Health Organisation (WHO), 2017).

Approximately one in six (17%) English adults reported symptoms of one common mental disorder in 2014 (National Health Group Digital (NHG) Digital, 2016), while one in five Australians aged 16-85 reported experiencing some form of mental disorder (Australian Bureau of Statistics (ABS), 2008). Depression, which involves a negative disturbance in mood (ABS, 2008), is the most common health disorder with an estimated three hundred million sufferers world-wide, accounting for 4.4% of the world’s population (WHO, 2017). Anxiety disorders (involving feelings of tension, nervousness or distress) are experienced by 3.6% of the world’s population (WHO, 2017). Anxiety disorders can cause individuals to fear or avoid stressful situations that evoke negative emotions (ABS, 2008), disrupting sufferers’ social lives and close personal relationships (Searle, 2017). The highest levels of anxiety and depression symptoms are experienced by 18-35-year olds (Casey, 2013).

Stress disorders, involving a state of persistent arousal and tension with low thresholds for becoming upset or frustrated (Lovibond and Lovibond, 1995) also affect a significant proportion of the population. Studies in the US report that the rising incidence of stress is negatively impacting adult health and wellbeing (American Psychological Association, 2017). According to a recent US study across nineteen industries (Mental Health America, 2017), a substantial proportion of poor employee mental health can be attributed to unsatisfactory workplace conditions and lack of employer support.

Mental Health of Academics and PhD Researchers

Not all academics or PhD researchers experience mental health issues; many experience good levels of wellbeing and report strong job satisfaction despite the occupational challenges (Kinman and Wray, 2016; Guthrie et al., 2018). Research on the mental health of academics and researchers has focussed mainly on occupational stress and burnout (Guthrie et al., 2018). Fifty per cent of university educators report high to very high levels of stress, whilst over one third regularly experience levels they consider unacceptable (Kinman and Wray, 2013). One longitudinal study found increasing demands on academics’ time along with a decline in the resources (role clarity, autonomy and support) that typically offset occupational stress (Kinman and Wray, 2016). Increasingly, academics are reporting higher levels of stress due to the massification and internationalisation of higher education (Kinman and Wray, 2016), business-led models of operation (Fanghanel, 2012), growing workloads with more administrative tasks, greater performance accountability and rising research expectations (Kinman and Wray, 2016), larger class sizes (Winefield et al., 2008), and regular restructuring and change (Whitley and Gläser, 2014). These growing occupational stressors cause the depletion of normal coping resources resulting in burnout (Kinman and Wray, 2013; Shin and Jung, 2014), with younger academics the most susceptible (Watts and Robertson, 2011; Zábrodská et al., 2018). Less research has been conducted on other psychological disorders in academia, however the few existing studies on depression and anxiety report higher levels than most other occupations (Edwards et al., 2009; Winefield et al., 2008) with rates similar to high stress occupations like social work, teaching and health (Goodwin et al., 2013; Watts and Robertson, 2011). Research on the mental health of PhD researchers has been
more prevalent, with more than 40% of researchers experiencing work-related stress, and burnout and depression (Guthrie et al., 2018).

**Factors Impacting Mental Health**

**Age** In the general population, age affects the incidence of psychological distress, with younger people aged 16-35 years experiencing more disorders than other age groups (NHGDigital, 2016; Mission Australia, 2017; American Psychological Association, 2017). Similar age-related effects for burnout are found in studies of PhD researchers (Watts and Robertson, 2011; Zábrodská et al., 2018). Gender Females experience a greater prevalence of psychological distress than males, including greater anxiety, stress (Bitsika et al., 2010) and depression (Bland, 1997). In England, more adult women over 16 years of age (19%) experience common mental disorders than same-aged men (12%), displaying more severe symptomology (10% compared to 6%) (NHGDigital, 2016). In Australia also more women (22%) report higher rates of mental disorders than men (18%) (ABS, 2008). More women experience anxiety disorders (18%) and depression (7.1%) compared to 11% and 5.3% of males respectively. Similar gender-related trends are also found in the US (American Psychological Association, 2017).

**Working hours** Working long hours is related to stress (Opstrup and Pihl-Thingvad, 2016) and depression (Peluso et al., 2011) in PhD researchers. Long hours often create work-family conflict for academics (Winefield et al., 2014).

**Theoretical Lens of Resilience**

In the main, the extant research on academic mental health has been characterised by a lack of theoretical justification (Kinman, 2016). Recent research has drawn on the job demand-control model to demonstrate that university work environments which provide adequate resources and control moderate the effects of occupational stress and positively impact academics’ mental health (Kinman, 2016). Another promising lens is the theory of resilience (Masten, 2018), which has been shown to be associated with positive mental health in BE students (Turner et al., 2017). Resilience is a process (Luthar et al., 2000) which enables an individual to cope and bounce back in the face of stress and adversity (Gerson and Fernandez, 2013). Caza and Milton (2012: 896) define resilience as ‘a developmental trajectory characterized by demonstrated competence in the face of, and professional growth after, experiences of adversity in the workplace. Each enables an individual to handle future challenges.

Resilience theory is based on a positive strengths-based paradigm which emphasises a proactive and preventive approach to managing stress (Herrick et al., 2014) to promote and protect mental health (Masten, 2018). Resilience is a multi-dimensional construct (Connor and Davidson, 2003), whereby assets and resources within the individual, their life and environment facilitate a capacity to adapt to environmental challenges (Windle, 2011). Winwood et al., (2013) have identified a particular set of protective factors for bolstering resilience in stressful workplaces: living authentically; finding one’s calling; maintaining perspective; managing stress; interacting cooperatively; staying healthy; and building networks. One of the goals of this current study is to learn more about the processes that promote resilience and positive adaptation to stressful work environments (Masten and Cicchetti, 2016) with the purpose of informing future individual and BE faculty practice.
Aim
The current study answers Guthrie et al.’s (2018) call to understand the prevalence of academic researchers’ specific mental health issues over and above occupational stress and to identify possible ways to address their needs. To do this, the present study adopts the theory of resilience (Masten, 2018) as a lens for exploring the under-researched issues of wellbeing and mental health in the BE discipline in higher education institutions. To our knowledge, no previous research has been conducted on the either the resilience or mental health of BE academics or PhD researchers. Therefore, the three-fold aims of this study are:

- to explore the resilience and mental health profile of BE academics and PhD researchers,
- to identify demographic characteristics related to the mental health of BE academics and PhD researchers, and to explore the protective relationship between resilience and BE academics’ and PhD researchers’ mental health.

METHODS
Sampling Strategy and Measurement Instruments
As this was an exploratory study suggested by academics at previous ARCOM conferences, a convenience sampling strategy was employed with data collected from attendees at the 2018 ARCOM Conference in Belfast. Participants responded to a public announcement at the end of a combined session on the final day. Respondents filled out a paper survey to assess resilience and mental health (depression, anxiety, stress and burnout). The DASS21 survey, a 21-item scale (Lovibond and Lovibond, 1995) was used to measure participants’ incidence and level of depression, anxiety and stress and showed an internal reliability of 0.89. Burnout was measured using Schaufeli et al.’s (2002) scale and showed a Cronbach’s alpha of 0.82. Resilience was assessed using the Resilience at Work (RAW) scale (Winwood et al., 2013) that measures seven protective and resilience-promoting attitudes (living authentically (holding true to personal values; good emotional awareness/regulation), finding your calling (doing work that gives a sense of purpose and belonging and aligns with your values), maintaining perspective (ability to reframe setbacks and stay optimistic) and behaviours (managing stress, interacting cooperatively, staying healthy, building networks) (Cronbach’s alpha = 0.78). Confirmatory factor analysis revealed that the scales loaded on their relevant factors indicating discriminant validity. All scales demonstrated adequate reliability, producing alpha scores over 0.70.

RESULTS
Demographic Characteristics
Of the survey respondents, 61% identified themselves as academics, and 28% were PhD students. Eleven per cent worked as consultants in the Construction Industry and were excluded from the analysis, leaving a sample of 53. Sixty per cent were males. Participants came from 12 different countries from all continents. The sample’s ages ranged between 22 -72 years with 67% over 35. Twenty-eight per cent had worked for 40 years or more, 16% between 30-39 years, 14% between 20-29 years, 23% 10-19 years, while 7% had only worked for 0-9 years. Almost 73% of participants lived with a partner, while 71% also had
children living with them. The mean hours worked per week was 41.5 hours, but time worked ranged from 0-80 hours, with 42% of the sample working over 40 hours and a further 15% working over 50 hours/week.

Mental Health Profiles

Table 1 shows the percentage of BE academics and PhD researchers who fall within the normal, mild, moderate, severe, and extremely severe classifications of depression, anxiety and stress disorders, as determined by their DASS-21 category scores (Lovibond and Lovibond, 1995). More BE PhD researchers experience depression (31%) compared to academics (20%). Anxiety disorders in BE PhD researchers (62%), are higher than previous studies, and also higher than the academics (26%) in the current study. However, both BE PhD researchers and academics experience a similar incidence of stress disorders, with one in three reporting symptoms.

Table 1: Incidence of depression, anxiety and stress among academics and PhD researchers

<table>
<thead>
<tr>
<th>Level</th>
<th>% Academics</th>
<th>% PhD Researchers</th>
<th>% Academics</th>
<th>% PhD Researchers</th>
<th>% Academics</th>
<th>% PhD Researchers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>80</td>
<td>69</td>
<td>74</td>
<td>38</td>
<td>70</td>
<td>69</td>
</tr>
<tr>
<td>Mild</td>
<td>3</td>
<td>0</td>
<td>6</td>
<td>19</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Moderate</td>
<td>17</td>
<td>19</td>
<td>13</td>
<td>25</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Severe</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>12</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Extremely Severe</td>
<td>0</td>
<td>12</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

Predictors of Mental Health

Preliminary tests were conducted to confirm there were no violations of the assumptions of normality, linearity, multicollinearity and homoscedasticity (Tabachnick and Fidell, 2001) before performing separate multiple regression analyses for each of the dependent variables (burnout, depression, anxiety and stress). Past research reveals that both academics and PhD students have higher levels of mental ill health than most other occupations (Edwards et al., 2009; Winefield et al., 2008; Guthrie et al., 2018). Because of the small sample size, the BE academics and PhD students were combined for analysis purposes, but the analysis controlled for the effect of being an academic or PhD researcher. The demographic characteristics (academic or PhD researcher, gender, age, hours worked, living with partner) together with the seven resilience sub-factors were entered into the regression equations as independent variables. A Pearson’s Product-Moment correlation analysis indicated that managing stress is positively correlated with maintaining perspective (r = .37, p < .01). Interacting cooperatively is also positively associated with managing stress (r = .30, p < .05). All statistically significant predictors of mental health are presented in the summary table (Table 2).

Together, the demographic variables and seven resilience sub-factors predicted 35.3% of the variance in burnout, with age (standardized beta (SB) = - .53*) and maintaining perspective (SB = -.47**) significant. For depression, the demographic variables and the resilience sub-factors predicted 42.2% of variance (F= 2.067, df=12,34, p=.04), with older age (SB = -.42*) and maintaining perspective (SB = -.49**) the two significant predictors. The demographic variables and resilience sub-factors predicted 48.6% of the variance in anxiety (F=2.683, df=12,34, p=.01), with longer working hours (SB = .28**) a significant positive predictor. In addition, being an academic...
(rather than a PhD researcher) (SB=-.38*), being older aged (SB = -.40*) and maintaining perspective

Table 2: Significant predictors of psychological states in regression analyses

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Burnout</th>
<th>Depression</th>
<th>Anxiety</th>
<th>Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic</td>
<td>.*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>.*</td>
<td>.*</td>
<td>.*</td>
<td></td>
</tr>
<tr>
<td>Hours worked</td>
<td></td>
<td>.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintaining perspective</td>
<td>.**</td>
<td>.**</td>
<td>.***</td>
<td>.***</td>
</tr>
</tbody>
</table>

(SB =-.63***) were significant negative predictors of anxiety. Together, the demographic variables and resilience sub-factors predicted almost 52% of the variance in stress (F=3.076, df=12,34, p=.005), however only maintaining perspective (SB = -.74***) was statistically significant. Taken together, these results indicate that higher levels of resilience are strongly related to better mental health in terms of lower burnout, depression, anxiety and stress in BE academics and PhD students. The ability to maintain perspective by reframing negative situations in a more positive light and maintaining optimism is particularly important to better mental health.

Discussion

Although mental health has been studied in other academic disciplines (Guthrie et al., 2018; Kinman, 2016; Kinman and Wray, 2016), until now, it has not been known whether those results can be generalised to educators in BE disciplines. This study fills a gap in our knowledge about the incidence of resilience, burnout, depression, anxiety and stress in BE academics and PhD researchers. The findings confirm that similar to other disciplines, mental health issues are greater than those that occur in the general population and in most other occupations. Therefore, mental health represents a serious issue for many educators and researchers employed in BE disciplines at universities around the globe.

The first research aim focused on identifying the mental health profile of BE academics and PhD researchers. BE academics and PhD researchers alike report a much greater incidence of depression than the world average, with PhD researchers experiencing the highest occurrence. Both groups experience a much greater incidence anxiety and stress than reported in the general population (cf. ABS, 2008; Crawford et al., 2011; WHO, 2017). To date, there is no known study of academics (Guthrie et al., 2018) using the DASS-21 measure of depression, anxiety and stress so it is not possible to make a direct comparison with academics in other disciplines. However, these findings are consistent with the few existing studies that have used alternative measures of mental health (e.g., Kinman and Wray, 2016; Watts and Robertson, 2011; Zábrodská et al., 2018). The present study confirms that many academics and PhD researchers in the BE disciplines experience multiple types of mental distress, with PhD researchers experiencing a greater incidence of depression and anxiety than academics.

The second research aim was to explore whether demographic characteristics are associated with the incidence of mental health issues in BE educators and PhD researchers. The findings show that being younger is related to a greater incidence of mental health issues (more anxiety, greater burnout, and lower levels of resilience), consistent with the greater vulnerability of people aged 16-35 in the general
population (ABS, 2008). In contrast, greater age is a protective factor in academic mental health, a finding consistent with other studies showing that older academics experience lower levels of burnout compared to younger colleagues (Watts and Robertson, 2011; Zábrodská et al., 2018). This finding suggests there needs to be greater support and attention given to the emotional wellbeing of younger colleagues in academia. With respect to gender and mental health, unlike other studies of the general population (ABS, 2008; NHGDigital, 2016), the present sample shows no difference between males and females, indicating that female BE academics and PhD students do not exhibit any mental health deficit. Consistent with other studies of academics and PhD researchers (Opstrup and Pihl-Thingvad, 2016; Winefield et al., 2014), longer working hours are associated with higher levels of burnout and anxiety. The third aim of this study was to explore the relationship between resilience and mental health (burnout, depression, anxiety, and stress). The results confirm that resilience is a significant predictor of the mental wellbeing of BE academics and PhD researchers. For universities wishing to promote their BE educators’ wellbeing, this study identifies managing stress as a potential target point for constructive interventions particularly since the academic career is known to be highly stressful (Kinman and Wray, 2016). Interacting cooperatively was found to be associated with managing stress, suggesting the preventative value of fostering collaborative teaching and research cultures within BE schools. The resilience protective behaviour of managing stress was also positively correlated with maintaining perspective. Notably in this sample, the ability to maintain perspective was the major predictor of good mental health. Those academics and PhD researchers who are better able to maintain perspective experienced less depression, anxiety and stress, and lower scores on the burnout scale. Since this is only a snapshot view of data collected at the one time, causation cannot be established. However, it is possible that these aspects of behaviour may be key areas to target for preventive faculty-level interventions to improve academic resilience. Training in perspective taking techniques and stress management are likely to be most beneficial. Through learning practices to manage their stress, academics may be better able to maintain perspective and protect their mental health when challenges occur in their workplace.

CONCLUSION

This study contributes both practically and theoretically to a new understanding of the mental health of academics and PhD researchers working in university BE disciplines. The results confirm that working in universities can be psychologically distressing for staff in the BE discipline. The findings suggest the need for further research to better understand the causes of BE educators’ distress, especially in younger colleagues. Future research could employ semi-structured interviews to gain a more in-depth understanding of specific factors. Further research could also explore whether BE academics and PhD researchers receive sufficient workplace support and attention to their psychological wellbeing. Research is also needed to identify the specific resources and interventions needed to promote and foster resilience and good mental health.

This study is exploratory. The limitation of a small convenience sample means the regression analyses should be interpreted with caution. Based on recent research (Guthrie et al., 2018), the BE academics and PhD researchers were combined to create a larger sample size, but our findings of a greater incidence and severity of depression and anxiety in BE PhD students suggest that future research should separate these two
groups. Larger sample sizes are also recommended. However, the sample included BE academics and researchers from multiple countries, suggesting the generalisability of the findings to different country contexts. Despite the limitations of sample size, this study provides new knowledge in the under-researched topic of the mental health in BE education. This study is suggestive of the prevalence and nature of the mental disorders that staff experience and identifies targeted areas for the improvement of employee mental health. Theoretically, the study also establishes the potential of resilience theory for explaining positive mental health and for suggesting interventions for improving the wellbeing of academics and researchers alike.

This exploratory study’s initial findings should be of concern to university administrators and BE discipline leaders since mental disorders are known to impair employees’ daily functioning and to diminish overall performance (Searle, 2017; Guthrie et al., 2018; WHO, 2017). As previous research has highlighted the prevalent occupational hazards in university workplaces, greater provision of resources, job control and supervisor support is called for, especially for younger educators and researchers (Kinman and Wray, 2016). Monitoring working hours, mentoring and fostering more collaborative and affirming work relationships are recommended structural changes. Mental health awareness and education is an advisable measure as early detection and referral to support services can benefit colleagues who are experiencing psychological distress. In addition, targeted preventative programs for addressing anxiety and stress through developing coping strategies like stress management techniques and perspective-taking will better equip BE academics with the necessary skills for managing the inherently stressful challenges in the university environment. It is critical that BE educators and researchers receive the support and resources they require to maintain positive mental health and wellbeing.

REFERENCES


Scott-Young, Turner and Holdsworth


SWISS CHEESE AND PERFORMANCE MODES: EXPLORING INTER-MODEL RELATIONSHIPS OF ACCIDENT CAUSALITY

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Given the continued high levels of safety accidents and incidents within the construction industry, accident investigation remains a vital tool in identifying the causal factors behind incidents, which can then be addressed to mitigate reoccurrence. For learning organisations, seeking to optimise their safety performance and culture, accident investigation is therefore able to provide relevant insights and suggest practical steps for positive change. Various models of accident causality have been developed to support such investigations, including Rasmussen’s ‘Worker Performance Modes’ and Reason’s ‘Swiss Cheese’ model, the former aligned to factors of human error and the latter to more complex systemic interactions within accident causality. Drawing on a large body of accident data (n=50) from a case study organisation, an empirical comparison was made of these two models in practice, to reveal and illuminate the relationships between them. The accident data was coded using a content analysis approach, and subsequently quantified to enable the identification of relationships between systemic errors and the performance modes of the workers at the time the incident occurred. By combining the models in this way, a better understanding is gained of how systemic errors and performance modes coincide.

Keywords: accident investigation, accident causality models, safety

INTRODUCTION

Despite improvements over recent decades, the UK construction industry’s accident rate is still cause for concern: The fatal injury rate (1.64 per 100,000 workers) is high at around four times the rate of all other industries, and around 2.6% of workers in this sector suffered from an injury - approximately 50% above rate for all industries, making it statistically significantly higher (Health and Safety Executive (HSE) 2018). Learning from accidents therefore remains a vital tool in identifying any causal factors which can then be addressed to mitigate reoccurrence (HSE 2013a).

There have been various models developed to support such investigations, two of which are Rasmussen’s ‘Worker Performance Modes’ and Reason’s 'Swiss Cheese Model', the former aligned to factors of human error and the latter to more complex systemic interactions within accident causality. This can roughly also be aligned to the two dominant causal factors also assigned to accidents on sites: Those of unsafe acts (i.e. worker performance modes) and unsafe conditions (i.e. a Swiss cheese
construct) (Smith et al., 2017). An accident investigation approach that draws on both human and systemic aspects is potentially able to provide more nuanced understanding of accidents, and therefore more robust insights to improve and change practice going forwards. The aim of this study was to analyse the relationships between these two models using accident investigation data from a case study organisation, to explore areas of synergy and conflict between systemic causes and worker performance, and so highlight areas for further research and interventions in practice.

**CONTEXT**

**Accident Investigation and Causality**

Accident investigation can help identify why the existing risk control measures failed and what improvements or additional measures are needed (HSE 2019). It can improve the management of risk in the future, help other parts of an organisation learn and demonstrate commitment to effective health and safety, and so also become valuable tools in preventing accidents. Such investigations form an essential component in reviewing and improving health and safety within an organisation and identify the events and circumstances relevant to the accident. Katsakori (2008:1012) suggests that ‘each accident investigation method should be revealing, which means that it distinguishes between events and underlying causes, in order to guarantee that the investigator will think about underlying causes, which are the less obvious reasons for an accident happening.’

Reiman and Rollenhagen, (2011:1265) note that 'it is often argued that over 80% of all accidents are caused by human errors or unsafe acts', however accidents are not caused only by human error, and if there has been an event then defences must have been breached, bypassed or missed. Human error is a symptom of deeper trouble within the system or organisation (Dekker 2002), in that it is often provoked by incompatible management or leadership practices and organisational weaknesses in work processes or values. Indeed, the notion of multi-causality within accidents was introduced by Reason at the end of the 1980s (Katsakori 2008:1007) and the understanding that the accident causation process is an interaction between latent and active failures has now long been accepted. Active failures are the immediate observable causes in an accident and so are easily identified, but in contrast, latent failures may be present in the system for many years, before being revealed by active failures and they are difficult to detect, as they are frequently hidden within an organisation's normal everyday operations. Individuals who work within complex systems make errors for reasons that generally run deeper through the organisation, and the HSE (2011:1) stress that 'blaming individuals is ultimately fruitless and sustains the myth that accidents and cases of ill health are unavoidable when the opposite is true'.

**Accident Investigation Models**

Le Coze (2012:448) observes that 'a wide selection of models are now available to investigators depending on the scope (micro, meso or macro) and purpose of these models'. These models are various based on a number of underlying theories and approaches, and have become highly complex in their structure, yet there have been 'few efforts to harmonise or synthesise the models and methods' (Grabowski et al., 2009:1187). As noted above, there has been a development from linear, causal models, which suggest accidents are simply the sequential result of technical factors,
human error or organisational problems (Hovden et al., 2010), others are much more complex with non-linear interdependencies, drawing on systems thinking for their theoretical foundation (Grabowski et al., 2009).

Indeed, systemic factors including those generated by management or organisational behaviour have also been incorporated into various accident models. For example, Hollnagel's (2004) Functional Resonance Accident Model (FRAM) is based on the concepts of emergence, whilst Ferjencik (2011) discussed the notions of singular causality, general causality, contextual factors, contributory factors and causal factors in the development of an Integrated Procedure of Incident Cause Analysis (IPICA). Leveson (2004:257) went beyond organisational boundaries in suggesting a model of socio-technical control which also incorporates the influences of legislation, regulations, certifications, and law. Yet this has added considerable complexity to the process of accident and incident investigation (Smith et al., 2017) and their utility in practice has been questioned (Hovden et al., 2010).

Accident investigation models should enable managers to make broader interpretations of their accident statistics in order to reduce the likelihood of future accidents (Gordon et al., 2005:148), and facilitate more nuanced understandings of the incident. Without such insights, follow up actions can be lacking. As the HSE (2013b:57) warn, if reporting and follow-up systems are not fit for purpose, for example if a blame culture acts as a disincentive to reporting near misses, then valuable knowledge will be lost. If the causes of precursor events are not identified and communicated, then recurrence is more likely. With these notions of utility and the need to avoid unnecessary and obfuscatory levels of complexity in mind, here two of the most prominent accident causality models are discussed in more detail to establish the foundations for the empirical work to follow. They are Reason's (1998) 'Swiss Cheese' Model and Rasmussen's (1997) Worker Performance Modes Model.

Figure 1 – Reasons 'Swiss Cheese Model' (Department of Energy 2012)

The Swiss Cheese Model (Figure 1) developed by James Reason (1998) is an example of the Epidemiological or Latent Failure Model. This is a complex, linear cause and effect model where accidents are seen as the result of a combination of active failures (unsafe acts) and latent conditions (unsafe conditions). The focus here is on the organisational contributions to the failure and views the human error as an effect, instead of a cause. Use of the Swiss Cheese model focuses investigators on complex interactions and on the organisational issues.
Reason (1998:295) himself advises that “here, the defences, portrayed as cheese slices, are shown as intervening between the local hazards and potential losses. Each slice represents one layer of defence. In an ideal world, all of these layers would be intact. In reality, however, each layer has holes or gaps. These gaps are created by active failures - the errors and violations of those at the human-system interface - and by latent conditions arising from the failure of designers, builders, managers and maintainers to anticipate all possible scenarios. The holes due to active failures are likely to be relatively short-lived, while those arising from latent conditions may lie dormant for many years until they are revealed by regulators, internal audits or by incidents and accidents. It is also important to recognise that, unlike the holes in Swiss cheese slices, these defensive gaps are not static, especially those due to active failures. They are in continuous flux moving around and opening and shutting according to local circumstances. For a disaster to occur requires the lining up of the holes to permit a brief trajectory of accident opportunity”.

Skalle et al., (2013, p183) suggest that 'most accidents can be traced to one or more of four levels of failure'. The ‘Swiss Cheese’ model, presents an organisation's defences against failure as a series of cheese slices where the holes represent weaknesses in the system. Skalle et al., explain that “the system as a whole produces failures when all of the holes in each of the slices momentarily align, permitting (in Reason's words) ‘a trajectory of accident opportunity’, so that a hazard passes through all of the holes in all of the defences, leading to a failure”. Salmon (2011:1159) adds that “the model describes the interaction between system wide ‘latent conditions’ (e.g. inadequate designs and equipment, supervisory and maintenance failures, inadequate training and procedures) and unsafe acts made by human operators and their role in accidents”.

Gibb (2006:2) notes that 'most safety systems have a number of layers to prevent a potential incident passing through them', however, due to human error, the layers all have holes that allow the potential incident to pass through that layer of the safety system. Gibb goes on to explain that, in most cases, 'the next layer in the system will intercept the potential incident and prevent its occurrence. However, this next layer also has holes' and an incident or accident will occur if all the holes in all the layers align. Reason’s model has been noted as being a 'success story’ thanks to its ability to visually incorporate principles of defence in depth coupled with human and organisational factors (Le Coze, 2012:448).

The Swiss Cheese Model therefore forms a good basis for incident and accident modelling within relatively complex organisations, focusing on ‘systemic’ issues and supporting contemporary views of human error. However, it does also exhibit several limitations of use, notably that 'it relies on failures up and down the organizational hierarchy but does nothing to explain why these conditions or decisions were seen as normal or rational before the accident' (Department of Energy, 2012:23).

**Rasmussen's Worker Performance Modes**

This limitation within in the Swiss Cheese Model can be mitigated with reference to human factors. Human Factors refer to 'environmental, organisational and job factors, and human and individual characteristics which influence behaviour at work in a way which can affect health and safety' (Health and Safety Executive 1999). Grounded in these factors, Rasmussen (1997) developed a classification of the different types of information processing involved in industrial tasks in a Skill-Rule-Knowledge Model.

This Model contains three levels of performance. At the skill-based level, performance is governed by patterns of pre-programmed instructions. The rule-based
level performance applies stored rules to form solutions. Knowledge-based performance is used in novel situations, where actions are planned on the spot by using stored knowledge and conscious analytic processes. As expertise in an area increases, control of performance moves from knowledge-based towards skill-based levels and all three levels can exist together (Mearns et al., 2003:3). Usually referred to as 'performance modes', these three levels of performance describe how the worker’s mind is processing information while performing the task (Department of Energy, 2012:29). Skill based errors relate to a correct understanding of the situation and correct intentions, but a lack of attention, resulting in slips, omissions, not recognising change in task requirements, system response, or plant conditions, due to some preoccupation. Rule based errors include misinterpreting the rule, or applying the wrong rule, or not recognising the need for a new rule. Knowledge based errors relate to an inaccurate mental model of the system, or process, or simply insufficient knowledge. The Department of Energy (2012:30) add that 'the performance modes refer to the amount of conscious control exercised by the individual doing the task, not the type of work itself. This is a scale of the conscious thought required to react properly to a hazardous condition.'

Summary

The Swiss Cheese and Worker Performance Mode models can be seen as complementary; bringing together organisational processes and behavioural explanations as identified through a human factors approach. It is suggested here that an exploration of areas of synergy and conflict between these systemic causes and worker performance may prove beneficial. For example, certain layers of the organisation may be more vulnerable to the negative consequences of certain types of worker performance modes in practice, and thus could benefit from focused interventions and changes in organisational practice.

METHOD

Data for this study comprised accident investigation reports (n=50) from a single case study organisation. This was essentially a sample of convenience as this specific data was generously made available by the organisation but remains a limitation of the study. A further potential limitation is the possibility of institutional bias within the data. In order to mitigate this, the data also included statements from those involved in the accident, or were witness to it, and records of other conversations or interviews held immediately following the event. Mobilising a positivistic methodology, the analytical process followed a number of distinct steps and involved both qualitative and quantitative analysis of the data. The data was analysed using an objective content analysis approach (Tonkiss 2004). Initially, each accident report was categorised to provide meaningful labels to support data management during the further analysis (such as: Type of accident, hazards identified, consequences etc.). The accident reports were then broken down on a 'line-by-line' basis to unpack the data in more detail and distil all potential causal factors or parties at fault within each accident report (here termed 'categories'). Subsequently three distinct Stages of analysis were undertaken:

- Stage 1: All Data Categories per Group per Model
- Stage 2: Single Dominant Category per Group per Model
- Stage 3: Single Dominant Category per Model

Stage 1 saw each category with each accident report coded with the relevant 'group' from within either of the two models. This process was inclusive, and more than one
category could be applied to one accident report line. For the Swiss Cheese Model, the groups were: Latent - cultural; latent - engineered; latent - process, latent - supervisory; active - individual. For the Worker Performance Mode Model, the groups were: Skill based; rule based; knowledge based. Following this qualitative content analysis, the data was sorted, and pivot tables created in order to quantify the data, identifying how many times each group code appeared across all 50 reports, or more specifically, each category within each report analysed.

Stage 2 applied further interpretive analysis to this coded data and mobilised a constant comparison approach to ensure consistency throughout the process. This reduced the multiple group codes as ascribed to each accident report line to one 'dominant' group code for each accident, and also ascribed the incident to a dominant party at fault.

Stage 3 then further distilled the analysis down into a single category for each of the models, able to again provide frequency distributions therein. From this data, comparison could then be made between the categories applied to each model group, able to show correlations between types of causal factor and to whom they could best be ascribed. Due to constraints of space, only data from the third and final analytical step has been presented here, with a focus on the final comparative analysis undertaken to present the data in a way that enables the relationships between the two models to be best illuminated.

FINDINGS AND DISCUSSION

Categorisation by Reason's Swiss Cheese Model

Following the analytical process set out above, the final categorisations of the accident report data against Reason's Swiss Cheese Model are shown in Table 1.

Table 1: Accident Categories for the Swiss Cheese Model

<table>
<thead>
<tr>
<th>Causal Code</th>
<th>No</th>
<th>%</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latent Cultural</td>
<td>15</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Latent Engineered</td>
<td>8</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>Latent Process</td>
<td>9</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>Latent Supervisory</td>
<td>6</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Active Individual</td>
<td>12</td>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>TOTAL:</td>
<td>50</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Latent conditions account for 76% of all failures at this level, with only 24% being active errors. To some extent this suggests that human error may not be as significant a contributory factor in accidents, as the majority here were associated with latent systemic defects away from the 'sharp end' of the operations, however as human error is spread across all layers or barriers of the Swiss Cheese Model, these findings should be treated within caution.

Categorisation by Rasmussen's Worker Performance Modes

Following the analytical process set out above, the final categorisations of the accident report data against Rasmussen's Worker Performance Modes are found in Table 2.
Table 2: Accident Categories for the Worker Performance Mode Model

<table>
<thead>
<tr>
<th>Causal Code</th>
<th>No</th>
<th>%</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill based error</td>
<td>13</td>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td>Rule based error</td>
<td>14</td>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td>Knowledge based error</td>
<td>23</td>
<td>46</td>
<td>1</td>
</tr>
<tr>
<td>TOTAL:</td>
<td>50</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Interestingly, the more fine-grained analysis of the data (the first two steps in the analytical process) saw a change in the findings that ultimately led to the dominance of the knowledge-based error categorisation as shown in Table 2. The first step in the analysis, which saw the categorisation of the line by line data resulted in rule-based errors being most frequent. The second step in the analysis, which distilled the findings into the dominant category per group per model, saw a further change in frequency and resulted in skill-based errors being most frequent. The final step in the analysis resulted in knowledge-based errors being identified as the dominant causal factor in the analysis, replacing skill and rule-based errors as the dominant grouping for the data as a whole.

Comparing the Two Models

Table 3 collates the parties at fault for the interpreted dominant errors and presents them within a grid that incorporates the two Models. The numbers refer to the initial investigation code, and the party at fault has been presented in the sector which reflects both the dominant Swiss Cheese (SC) layer and Worker Performance Mode (WPM) as identified through the three stages of analysis.

Table 3: Causal Grid for Parties in Error

Table 3: Causal Grid for Parties in Error

The analysis shows a dominance of Skill Based Error (WPM) by the Contractor Operative in the Active - Individual layer (SC) and of Knowledge Based Error (WPM) by the Staff Organisation / Staff Management in the Latent - Cultural layer (SC). These findings are consistent with Mearns et al., (2003:2) who note that active errors are most likely to be caused by front-line operators (e.g. control-room crews, production operators) and their skill or lack thereof, whereas latent conditions are more likely to be caused by those who are removed from the direct control interface (e.g. designers, high-level decision makers, managers, construction workers and maintenance personnel) and due to their knowledge and subsequent decision making.
The parties at fault within Table 3 are consistent with the literature, and so perhaps not surprising, however this analysis does support a combined model approach in practice, able as it is to empirically demonstrate the relative frequencies of each categorisation and so provide direction for more focused research or intervention.

An anomaly to this is the frequency identified in the Knowledge Based Error (WPM) / Latent - Process layer (SC) relationship. Knowledge-based activities involve problems solving and often occur in response to a totally unfamiliar situation where there are no rules or skills to guide the individual. The person must rely on understanding of the system, scientific principles and theory related to the system. In this situation attention is more focused and often understanding of the problem is patchy, inaccurate or both. Yet when this is found within the Process Layer of operation from the Swiss Cheese Model, which is associated with a lack of or inadequate awareness of the requirements of management control procedures and processes, there is clearly dissonance. Knowledge of the processes in place to ensure safety seems to be lacking and is therefore cause for concern. This finding is again worthy of further research to better understand this relationship in practice.

The findings were also mapped onto the familiar Swiss Cheese Model structure as shown in Figure 2. This seeks to present the dominant holes in the organisational layers and their proportions. Additionally, the holes are presented as Black for Staff Groups and White for Contractor or External Groups with an indication of the Worker Performance Mode. However, it must be noted that the holes are not dynamic and there is no attempt here to represent to magnitude of the holes relative to one another (e.g. how large or small any particular hole is).

Figure 2: Relative Holes in the Organisations Layers

What is evident in Figure 2 is that Knowledge Based Error, particularly by the Staff Groups, is the dominant issue within the Latent - Cultural layer. On the opposite end of the Swiss Cheese model and organisational layers, Skill Based Error, particularly by the Contractor Groups, is the dominant issue within the Active - Individual layer. This reinforces the pattern suggested in Table 3 The Staff Organisation and Staff Management feature heavily on the Latent - Cultural layer and particularly within the Knowledge Based Error mode. The Active - Individual layer finds the Contractor Operative to be the dominant group at fault, particularly within the Skill Based Error mode. This indicates a relationship between the barrier analysis and the worker performance mode. The weakness highlighted with the staff organisation operating within Knowledge Based Error mode and in the Latent - Cultural layer is a
particularly intriguing topic. Given the impact and influence that the organisational and management layers have on the subsequent layers, it is interesting to speculate what cascading effects that improvements at this layer would have.

More crucially it would appear that the issues have gone un-resolved for some time. This could be attributed to the fact that the case study organisation may have a lack of understanding or appreciation of where their vulnerabilities really exist and have therefore been unable to take action within the specific areas.

CONCLUSIONS

The empirical analysis was able to demonstrate the following relationships between the two Models:

- Cultural (latent) causal factors relate to knowledge-based error modes more, and organisational and management groups feature as the dominant parties at fault.
- Engineered (latent) causal factors relate to knowledge and rule-based error modes but there is no substantive evidence of a dominant party at fault.
- Process (latent) causal factors across the knowledge-based error mode but there is no substantive evidence of a dominant party at fault.
- Supervisory (latent) causal factors across the rule and skill-based error modes and the supervisor group features as the dominant party at fault.
- Individual (active) causal factors across the skill-based error modes and the operative group features as the dominant party at fault.

While there are strong relationships identified that appear logical there are also relationships which appear unusual, and further research should look to either prove or challenge these apparent relationships, for example within the process (latent) layer as indicated. The weaker relationships may also benefit from further assessment to ascertain if a substantive relationship can be claimed, as is evident within the engineered and process layers.

The frequency of accidents within each categorisation supports existing literature, but also highlights areas for further research and suggestions for practice. For example, research can now look to better unpack how specific latent factors influence and affect specific error modes as identified. More practically, the findings have revealed specific groups within an organisation that are vulnerable to specific error modes, and which can now be targeted with focused safety interventions that directly look to address those errors in practice.

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IMPROVING PRODUCTIVITY AND WORKER SAFETY: AN ACTION RESEARCH USING OSM WITH CRANE ERECT

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The challenge of improving productivity and worker safety within construction is always a daunting task as workers feel they are squeezed with an ever-dwindling resource pool. However, improving productivity and safety using OSM with crane-erect requires workers to have appropriate expertise. The potential benefits of Off-Site Manufacturing and the integration of timber kit crane-erect homes is considered as one of the most viable options in terms of delivering homes that are affordable, and minimising many of the safety hazards associated with the build process. This paper adopts an action research approach to evaluate the challenges regarding improving site productivity and safety through the implementation of OSM using crane-erect. The data collection involved assessing the labour uptime and downtime to install the wall panels, floor cassettes and the roof truss for six plots including labour and crane utilization. The findings suggest that the implementation of crane-erect requires adequate planning to avoid disruptions for other plants and tradesmen. Incorporating the delivery of the roof truss together with the timber kit will simplify the roof truss installation and also minimise the exposure time for the joiners to work at height. The operatives involved in loading of plasterboards to plot floor decks experienced significant increase in manual handling. However, it takes three days to complete the fittings of the shell, make it water tight with the internal kit, fire stop and installation of external fixtures (fascia and soffits). This is considered to significantly reduce time, health and safety risks, and productivity. Overall, the average percentage uptime for the six plots was 83%, but the housebuilder is keen to further improve and maximise efficiency above 90% per plot as this could lead to more plots erected per day using the crane erect.

Keywords: crane erect, productivity, timber kit, worker safety

INTRODUCTION

The UK house building business faces significant challenges in the delivery of new cost-effective homes of quality, quantity, and environmental sustainability within a very limited time frame. The potential benefits of Off-Site Manufacturing (OSM) and the integration of mobile crane-erect build for the timber kit is now considered as one of the most viable options by housebuilders for constructing new private homes, (Venables et al., 2004; Hinze, et al., 2013; Eastman and Sacks 2008; Blismas and Wakefield 2009; Fulford and Standing 2014). The use of mobile-craines with telescopic boom (high lifting capacity and short set up time) and the capability to travel within rugged site terrain made it useful due to its rapid deployment to mechanically lift heavy loads such as the OSM timber kits. However, the uptake of

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the non-traditional timber kit using crane-erect within the UK construction has been lower than expected (Taylor 2010), as opposed to the traditional linear construction where each individual step is constructed entirely or largely on site. Goodier and Gibb (2007) define offsite construction (OSC) or offsite manufacturing (OSM) as the manufacture and preassembly of building components, elements or modules before installation into their final locations on a construction site. Based on the degree of offsite work undertaken on the product, OSM can be classed into four different levels such as component and subassembly; non-volumetric preassembly; volumetric preassembly; and modular building (Gibb 1999). There are ongoing considerations regarding fully adopting the use of non-volumetric preassembly timber kit crane-erect method of house building by UK house builders in terms of delivering homes that are affordable and removing or reducing many of the safety hazards associated with the build process. This is because timber kit OSM with crane-erect is considered to include reductions in time, defects, health and safety risks, environmental impact, and whole-life cost, and a consequent increase in predictability, productivity, whole-life performance and profitability when satisfactorily implemented (Venables et al., 2004; Hinze et al., 2013; Blismas and Wakefield 2009; Fulford and Standing 2014). This action research evaluates the challenges regarding improving site productivity in house building through the implementation of timber kit OSM using crane-erect by the contractor and to potentially roll it out across their entire business units. This study was carried out with one of the UK’s largest independent house builders towards improving productivity and worker safety within its current development.

Productivity and Construction Worker Safety

The construction industry is always seeking ways of improving its productivity and management processes whilst reducing project duration, cost, defects and eliminating Occupational Health and Safety (OSH) incidents. The traditional methods of construction where each individual step is entirely or largely constructed on site before the project can move on to the next phase struggles to deliver on these objectives. Therefore, a way of resolving some of these challenges by one of the independent housebuilders is the incorporation of timber kit OSM with crane-erect as an alternative to improving productivity and safety.

Construction is considered as one of the most complex in nature, physically demanding, and labour-intensive industry that is interdependent in terms of manpower and resources and this could often lead to some problems of inefficiencies in operations (Dubois and Gadde, 2002). As a result of this, workers tend to be more prone to significant risks of injuries, ill health or fatalities associated with their tasks/jobs within the workplace (Hinze, et al., 2013). Due to the complexity of the construction industry and the ever-increasing drive for higher productivity, worker safety can sometimes take the back seat (van der Molen et al., 2005). However, the success of this industry could be considered to be dependent on the effectiveness of the management to increase productivity and performance whilst incorporating and implementing best practices in terms of safety, health and the environment. Studies have shown that OSM can contribute to addressing some of these challenges facing the construction industry (Blismas and Wakefield 2009) and the independent housebuilder has considered the incorporation of crane-erect mechanism as a way of further improving productivity and safety. Venables et al., (2004) identified that OSM technology has the potential to reduce cost, time, defects, health and safety risks and environmental impact and consequently increase predictability, whole life performance and profits over long term. Eastman and Sacks (2008) indicated that
OSM of building components have significantly become more labour productive compared to on-site activities and the overall growth rate of OSM productivity is greater than comparable on-site sectors. Therefore, the adoption of timber kit OSM with crane-erect could potentially reduce the time for on-site construction due to more factory-based production; reduce build cost through the reduction of time spent on site thereby improving efficiency; reducing material wastage and enhancing construction OSH.

Initiatives such as joint management systems where safety management systems are integrated with operational management systems have also been put forward as an alternative towards further improving both safety and productivity within the construction industry, (Choudhry 2017). This indicates that elements of productivity and safety could be managed by the safety and project managers by sharing the responsibilities of safety and operations. These could influence the safety performance of the project due to improved safety records, having effective controls in place for both contractors and subcontractors and the ability to closely monitor and supervise ongoing work. Incorporating this initiative requires the management to consider safety as a core part of all operational decisions which could invariably have a positive impact on productivity. Therefore, improving productivity and safety using OSM with crane-erect could lead to stability which could mitigate work-related accidents, injuries or fatalities while delivering on the project with minimal quality defects, time delays or associated cost overruns.

Some housebuilders are now adopting the concept of OSM with crane-erect but, there are issues around uptake due to lack of expertise (skill, knowledge and experience), transport and logistical problems, the complexity of the interface between systems, and the inability to freeze the design during the early stages (Blismas and Wakefield 2009; Rahman 2014). Other factors such as the resistance culture within the workplace (e.g. attitudinal barriers); lack of knowledge amongst the house builders regarding the available systems and their use; manufacturing capacity that are somewhat unreliable are considered as some of the obvious concerns that are usually raised with timber kit OSM with crane-erect builds, coupled with the rigidity of sequences and the overlap of stages that make co-ordination difficult, (Dubois and Gadde 2002). Therefore, the potential for the housebuilder to maximise timber kit OSM with crane-erect can be achieved if the decision to implement OSM and crane-erect is better understood and properly managed.

The use of OSM with crane-erect for this project hinges on the fact that the construction industry amongst other things suffers from low levels of productivity and safety when compared to other industries (Fulford and Standing 2014), with labour productivity having a major impact on project performance and the housebuilder has linked this with their existing management strategies. The decision by the housebuilder (management) to use crane-erect mechanism to drive safety and to improve productivity and performance also indicates that management-driven safety could be mutually dependent on productivity and performance.

Studies have looked at the relationships between productivity and workplace safety in construction and there is a consensus that the commitment of the management to safety could significantly influence the safety climate within the workplace (Zohar 2002; Zohar and Luria 2005; Newaz et al., 2019; Casey et al., 2017). When safety and productivity are assigned same amount of attention within the workplace, it suggests a sign of genuine commitment of the management towards workplace and
Improving Productivity and Worker Safety

Task-based safety (Lawani et al., 2018), and this could often mean workers complying with safety to achieve productivity targets without necessarily increasing the complexity of the production systems. However, the concept of improving productivity is often perceived as additional pressure on workers to achieve higher job demands while still adhering to working safely (McLain and Jarrell, 2007). It has also been identified that when safety and productivity goals compete for workers’ attention within the workplace due to pressures resulting from productivity, safety often deteriorates while productivity becomes a priority due to better production performance and the culminating financial incentives (Reason 2000; Mitropoulos and Cupido 2009).

The use of mobile cranes for lifting operations is considered as an important piece of machinery that facilitates the workflow but at the same time with severe consequences if things do go wrong. Using mobile crane-erect to improve safety and productivity could also enhance the ergonomic features within the workplace which could reduce occupational injuries whilst improving labour productivity and quality (Neumann and Dul 2010; Westgaarda and Winkel 2011). This could result in eliminating potential hazards and safety risks within the construction site. However, research has shown that one-third of construction fatalities occurred in crane-related accidents (Neitzel, et al., 2001) and that mobile cranes account for nearly 70% of most crane-related fatalities within the industry (Fang, et al., 2016) as compared to tower cranes that operates within a stationary position. This is because the use of mobile cranes necessitates it to move across sections of the site and plots to enable it perform its lifting tasks for the build process such as lifting the wall panels, floor cassettes, installations of roofs and lifting of other materials required for the build phase. To improve productivity and safety within the site, adequate planning processes and monitoring of the mobile crane onsite movement and lifting operations would require enhanced monitoring which would directly have an impact on the safety of the workforce. That means there should be a lifting plan suitable and sufficient for the work being carried out by an experienced crane operator and banksmen based on the Lifting Operations and Lifting Equipment Regulations 1998 and Provision and Use of Work Equipment Regulations 1998.

This study evaluates the benefits of using OSM timber kit through an actual site trial using crane-erect. To assess the impact of OSM productivity and safety, the approaches evaluated the aspects of productivity related to the earlier shell completion of the houses using pre-fabricated wall panels; finished floor cassettes erected using a crane with no safe working platform; early ground roof assembly, felt and batten and lifted to final place and the OSH benefits that mitigates manual handling.

Rationale for this Study

This study assessed a UK housebuilder in its quest to improve productivity, performance and safety practices through the implementation of mobile cranes to erect timber kit homes. To achieve this aim, the study fulfilled the following propositions:

1. How would addressing process efficiency and OSH related to the build processes improve productivity?

2. Will embracing OSM with crane-erect technological shift disrupt the established relationships with various trades and impact productivity?

3. Would improving the housekeeping and material management due to downstream site process delivery (just-in-time) have an impact on productivity?
METHODOLOGY

This study required the researcher to be physically present on site and embedded within the workers. It required responsibility for on-site strategy through site monitoring and observations, informal interviews and analysis of on-site activities to address issues under study, (Creswell and Creswell 2018). Such an approach has been used in organizational studies to improve practice for example, managing technological innovation and processes of Swedish building component manufacturers (Larsson et al., 2006). The adopted methodology involved on-site monitoring and assessment of site productivity and safety of some specific tasks being undertaken by the tradesmen; like the joinery and roof work and tasks involving the crane operators and banksmen. This explains the focus of the examination of timber kit OSM with crane-erect as opposed to the conventional traditional build towards a business case that creates value and as a form of competitive advantage for the company. The information which is gathered by actually talking directly to the workers and seeing them perform, behave and act within their context defines this qualitative research, (Creswell 2014).

It involved cases within a real-life, present context or setting over time (Yin 2014; Creswell and Poth 2018), with the researcher gathering information from multiple sources e.g. observing and taking field notes on the behaviour and work activities of individuals on site (Creswell and Creswell 2018). The use of qualitative audio-visual and digital tools (a time-lapse camera with video capabilities) and adopting face-to-face unstructured and generally open-ended interviews with workers and managers to elicit views and opinions from the workforce was adopted (Creswell and Poth 2018; Creswell and Creswell 2018). The information collected was focused on multiple house types, dimensions and designs within the development by adopting the same logic of replication (Creswell and Poth 2018). This type of action research involved the researcher collaborating with the site operatives in the assessment of their labour productivity of the build process of timber kit OSM homes with crane-erect. This research approach could be effective for developing solutions to problems identified, of which the Dargavel Project is a good example. However, the researcher needed to be able to lay aside their own value judgments sharpened by own practice in order to allow other voices to inform the research. Therefore, maintaining the balance between drawing from those available resources and the researcher giving up their own ideology in order to objectively collect and analyse research information was important. This case study development could potentially inform the independent house builder towards developing strategies for optimizing the use of crane-erect technology, evaluating its commercial benefits and benchmarking the perceived good practice with a view to rolling out an improvement program across the wider business to enhance productivity and safety, efficiency, minimizing construction waste, and building sustainable homes.

The data collection involved assessing the labour uptime to install the shell for six plots including the kit erect labour and crane utilization for the different house types. This involved measuring the labour time of the joiners involved in the installation of the roof truss, the kit erect installation and any extra labour assistance of apprentice joiners for the floor cassette and wall panels. The measurement also captured the uptime and downtime of the crane usage covering both the operator and the banksmen as part of the contract hire agreement.
FINDINGS, DISCUSSION AND CONCLUSION

How would addressing process efficiency and OSH related to the build processes improve productivity?

The use of mobile crane for the build process requires adequate planning for on-site access, and the planning of the crane hard standing position situated away from the job site access road and pedestrian walkway to avoid disruptions for other plants and tradesmen as this previously led to loss/delay of work programme, (Neitzel, et al., 2001; Fang, et al., 2016).

The formation of the roof truss on site could take up to two days to complete depending on the number of joiners assigned; their level of skill and experience; and the dimension of the roof truss. For process efficiency and progress, the timber kit and the roof truss required for subsequent plots should be delivered at the same time with the timber kit for reasonable progress to be made in forming the truss. Incorporating the delivery of the roof truss and timber kit together will simplify the roof truss installation and this could be achieved through proper planning of the joinery work as the allocated time for the formation of the roof truss on ground has no impact on other work packages. This would also minimise the need for joiners to work at height which thus minimise the risk of a fall from height.

This study indicates that the adoption of OSM timber kit erect significantly addressed workplace OSH issues most especially reduced manual handling involving wall panels, floor cassettes and roof trusses which are lifted into position using the crane. The use of crane-erect minimised the exposure times of operatives required to work at height thus preventing the need for safety decking and fewer risks to manage. Therefore, the use of scaffolds and their adaptations were completed quicker, closed off and usable (i.e. safer) and their management by competent scaffolders during and after the lift processes improved joinery efficiency and safety on site, (Hinze et al., 2013; Fulford and Standing 2014).

However, the two operatives assigned with the tasks of loading the plasterboards to the floor decks and moving windows and doors into place for fittings experienced significant rise in manual handling whilst loading to the deck of the ground and first floor for joinery first fix. The two operatives manually lifted 240 - 515 sheets of plasterboards (24kg per sheet) depending on the different house type which amounts to 5,760kg - 12,360kg of manual handling without mechanical assistance. Based on the Manual Handling Operations Regulations 1992, it states that if, ‘so far as is reasonably practicable’, handling the load cannot be avoided, then consideration should be given to whether the lifting operation can be either automated or mechanised to eliminate the manual aspect of the handling. This specific task was found not to improve productivity neither did it improve safety practices but rather could lead to increased cases of musculoskeletal disorders (Neumann and Dul 2010; Westgaard and Winkel 2011). This indicates that joint management systems (Choudhry 2017) that are integrated with operational and safety management systems to potentially improve safety, process efficiency and productivity were not adequately considered.

Will embracing OSM with crane-erect technological shift disrupt the established relationships with various trades and impact productivity?

The findings present emerging challenges and opportunities associated with the site monitoring study. The site trials of the OSM with crane erect established a positive stance for the company as they plan to change their build process from traditional to
crane-erect. The findings focusing on labour productivity assessed the kit erect joiners and crane systems being used for the build phase for the six plots. The acquisition of data for labour and cycle time was carried out by onsite researcher through observation and recording of the construction process - the start and completion times of individual activities and the number of operatives involved in undertaking such activities. In situations where concurrent measurements needed to take place, the researcher moved between such activities by documenting them through short time lapse video clips and photographic evidences.

The timber kit lifting operations for the ground and first floor wall panels, floor cassettes and the formed roof truss should adopt a planned sequence and drawings supplied with the kit to minimise OSH risk (Fulford and Standing 2014). The measurement of productivity for the kit erect joinery fix relied on the same available team of joiners based on their levels of skill and experience (Blismas and Wakefield 2009; Rahman 2014; Dubois and Gadde, 2002), the size and dimensions of the plots and the weather conditions. For the six plots, there was a consistent team of joiners responsible for the joinery fittings. The researcher measured the time taken to lift and install the ground floor panels, the lifting and installation of the floor cassettes to position and the first-floor wall panels. The lifting of the roof truss craned into position involved the joiners completing the process of nailing and securing the roof while the full kit erect was achieved within a working day. Subsequent tasks like nailing of the internal kit, fire stop and installation of external fixtures (fascia and soffits) were completed within three days and water tight. This is considered to significantly reduce time, health and safety risks, environmental impact, and productivity (Venables et al., 2004; Hinze et al., 2013; Blismas and Wakefield 2009; Fulford and Standing 2014).

**Table 1: Productivity by House Type**

<table>
<thead>
<tr>
<th>Code</th>
<th>Plot</th>
<th>GIA m2</th>
<th>FF Area m2</th>
<th>Uptime Hrs</th>
<th>Downtime Hrs</th>
<th>Total Time Hrs</th>
<th>Productivity m2/man hr</th>
<th>Uptime %</th>
<th>Downtime %</th>
</tr>
</thead>
<tbody>
<tr>
<td>NWD</td>
<td>48</td>
<td>177</td>
<td>102</td>
<td>110</td>
<td>21</td>
<td>131</td>
<td>1.35</td>
<td>84</td>
<td>16</td>
</tr>
<tr>
<td>HDN</td>
<td>50</td>
<td>140</td>
<td>77</td>
<td>105</td>
<td>22</td>
<td>127</td>
<td>1.1</td>
<td>82.7</td>
<td>17.3</td>
</tr>
<tr>
<td>LRT</td>
<td>46</td>
<td>150</td>
<td>75</td>
<td>115</td>
<td>22</td>
<td>137</td>
<td>1.09</td>
<td>83.9</td>
<td>16.1</td>
</tr>
<tr>
<td>NWD</td>
<td>45</td>
<td>177</td>
<td>102</td>
<td>124</td>
<td>28</td>
<td>152</td>
<td>1.16</td>
<td>81.6</td>
<td>18.4</td>
</tr>
<tr>
<td>NWD</td>
<td>44</td>
<td>177</td>
<td>102</td>
<td>116</td>
<td>25</td>
<td>141</td>
<td>1.26</td>
<td>82.3</td>
<td>17.7</td>
</tr>
<tr>
<td>DWD</td>
<td>43</td>
<td>117</td>
<td>65</td>
<td>101</td>
<td>22</td>
<td>123</td>
<td>0.95</td>
<td>82.1</td>
<td>17.9</td>
</tr>
<tr>
<td>Ave</td>
<td>156</td>
<td>87.2</td>
<td>111.8</td>
<td>23.3</td>
<td>135.2</td>
<td></td>
<td>1.15</td>
<td>82.8</td>
<td>17.3</td>
</tr>
</tbody>
</table>

Table 1 shows the productivity by house type based on the floor area and their gross internal area. The dimension of the house was a major determining factor related to the uptime and downtime of the workforce. However, Plot 45 (NWD) significantly had longer uptime and downtime compared to other plots of similar dimension. This longer uptime and downtime was associated to the adverse weather condition which slowed the productivity of the workforce during the kit erect process. The productivity m2 per man hour is based on the gross internal (floor) area divided by the total time in hours with an average productivity m2/man hour at 1.15. Future plots to be developed are now benchmarked against this average productivity value of 1.15 for other development. Overall, the average percentage uptime for the six plots was 83%, but the housebuilder is keen to further improve and maximise efficiency above 90% per plot and this could lead to two or three plots erected per day using the crane lift.
Would improving the housekeeping and material management due to downstream site process delivery (just-in-time) have an impact on productivity?

The delivery of plasterboards, windows and doors onsite were on a 20-tonne commercial lorry and guided to the designated materials delivery point. The inspection of delivered materials is carried out by the site operative (forklift driver) to ensure it matches the order details; that there are no signs of damages during transit; they remain wrapped, protected and placed on pallets and stored on site at the storage area. The plasterboards, doors and windows are then moved around the site by the use of a forklift truck (FLT) to the designated plots where required by the joiners. This minimised the time for operatives to manually move materials across site thus having a positive knock-on effect on improved labour time per plot.

Housekeeping activities related to material movement and distribution around the site from storage to designated plots was carried out using forklifts. This process was carefully planned to ensure no damage was caused to the underside or faces of the plasterboards, windows or doors during conveyance and this process minimised the amount of materials damaged and dumped in the skips. The plastic packaging used for wrapping materials and pallets were adequately stored in designated areas or skips meant either for recycling or reuse thereby keeping the floors and entire site clear of obstructions and promoting a tidy workplace.

The use of the 50-tonne mobile crane had its own safety merits but with differing risk profiles and safety factors to manage and control during the build process (Neumann and Dul 2010; Westgaarda and Winkel 2011; Neitzel, et al., 2001). The study identified that the crane was engaged in lifting activities for a total of 19.5 hours for the six plots with a downtime of 20.5 hours. Only two plots (46 and 43) were identified to have greater uptime than downtime, see Table 2.

### Table 2: Crane Uptime and Downtime in hours for six plots

<table>
<thead>
<tr>
<th>Crane Lift</th>
<th>Plot 48</th>
<th>Plot 50</th>
<th>Plot 46</th>
<th>Plot 45</th>
<th>Plot 44</th>
<th>Plot 43</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uptime Hrs</td>
<td>2.5</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Downtime Hrs</td>
<td>3.5</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Total Hrs</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

The absence of daily/weekly workflow as observed onsite suggests that inadequate planning and scheduling of work packages by the site management team (Choudhry 2017); disorganised delivery arrangement of the timber kits (haulage and stacking) and adverse weather conditions (very high winds) could have a negative impact attaining optimum use of the crane for the timber kit erect. All these factors could potentially have led to risk of delays and disruptions which could accelerate some costs incurred on the project as opposed to the assumptions that OSM technology has the potential to reduce cost, time, defects, health and safety risks and environmental impact, (Venables et al., 2004). Improving the housekeeping and material management due to downstream site processes has improved worker safety, impact on the quality of the build, improved labour productivity and construction cycle time to get the building water tight, and reduction in the construction material waste.
REFERENCES


INDUSTRIALISED CONSTRUCTION
A CONCEPTUAL MODEL TO FACILITATE THE INTERFACE MANAGEMENT OF OFFSITE BATHROOM CONSTRUCTION

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Offsite construction (OC) can help mitigate the interface problems that can sometimes arise in onsite construction. However, interface problems that occur when using offsite bathrooms are considered by industry to be even more detrimental than onsite construction interface problems, if not managed adequately. This research focused on organisational interface management (IM) and its relationship to the successful execution of various forms of offsite bathroom manufacture and installation. The aim of the research was to identify and understand the interconnectivity between the main process and people factors that influence IM in relation to the offsite manufacture and onsite installation of bathrooms in construction. A literature review identified and explored 16 factors that could have an influence on the organisational IM of offsite bathroom construction (OBC). 82 semi-structured interviews were conducted, on eight case study projects. Quantitative data were analysed using frequency tables and the Wilcoxon sign rank test; qualitative data was analysed thematically. A ranking analysis reduced the 16 factors to 9 as the main factors to the IM of OBC. These nine factors comprised six process factors (procurement, design management, supply chain management, health and safety, tolerance and quality) and three people factors (communication, client/design team and the role of the project manager). A conceptual model was consequently developed, holistically integrating these nine factors and their sub-factors, which could consequently be applied to help facilitate the future successful implementation of OBC.

Keywords: interface management, offsite construction, tolerances, modular

INTRODUCTION

The recent Farmer Review (2016) acknowledged that a high level of fragmentation and complexity resides within the UK construction industry and that a more modern approach that embraces offsite construction (OC) would contribute to the wellbeing of the industry. Fragmentation has led to interface management (IM) emerging as an important theme, worthy of additional in-depth research than currently exists (Fellows and Liu, 2012). OC is considered to generate less interface problems in comparison to traditional construction (TC) (Blismas et al., 2006). However, the impact of interface problems within the offsite bathroom process is considered a constraint and disadvantage (Rahman, 2014). Elnaas et al., (2014) argue that IM is an area of research that the construction industry can no longer afford to ignore in respect to OC, and offsite bathroom construction (OBC) in particular. This research therefore focuses on organisational IM in relation to OBC by identifying and exploring the

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relevant process and people factors that contribute to organisational IM, as applied to OBC.

LITERATURE REVIEW

A review of IM and OC literature was conducted to establish the main process and people factors that influence this relationship. However, as no OC completely excludes TC (e.g. groundworks), a review of relevant literature on TC that relates to process and people factors, was also conducted.

Traditional Construction (TC)

TC refers to customs and practices of the construction process that have remained unchanged for a considerable period of time. Moreover, the traditional view of building construction consists invariably of ‘a process of preparing a site, bringing in materials and components, forming materials into elements such as frames, walls and roofs, assembling readymade components, installing services and then finishing ready for occupation’ (Morton, 2008, p. 152). While simplistic in description, it belies the complex processes and the high people content required to complete a project (Durdyev and Ismail, 2016). It is argued that offsite manufactured elements such as structural steelwork, pre-cast sills and lintels and timber roof trusses are components that fit within TC (Gibb, 2001; Davidson, 2009; Goh and Loosemore, 2017; Lawson et al., 2014). Davidson (2009) confirms that offsite has been prevalent in traditional post-war construction not only in the form of component parts but also as whole buildings. Andujar-Montoya et al., (2015) identified supply chain management, lean construction, design management, communication, culture, integration and the role of the project manager as important process and people factors that contribute to the success of a traditional project. Furthermore, Andujar-Montoya et al., (2015) agree with Davidson (2009) that most of the problems associated with low productivity in TC stem from the people involved in the processes, none more so than the role of the project manager. A further survey by Durdyev and Ismail (2016) identified insufficient supervision and the competency of the project manager as a major people factor, which can both hinder and contribute to the success of a project.

Offsite Construction (OC)

Goh and Loosemore (2017) argue that the relationship of the client/design team is an important people factor in the uptake of OC. However, Tam et al., (2007) profess that once the contract is awarded, the client has little involvement in the execution of the project. Ozorhon and Oral (2017) compare the complexity of construction to that of a complex ‘mosaic’, which entails numerous interfaces and boundaries between the many organisations. They highlight the procurement route and design management as two factors which have an impact not only on TC but also OC. Abbasianjahromi et al., (2016) agree, adding that the procurement route and communication between the main contractor and subcontractors/manufacturers should be given the same level of importance as is given to the client/main contractor contract. Akintan and Morledge (2013) posit that the people factor of integration has an impact on the organisational interface between the many stakeholders involved in both traditional and OC. A review of historic OC projects which failed and contributed to its negative perception identified the following as factors that could aid its recovery: design management, lean construction, tolerance, quality and a positive perception (Winch, 2003). Goodier and Gibb (2007) identified cost as a further barrier to the uptake of OC. Blismas et al., (2006) argue that the direct cost comparison between traditional and OC are too
narrow in their approach, such that direct and indirect cost would create a more realistic comparison in the form of whole life costing, emphasising it as a factor in relation to the main themes of traditional, offsite and IM. A comparative study of the manufacturing industry relative to OC identified the following factors as implicit to the execution Gibb (2001): client/design team, whole life cost, quality, supply chain management, leadership, design management and tolerance. Moreover, Blismas and Wakefield (2009) identified design management, tolerance, perception, whole life costing and lean construction as factors that can have an important influence on the success of OC. Smith et al., (2013) emphasised the procurement route as of equal importance to the successful uptake of OC, whereby OC should be given equal standing as TC in the form of procurement used by building standards.

It has been widely accepted that time, cost and quality are the three main guiding factors that drive construction. However, Blismas et al., (2006) argue that when consideration is given to OC, factors such as quality, whole life cost, culture, health and safety and sustainability need to be elevated to the same level of importance as time and cost for the management of the offsite process. Gibb (2001) identified lowest whole life cost as a main driver for the uptake of OC. A survey in China to determine the constraints to OC identified process factors ranging from tolerance, procurement, design management, whole life costing and supply chain management and people factors such as communication, perception, client/designer, culture, perception and integration (Zhai et al., 2014). In Australia, (Blismas and Wakefield, 2009) identified procurement as a major constraint to OC along with people’s perception.

**Interface Management (IM)**

IM has had little exposure in general management literature, and in construction literature in particular. A number of definitions, however, do exist. Morris (1983) identified IM as either ‘static or dynamic’. Stuckenbruck (1983, p 40) identified three distinct interface categories: personal, organisational and system. In the context of project management, Healy (1997, p268) defines IM thus: ‘an interface is a boundary where an interdependence exists across that boundary and where responsibility for the interdependency changes across that boundary’. It could be argued that this definition aligns with Morris’s dynamic relationship. Gibb (2001) also identified three distinct interface categories, with particular relevance to OC: physical, contractual and organisational.

This research has focused on organisational in the pursuit of identifying the relevant process and people factors that contribute to the successful implementation of OBC. The theoretical approach used for this research is founded on ‘Organisational Theory’, due to organisational IM being a major focus used to research the relationship of IM to OBC. Greenwood and Miller (2010 p 78) define organisational theory as ‘an understanding of how to organise people and processes by organisational design, in order to collectively accomplish desired ends’. Luhman and Cunliffe (2013) defines organisational theory as ‘the study of how organisations function and how they affect and are affected by the environment in which they operate’. Both definitions capture the complexity and diversity of organisational theory. Furthermore, Tennant and Fernie (2014) argue that organisational theory is the bedrock theory for most construction management research that relates to people and process issues. This paper offers the following definition: ‘Organisational IM can be defined as an intangible entity, which requires a dynamic approach to the process and people factors
that influence the interdependencies that span between organisations for the good of the project’ (McCarney, 2017). Shan and Zhang (2012) argue that approximately 70% of all problems on construction projects are associated with interface issues. Morris (1983) identified design management as an important process factor to reduce interface problems over the life cycle of a project. However, White and Marasini (2014) add that not only design management but procurement, and integration are factors that require fuller attention in a quest to reduce IM in a fragmented industry. Danby and Painting (2007) argue that communication is an important people factor, none more so than when involved with volumetric interface problems. Furthermore, Fellows and Liu (2012) argue that good communication skills are central to resolving the many conflicts that occur at the organisational boundaries and interfaces, thus promoting a culture of integration, two further people factors that have been previously identified. Pryke (2004) posits that the current procurement routes are a main contributor to the many interface problems that occur on all forms of construction projects. Furthermore, the role of the project manager in the control of interfaces is considered an emerging theory in construction management (Shokri et al., 2016).

The review of literature, focussing on the themes of TC, OC and IM suggested several factors, grouped into 16 process and people factors (Table 1).

**Table 1: Process and People Factors**

<table>
<thead>
<tr>
<th>Process Factors</th>
<th>People Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procurement</td>
<td>Communication</td>
</tr>
<tr>
<td>Supply chain management</td>
<td>The role of the project manager</td>
</tr>
<tr>
<td>Whole life costing</td>
<td>Leadership</td>
</tr>
<tr>
<td>Health and safety</td>
<td>Culture</td>
</tr>
<tr>
<td>Design management</td>
<td>Client and design team</td>
</tr>
<tr>
<td>Lean construction</td>
<td>Perception</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Integration</td>
</tr>
<tr>
<td>Tolerance</td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td></td>
</tr>
</tbody>
</table>

**METHODOLOGY**

The research framework adopted has been founded on the ‘Research onion’ approach (Saunders et al., 2016), with the layers representing the various steps required to form a comprehensive methodology. The first layer reviews alternative philosophies. The pragmatism philosophical approach was adopted, due mainly to the practical nature of the research. The second layer focuses on approaches, namely deductive and inductive. The qualitative and quantitative data collected allowed both approaches to be used in the applied methodology. The third layer strategies offer various options, from archival research through to experimental; this research being based on case study. Eight UK case studies were identified; the criteria for acceptance being that the project required an element of OBC, and that as a group there was a variety of building types. The eight case studies comprised of three new build student
accommodation, two refurbished hotels, one new build prison, one new build office and one military accommodation.

The fourth layer relates to methods of data collection, with this study being mixed methods. The pragmatism philosophy aligns with the mixed method choice of data collection, which allows the inductive and deductive approaches to be incorporated into the analysis. Jogula and Pansiri (2011) argue that doctoral studies that relate to management research should embark on mixed methods research, thus exposing the student to both forms of analysis.

The fifth section relates to time horizons, longitudinal or cross-sectional; this research focused on cross-sectional due to the interview process adopted. A pro forma was created (20 pages), consisting of general questions, interface management, process factors, people factors, and ranking questions around the 16 factors. A pilot study was conducted consisting of six interviews, after which 'leadership' was deleted as it was considered to be included in the role of the project manager. The 82 semi-structured interviews were conducted with 11 No Clients, 31 No Main Contractors, 15 No Subcontractors, 15 No Design Teams and 10 No Manufacturers, all with a level of OC experience. The interviews were carried out face to face either onsite or in the interviewee's company office. The interviews on average lasted for one hour.

The sixth and final layer of data collection and analysis for this research comprises of quantitative and qualitative data. The quantitative data were analysed using Minitab to identify frequency of occurrence. As the data gathered was classed as ordinal, the non-parametric test Wilcoxon Signed Rank test was used to check the significance of the date to the median at the 5% level. The qualitative data were analysed using Thematic Analysis. Each section of qualitative data was analysed manually using MS Excel to identify themes that emanated from the verbal responses applicable to each question.

Analysis and Findings

31 interviewees were from a trade background, 43 from a graduate background and the remaining 8 from a trade/graduate background. The age range was predominantly within 30-39 and 40-49 years. A further analysis of each of the disciplines confirmed on average a ratio of onsite/offsite bathroom experience of 2/1. A standard two-part question was used for each of the factors, utilising a 5-point Likert scale and encouraging comments from the interviewees.

Prior to analysing the data gathered relating to each of the factors, data accrued from the proforma's final three ranking questions, each to establish the order of importance of the factors from a scale of 1 to 5 in relation to the following:

1. 'Offsite forms of bathroom construction'
2. 'IM of traditional bathroom construction'
3. 'IM of offsite forms of bathroom construction'

Weightings were calculated for each factor and ranked in the form of individual tables applicable to statements 1-3, the top ranked factor achieved a score of 5. A cumulative table encompassing the total weightings applicable to each factor amassed from the three tables established a comprehensive order of ranking for all the factors. Design management achieved a total weighting of 573, while culture achieved 21. A review of the total weighted scores for each factor resulted in an obvious arbitrary cut-off point, where the total weighted score was 150 or less, resulting in six factors (lean
construction, integration, sustainability, whole life costing, perception and culture)) not continuing to be analysed. The data applicable to each question/statement in reference to the remaining nine factors, allowed individual frequency tables to be constructed using Minitab from the counts applicable to the five-point Likert scale. The response of each factor to its significance to improving IM in bathrooms, achieved on average a combined ‘agree’/'strongly agree’ percentage of 96% confirming the relevance of the factors to the question. The Wilcoxon signed Rank Test, a non-parametric test, was used to check the significance of the population at the 5% level. The results of the test confirm that the population confirm the significance of the nine factors to improving IM in bathrooms. The second statement/question, which questioned whether the factor had more influence on offsite than onsite bathroom construction achieved a more mixed response. The following factors agreed with the question: procurement, supply chain management, health and safety, design management and quality. However, the following factors disagreed with the statement: tolerance, communication, the role of the project manager and client/design team. The Wilcoxon signed Rank Test confirmed the significance of the part B results at the 5% level, apart from tolerance and client/design team factors which were not significant, the remaining seven were identified as significant at the 5% level.

The additional comments made by the interviewees to the questions/statements were transcribed in MS Excel. Worksheets were created for each question applicable to a factor. The data was analysed manually, adopting a thematic analysis approach to establish relevant sub-factors. The sub-factors were ranked in order of the number of times the sub-factor was repeated by the interviewees. In the interest of brevity, the top two or three sub-factors, applicable to each statement, were analysed collectively with all the sub-factors relevant to the factor. A further discussion of the relevance of the sub-factor to the literature confirmed the relevance of the sub-factor to the factor. A figure was created for each of the individual factors to denote the relevant sub-factors. The final outcome of the data analysis resulted in the formation of a conceptual model (Figure 1), which displayed the cumulative relationship of the established factors to their sub-factors.

CONCLUSION

16 factors, nine process and seven people were established via literature. A ranking analysis, whereby only factors with a cumulative score greater than 150, consequently reduced this to nine, six process and three people, thus highlighting the prominence of process over people factors on the IM of OBC. The main finding of the research is the conceptual model, incorporating the six process factors of procurement, design management, supply chain management, health and safety, tolerance and quality and the three people factors of communication, client/design team and the role of the project manager. The factorial interrelationships were identified via sub-factors; e.g. i) the sub-factor of early communication was attributed to the success of the procurement and project manager; ii) the people factor of leadership, discarded as a result of the pilot study, later emerged as a sub-factor of health and safety; and iii) procurement route was established as a relevant sub-factor to the people factor of the client/design team. It is considered that the aim of the research has been achieved, as the model demonstrates the interconnectivity of the factors, through the identification of the sub-factors identified from the data and analysis. Although the premise of the research was the relationship of IM to OBC, for which the conceptual model should aid the understanding and success of this process, it is reasonable to also propose that the model could potentially be used to advance the success of other forms of OC.
A Conceptual Model to Facilitate Offsite Bathroom Construction

Figure 1: Conceptual model of the relationship of IM to OBC

REFERENCES

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A Conceptual Model to Facilitate Offsite Bathroom Construction


OFFSITE MODULAR CONSTRUCTION CHANGES THE LOCATION OF ACTIVITIES, AS MODULES ARE FABRICATED IN FACTORY CONDITIONS AND THEN ASSEMBLED ON THE CONSTRUCTION SITE. AS THE PUBLIC SECTOR SEeks TO PROMOTE SUCH OFFSITE MODULAR CONSTRUCTION, NEW QUESTIONS ArISE ABOUT HOW TO IMPLEMENT AND SUPPORT REGIONAL INNOVATION SYSTEMS THAT ENABLED THE TRANSFORMATION OF CONSTRUCTION INTO A MANUFACTURING PROCESS. THIS PAPER EXPLORES SOME OF THE KEY CHALLENGES AND SOLUTIONS TO SUPPORT OFFSITE MODULAR CONSTRUCTION IN THE UK. THE ANALYSIS FOCUSES ON OFF-SITE MODULAR CONSTRUCTION ADOPTION IN THE SHEFFIELD AND D2N2 LEPs THROUGH A WORKSHOP, SITE-VISITS, DESK-BASED RESEARCH AND SEMI-STRUCTURED INTERVIEWS WITH MAJOR REGIONAL STAKERS INCLUDING BOTH LARGE AND SMALL/MEDIUM FIRMS AND LOCAL AUTHORITIES. THE FINDINGS IDENTIFY AND CATEGORIZE THE MAIN ISSUES IN FOUR MACRO AREA SUCH AS: SKILLS-SET AND TRAINING COURSES CHANGES, SUPPLY CHAIN CollaborATIONS, INTER-REGIONAL ECONOMIC COLLABORATION, ACADEMIA-LOCAL AUTHORITY COLLABORATION. THE PAPER CONTRIBUTES TO THE REGIONAL AND LOCAL SYSTEM INNOVATION LITERATURE BY SUGGESTING SOLUTIONS TO INFORM AND GUIDE LOCAL POLICY AUTHORITIES TO OVERCOME THE CRITICAL CHALLENGES FACED BY SMALL MEDIUM ENTERPRISES (SMEs) IN THE CONSTRUCTION INDUSTRY.

Keywords: off-site, modular construction, regional innovation, manufacturing

INTRODUCTION

Offsite construction, or modern method of construction, refers to the innovative practice of producing construction components in a manufacturing factory, transporting components to construction sites, and finally assembling the components to create buildings (Pan and Goodier, 2011). Previous studies have analysed both advantages and disadvantages related to the switch from the traditional on-site to the modern off-site modular construction (Pan and Goodier, 2011).

The main benefits are related to reductions in cost, time, safety risks, and environmental impact (Eastman and Sacks, 2008). Considering these benefits, over the last 20 years, many governments have supported the offsite construction as an alternative to onsite construction (Mao et al., 2015). For example, the Hong Kong Buildings Department has implemented two incentive schemes in favour of offsite (Jaillon 2009). In 2017, the UK. Government has also launched its new industrial strategy, supporting offsite construction, aimed at modernising the sector and increasing skills and productivity. However, previous research has also identified several challenges for the adoption of offsite construction. The key issues regard the inability to make changes in the industry, lack of skilled workers, transportation

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constraints, and supply chain integration (Agarwal et al., 2016). Relatively little is known about how construction companies and policy makers can actually implement and support the transformation of the construction industry into a manufacturing process.

This paper aims to identify the main issues and explore novel solutions to support offsite modular construction in the UK. By building upon the recent literature of regional innovation that shifted the attention from national level to local dimension (Parrilli et al., 2010), the analysis focused on regional and local levels. Particularly, we explore the off-site modular construction issues in the Sheffield and D2N2 (i.e. Derby, Derbyshire, Nottingham, Nottinghamshire) Local Enterprise Partnerships (LEPs). We collected and combined both secondary and primary data. The former illustrates an overall picture of the construction industry in Sheffield and D2N2 areas. The latter provides novel insights regarding the main issues in offsite adoption. Our findings contribute to the regional and local innovation system literature by suggesting managerial and policy solutions to overcome the critical challenges faced by Small Medium Enterprises (SMEs) in the construction industry.

Theoretical Background

Innovation in Construction

Offsite construction is a process innovation that changes the practices of producing, assembling and transporting of the traditional onsite construction (Pan et al., 2012). It enhances the building quality, reduces overall costs, and shortens completion time (Cooke and Murray, 2003). However, previous research has also identified several challenges for the adoption of the offsite construction, such as the inability to make changes in the industry, lack of skilled workers, transportation constraints, and to integrate the supply chain (Doran and Giannakis, 2011).

To extend understand of the opportunities and barriers to the adoption of offsite modular construction, this paper draws on work on Regional Innovation Systems (RIS) in an analysis that includes the activities of and connections between large firms, small firms, and local government authorities.

Regional Innovation System

The RIS can be described as "the institutional infrastructure supporting innovation within the production structure of a region" (Fagerberg et al., 2005: 299). The interest in the regional and local dimension has had increasing research attention since the 1990s (Cooke, 1992) as a consequence of the increasing interested of globalization effects, such as the external economies of scale that co-located firms may accrue from the expansion of markets and trade liberalization (Pyke and Sengenberger, 1992). At that time, scholars focused their studies on regional and industrial systems developed in the Western world (Scott, 1988). Remarkable examples are the textile districts in Carpi and Prato (Italy) (Brusco, 1990), the Scientific City of the Southern Paris region (France), and the Silicon Valley complex (United States) (Scott, 1988; Cruz and Teixeira, 2010).

The regional and local approaches sustain that the development of regions is affected by the institutions, local culture, historical paths, and technological trajectories (Audretsch and Feldman, 1996; Cruz and Teixeira, 2010). The underlying assumption of the regional and local perspective is that inter-firm networking, inter-personal connections, and local activities stimulate collective learning and continuous innovation (Asheim and Isaksen, 2002). In addition, policy activities are able to mobilize resources and institutions towards the development of local areas (Storper
and Scott, 1995). To sum up, this research view sustains that firms’ relationship and local policies play a key role in fostering social development and economic growth of local areas (Parrilli et al., 2010). Following this view, our analysis paper explores the managerial and institutional support needed by firms, embedded in a local area, to overcome challenges for the adoption of the offsite modular construction.

**Context and Methods**

To explore how the transformation of construction into a manufacturing process (from onsite to offsite) is enabled at a regional level, this analysis focused on Sheffield and East Midlands regions. These two regions host some of the big players of the UK construction such as Rolls Royce (near Derby), Laing O'Rourke (in Bolsover) and the Advanced Manufacturing Research Centre (AMRC) (in Sheffield). These firms are all involved in modular approaches to off-site in relation to various forms of civil infrastructure, such as housing and small modular reactors.

After an exploratory analysis, the focus of the analysis shifted from a regional level to a local area level. Particularly, we have decided to analyse the Local Enterprise Partnerships (LEPs). The LEPs are business led partnerships between local authorities and local private sector businesses. LEP boards are led by a business Chair and board members are local leaders of industry (including SMEs), educational institutions and the public sector. There are 38 Local Enterprise Partnerships across England.

LEPs play a central role in determining local economic priorities and undertaking activities to drive economic growth and job creation, improve infrastructure and raise workforce skills within the local area. Consequently, in order to collect novel insights regarding the transformation of the UK. The regional level construction industry we chose to study is in the Sheffield City Region LEP and Derby, Derbyshire, Nottingham, Nottinghamshire (D2N2) LEP.

**Quantitative Data Analysis**

This analysis relies on secondary quantitative data in order to have an overall picture regarding Sheffield and D2N2 construction and manufacturing industries. The UK Office for National Statistics (ONS) is the main resource for collecting quantitative data. Since this paper aims to explore how to enable the transformation of construction into a manufacturing process, the first step of the analysis focuses on statistical information regarding manufacturing and construction firms in LEPs (which are database selection, geography selection, data selection, employment size band, size selection and legal status selection). We have selected "UK Business Counts - enterprises by industry and employment sized band (2010 to 2018)" as the database, which has been compiled from the Inter Departmental Business Register (NOMIS, 2019). When looking at the employee data, key steps were selecting database, geography, data, employment, industry, and percent. "Business Regional and Employment Survey: open access" was selected as the main database, which counted the amounts of employees based on where they work (NOMIS, 2019). In order to have a comprehensive understanding of both manufacturing and construction industries the analysis includes core and "non-core" activities listed in the NACE classification. The following key words have been selected: "manufacturing", "construction", "manufacture of clay building materials", "manufacture of cement, lime and plaster", "manufacture of other special-purpose machinery".
Qualitative Data Analysis

In order to collect novel insights regarding the main issues in offsite adoption, the research team have organized and conducted a workshop, site-visits, and semi-structured interviews with major regional stakeholders including large and small medium firms, and local authorities. The sample of the analysis has been chosen by following a purposive sampling strategy. The Advanced Manufacturing Research Centre (AMRC) In Sheffield has been selected because it is considered one of the world-leading research and innovation manufacturing centres. The key policy informants (e.g., senior managers of the Sheffield City Region LEP and D2N2 LEP) have been identified by adopting a snowballing approach. The data collected from Sheffield City Region (SCR) and D2N2 are illustrated in Table 1.

Table 1: Data collection in the Workshop and in the Sheffield City Region and D2N2 (i.e. Derby, Derbyshire, Nottingham, Nottinghamshire) LEP areas

<table>
<thead>
<tr>
<th>Details</th>
<th>Durations</th>
<th>Records/documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop Event: Modular Offsite Construction and Digital Manufacturing</td>
<td>Group 1 in Breakout Session</td>
<td>0.5 hour</td>
</tr>
<tr>
<td></td>
<td>Group 2 in Breakout Session</td>
<td>0.5 hour</td>
</tr>
<tr>
<td></td>
<td>Group 3 in Breakout Session</td>
<td>0.5 hour</td>
</tr>
<tr>
<td>Interviews Semi-structured Interviews</td>
<td>Leadership Graduate Engineer</td>
<td>1.5 hours</td>
</tr>
<tr>
<td></td>
<td>Director at Explore Manufacturing</td>
<td>0.5 hour</td>
</tr>
<tr>
<td></td>
<td>D2N2 LEP Lean Adviser</td>
<td>1.5 hours</td>
</tr>
<tr>
<td></td>
<td>D2N2 LEP</td>
<td>1 hour</td>
</tr>
<tr>
<td></td>
<td>D2N2 LEP</td>
<td>1 hour</td>
</tr>
<tr>
<td>Informal Interviews</td>
<td>Sheffield City Region Explore Manufacturing</td>
<td>8 hours</td>
</tr>
<tr>
<td></td>
<td>Sheffield City</td>
<td>1 week</td>
</tr>
<tr>
<td></td>
<td>D2N2 Derby</td>
<td>2.5 days</td>
</tr>
<tr>
<td></td>
<td>D2N2 Nottingham</td>
<td>2.5 days</td>
</tr>
</tbody>
</table>

The workshop was held at the Advanced Manufacturing Research Centre (AMRC) In January 2019. This workshop aimed to invite local small-to-medium sized enterprises (SMEs) and understand how SMEs engage as well as what support they need to take up off-site modular construction. The attendees were separated in three groups (each of about 10 people) and these groups discussed about the issues faced by regional SMEs to engage in modular construction. Guide questions included "how can you/SMEs build capacity to enhance the productivity of the supply chain for modular construction?", "what supports do you need to engage in modular construction?", and "how can you use digital technologies in modular construction?". The questions aimed to explore how off-site modular construction firms develop system architecture as well as how local organizations support regional innovation. Interviewees were able to discuss freely on the basic semi-structured questions.

Semi-structured interviews with senior employees in leading off-site construction at SCR and D2N2 were undertaken to understand the interrelationships between the main participants in off-site modular construction and the relationships between construction firms and other parties (e.g. governments, universities, non-construction firms). Interviews were audio recorded and transcribed. The analysis of the text-
based data relies on a coding process (Marshall and Rossman, 1990) which aims to cluster related words or phrases mentioned by the interviewees in order to develop categories. Each category is identified by a label that explains the meaning of the cluster words or phrases. The analysis has been conducted by adopting NVivo. NVivo, a Qualitative Data Analysis (QDA) Computer software package that allows researchers to discover and map tendencies, recognize themes and derive conclusions. The aim of Nvivo is to create "nodes" that highlight key words, clusters of words, or phrase in the text. The authors of this paper have adopted the NVivo "codes" to support the data coding.

The first author of the paper has also spent one-week in Sheffield City Region and one-week site visit in D2N2 to collect more insights regarding their history and regional innovation system evolution.

FINDINGS

The analysis aimed to identify challenges and solutions to support offsite modular construction in the UK. The secondary quantitative analysis provides an overview of Sheffield and D2N2' geographic location, and an accurate and deep understanding of firms' characteristics and labour demand in the construction and manufacturing industries. The qualitative analysis, instead, reveals the actual issues faced by construction companies in adopting the offsite modular construction and provides novel solutions to inform policy makers.

Quantitative Analysis

The first part of the quantitative analysis aims to understand the geographic location of both Sheffield City Region and D2N2. The analysis shows that the two regions overlap each other. Figure 1 illustrates that Sheffield City Region (in red) includes Sheffield, Barnsley, Rotherham, and Doncaster, and four local government districts in Derbyshire (in green- Derbyshire Dales, Chesterfield, Bolsover, and North East Derbyshire) And one district in Nottingham (in blue-Bassetlaw).

Figure 1: Locations of SCR and D2N2 (ONS, 2019)

The second part of the analysis provides a general overview about the firm size distribution and labour demand fluctuations in Sheffield and D2N2 LEPs.
According to the ONS (2017), in Sheffield City Region LEP there are 8,020 construction firms, including 7,495 micro-sized enterprises (0-9 employees), 460 small-sized enterprises (10-49 employees), 55 medium-sized enterprises (50-249 employees), and 10 large-sized enterprises (250+ employees). D2N2 contains 3,750 micro-sized construction enterprises (0-9 employees), 980 small-sized enterprise (10-49 employees), 295 medium-sized enterprises (50-249 employees), and 50 large-sized enterprises (250+ employees).

The NOMIS (2019) - Official Labour Market Statistics- reports that, from 2005 to 2017, in Sheffield, the ratio of employees in construction and total employees reduced from 11.4% to 7.9%, whereas it decreased from 9.1% to 8.0% in D2N2.

Since the offsite construction predicts a transformation of construction into a manufacturing process, the third section of the analysis focuses also on the manufacturing industry in Sheffield City Region and D2N2. The manufacturing industry in both areas are relatively prosperous. There are 4,080 manufacturing firms in SCR, and 5,110 manufacturing firms in D2N2, which are more than the average amount of manufacturing firms in the LEPs (3,335 manufacturing firms) (NOMIS, 2019). The number of employees in manufacturing firms is highest in D2N2 except Leeds City Region (NOMIS, 2019). At D2N2, 4,225 employees work in construction-related manufacturing companies, which is almost twice as large as the South Eastern region with the second-highest number of employees (NOMIS, 2019).

According to a Sheffield City Region report, the city's economic growth plan aims to exploit the manufacturing advantage developed over time (Sheffield City Region, 2014). Sheffield, indeed, has an international reputation for metallurgy and steel-making. This industry is based on the Sheffield local resources such as iron, coal and water power supplied by the local rivers. The D2N2 LEP report (2017) Describes D2N2 as on one of the largest industrial bases in the UK (D2N2 LEP, 2013: 7). In D2N2, indeed, are based some of leading manufacturing companies, such as Rolls Royce and Toyota. D2N2 LEP aims to rely on its industrial competitive advantage to develop a place-based approach to deliver the Industrial Strategy (D2N2 LEP, 2017).

Qualitative Analysis

This section summarises the insights collected from the workshop at the Advanced Manufacturing Research Centre (AMRC) In January 2019 and from the interview at D2N2 LEP that took place on May 2019. The workshop aimed to identify the challenges faced by SMEs in adoption modular offsite construction and explore effective solutions to inform policy makers. The interview at the D2N2 LEP looked at the policy's perspective regarding the regional innovation in construction. The result of the analysis has identified four main categories such as: skills-set and training courses changes, supply chain collaborations, inter-regional economic collaboration, academia-local authority collaboration. Table 2 illustrates the relationship between text-based data and category labels.

Skills-set and training courses changes

The adoption of the offsite modular construction and of novel digital technologies, such as Geographic Information System (GIS) And Building Information Modelling (BIM), require a job skills-set change. During the breakout sessions of the AMRC workshop, the authors aimed to explore this issue. The result of sessions revealed that construction companies are not able to predict the job skills needed to face the challenges in the industry. Construction companies are looking for young people with
less specialised skills who can adapt to changes. However, the currently labour supply does not fit with the current demand.

Table 2: Quotes and category labels

<table>
<thead>
<tr>
<th>Quotes</th>
<th>Categories</th>
<th>Macro categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>“With a modular reason... it makes all the tasks simpler, so a person can be able to cover all the trades. So, in that way, we need a person with multi-skills” (AMRC workshop).</td>
<td>Multi-skilled employees/workers</td>
<td></td>
</tr>
<tr>
<td>“There are no multi-skills courses out there...the framework that we have to work and deliver probably doesn’t meet what you need, so it’s going to need a new standard” (AMRC workshop).</td>
<td>Lack of multi skills training courses</td>
<td>Skills-set and training courses changes</td>
</tr>
<tr>
<td>“To motivate young people who already 20s, they sought of explained it... they can advance their digital skills...and before they are 30, they are going to be quite senior positions” (AMRC workshop).</td>
<td>Professional and fast-moving career</td>
<td></td>
</tr>
<tr>
<td>“I think about one of the most successful things that I saw is from a large company (anonymized by the research team) that does a kind of speed dating for SMEs... all of their buyers are present in a room and then SMEs show where they are...” (AMRC workshop)</td>
<td>Orchestrated collaboration</td>
<td>Supply chain collaborations</td>
</tr>
<tr>
<td>“So, people in supply chain are in partners rather than competitors” (AMRC workshop)</td>
<td>Coopetition vs competition</td>
<td></td>
</tr>
<tr>
<td>“We recognize the need to do more work across the LEP geographies and overlapping functional economies moving forward” (D2N2 LEP Informal interview).</td>
<td>Inter-regional economic relationship</td>
<td>Inter-regional economic collaboration</td>
</tr>
<tr>
<td>“We have invested in advanced manufacturing building of our local University (Nottingham)... we probably need to just look over work construction features in the portfolio of innovation and projects that we that we have supported” (D2N2 LEP semi structured interviews).</td>
<td>Exploitation of the past relationship</td>
<td>Academia-local authority collaboration</td>
</tr>
<tr>
<td>“To try to understand construction a little better and its relationship with innovation... it (funding program) was looking for all three of our local universities collaborated to try to support innovation over the key sectors” (D2N2 LEP semi structured interviews).</td>
<td>Collaboration between local institutions and universities</td>
<td></td>
</tr>
</tbody>
</table>

By exploring the causes reasons linked to the shortage of labour supply, the participants at the AMRC workshop sessions highlighted the need for training courses to educate young people in a wider range of skills than in the past. According to the participants of the AMRC workshop sessions, another reason linked to the shortage of labour supply is that most of the young people are not aware that working in construction industry allows them to pursue a fast-career job. The mismatch between labour supply and demand is recognized as one of the critical challenges to face the transformation of the construction industry.

Supply chain collaborations

The AMRC workshop aimed also to explore novel managerial strategies to supports SMEs in facing the transformation of the construction industry. The attendants of the breakout sessions highlighted the willingness and the need for collaborative
relationships with other SMEs in the supply chain and larger firms. Particularly, there is a general agreement that a single small firm cannot make any change but believe in the advantages of networking. In order to do so, SMEs are willing to adopt cooperative rather than competitive market strategies.

**Inter-regional economic collaboration**

Since D2N2 is considered as a strategic regional trading area, which supports movement of products, materials and labour across regional boundaries, we have conducted interviews with a project manager from the D2N2 LEP to understand the policy strategies to support construction and manufacturing companies of the area and the collaborative strategies across regions and LEPs. Our research shows that, so far, the D2N2 LEP strategic plan has mainly focused on a local perspective, however there is a willingness to support collaborations among LEPs.

We have also conducted a semi-structured interview at the D2N2 LEP, to explore the effects of the transformation of the construction industry in a manufacturing process. Our findings show that the adoption of offsite construction may have a crucial impact for the regional GVA. This because many construction activities will be moved from on-site locations to factories located across regions.

**Academia-local authority collaboration**

The authors of the paper have explored at the AMRC workshop and with semi-structured interviews with D2N2 LEP managers the relationship between industry, universities, and policy institutions. Findings from the interview with D2N2 LEP shows that local authorities rely on collaboration with local universities. The adopted strategy focuses on the exploitation of the local resources to develop new knowledge. D2N2, in particular, supports local universities to understand how to support and implement innovation in the construction industries. Evidence from the AMRC event shows also that large construction firms rely on established collaborations with universities and technologic institutions. Instead, small medium enterprises are looking for strategic support from universities or a big player to develop and adopt new technology. Leading construction firms have already a long-term relationship with universities or technology institutions. For example, AMRC, located in Sheffield City, plays a crucial role for developing new technology and pushing regional innovation. More networking with technical institutions and higher educations would support the innovation process at regional level.

**DISCUSSION AND CONCLUSIONS**

This study provides evidence on the key challenges and solutions to support offsite modular construction in the UK. The analysis focuses on off-site modular construction adoption in the Sheffield and D2N2 LEPs. We have classified the key issues in 4 macro categories such as skills-set and training courses changes, supply chain collaborations, inter-regional economic collaboration, academia-local authority collaboration. Our findings reveal managerial and policy solutions to support construction companies. In line with the regional innovation literature (Fagerberg et al., 2005), our findings show also that the development of the regions is affected by the historical paths and institutions (Cruz and Teixeira, 2010). Our findings confirm also that inter-firm's relationship, especially for SMEs, is considered as key strategic choice to support regional development. This study reports also the importance of the collaboration across regional boundaries. This paper has a few limitations that might represent avenues for future research. First, our research considers two of thirty-eight UK LEPs, further research could explore issues and challenges across UK. Second,
our results provide a static overview of the current picture of the construction industry, future research could extend the results by analysing in longitudinal perspective what support SMEs need to enable the transformation of construction industry.

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PERFORMANCE MANAGEMENT
EFFECTS OF PROJECT MANAGERS’ GOAL ORIENTATION ON PROJECT PERFORMANCE

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Although recent research demonstrates the importance of goal orientation in team performance, it has largely neglected the effects of leader goal orientation in project team. This study investigates whether and how project managers’ goal orientation affects project outcomes. Based on existing literature, we hypothesize that three dimensions of project managers’ goal orientation (employee development orientation, demonstration of ability orientation, and avoidance of failure orientation) are associated with project performance when mediated by team cohesiveness and knowledge sharing. Structural equation modelling (SEM) is conducted based on a sample of project managers and team members across 226 projects in Chinese construction industry. The empirical findings confirm that employee development orientation and demonstrating ability orientation of project managers can have a direct positive influence on team cohesiveness and knowledge sharing that can indirectly lead to improved project performance, when mediated by team cohesiveness. However, within the Chinese context, there was no significant negative impacts of avoiding failure orientation on these outcome variables. By uncovering how project managers’ goal orientation generates impact on project outcomes, we believe it will provide a deeper understanding into how project managers might better lead project team to attain desired project performance outcomes.

Keywords: goal orientation, team cohesiveness, knowledge sharing, performance

INTRODUCTION

Many studies have suggested that interpersonal skills are more important to project outcomes than technological tools (Chiocchio and Hobbs, 2014). Based on Thamhain’s (2013) investigation, dealing with people in project situations is often counted as the most challenging issue for project managers. Indeed, inadequate support or inappropriate behaviour patterns of project managers may fail to guide, motivate or coordinate project team members, and subsequently lead to project failure. Better understanding the skills of project managers that yield desired outcome is now required.

Since Turner and Müller (2005) suggested leadership style as a critical success factor on projects, a number of scholars have attempted to verify the impact of various leadership styles on project outcomes (e.g., Yang et al., 2011). According to their findings, project managers have a high degree of influence on their teams and thereby outturn performance. Yet, it fails to explain how they lead to particular outcomes.

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Achievement goal theory indicates that goal orientation embodies leader’s achievement priorities and patterns of behaviour (Dragoni, 2005). By setting up goals, prioritizing working processes, establishing performance directives, and structuring team member’s attention, leaders exert a strong situational influence over subordinates. In general organization, leader goal orientation and its outcomes have been investigated, whereas, little consideration has been given to project-based organizations. Moreover, differences may exist in the context of Chinese culture when employing goal orientation theory which derived from western studies. Therefore, the emphasis of this study is on project managers’ goal orientation and how that influences project outcomes directly as well as indirectly through intervening variables within the Chinese context.

In particular, we address two key issues in order to examine the relationship between project managers’ goal orientation and project outcome. The first question of this study is “What is the relationship between project managers’ goal orientation and project performance?” Dainty et al., (2004) have suggested that goal orientation is an essential human skill of project managers and a predictor of project performance. However, leader goal orientation contains several subcomponents. Prior studies merely examined the overall leader goal orientation rather than exploring the impact of lower level components. A deeper investigation on the effect of different project managers’ goal orientations allows both researchers and practitioners to have a better understanding of the relationship between the role of the project manager and project outcome.

The second research question of this study is “How do project managers orient team members to fulfil project tasks?” To date, the processes through which project managers’ goal orientation predicts project outcomes have remained relatively unexplored. Thus, we aim to uncover the mechanisms to provide evidence on how project managers’ goal orientation affects project outcome. Scholars like Gupta et al., (2010) highlighted the need for team process-related variables as an influence on leadership and project outcome. Following up on their calls, this research focuses on two important team processes—team affective process and team behavioural process—to reflect how team members feel and act through socioemotional and task-focused interaction. Previous research has suggested that leaders motivate followers by shaping shared affect within teams, for example, team cohesiveness (Pillai and Williams, 2004). Team cohesiveness can be thought of as a process that reflects members’ attraction and motivation to remain united and their commitment to the task. We consider the role of team cohesiveness as a team affective process and assume it might give clues on how team members react emotionally to project managers’ goal orientation. Secondly, in addition to the importance of affective process, it is also possible that leaders realize better team performance by shaping beneficial behaviours within teams. Knowledge sharing is a behavioural process for disseminating and exchanging task-relevant information with each other. In project teams, sharing knowledge can increase project work efficiency and effectiveness. As such a critical team behavioural process, it is necessary to investigate how project managers’ goal orientation motivates team members sharing knowledge to enhance project performance. In sum, we examine if an intervening mechanism exists and how project managers’ goal orientation aids or impedes team cohesiveness and knowledge sharing behaviour, which in turn are reflected in project performance.
Theory and Hypotheses

Leader goal orientation is defined as the pattern of cognition and action that result from an individual’s being as well as external environment to initiate work-related behaviour, and to determine its form, direction, intensity, and duration. According to Dragoni (2005), leader goal orientation differs from individual or team goal orientation. In a refinement of goal orientation theory, Dragoni (2005) divides leader goal orientation into three categories: employee development orientation, demonstrating ability orientation, and avoiding failure orientation. Leaders who exhibit employee development orientation pay close attention to team members’ self-development. They usually set up specific learning goals and provide various developmental activities to convey their learning commitment. Also, they stress the importance of being innovative and encourage employees to use new work approaches. Leaders who prioritize demonstrating ability orientation strive for excellent performance by employing outperformers. This type of leader explicitly focuses on enhancing team image and proving team accomplishments. Leaders who prefer avoiding failure orientation concern to those who made mistakes or showed subpar performance. In their perception, making no mistakes is the most effective way to high performance. Our study endorses this classification and further apply it to project managers’ goal orientation in the Chinese project context. The conceptual model is presented in Figure 1.

Figure 1: Conceptual model of the present study

The Relationship Between Project Managers’ Goal Orientation and Project Performance

Organizational studies have verified that leader goal orientation is related to team performance (e.g., Huang et al., 2017). Leaders who take time to understand how their personal thoughts, motivations, and behaviours affect followers are integral to organizational success. From project perspectives, project managers with an employee development orientation expect to finish project goals by enhancing team members’ capability. These project managers model the importance of learning and value team growth and development. For example, they implement various training courses for work performance improvement and encourage experimentation with new work approaches for innovative skill development. Barber and Warn (2005) suggested project benefits from those innovative methods and improved skills of project members. Guided by employee development goal orientation, team members have a strong motivation to develop their competence and exhibit a higher level of task performance. Porter and Latham (2013) highlighted that a learning goal
orientation was crucial to performance, especially when a team is operating in an uncertain environment. Thus, we propose the following:

**H1:** Project managers’ employee development orientation is positively associated with project performance.

Project managers with a demonstration of ability orientation pursue high project performance by assigning task to those outperformers. Such project managers underline the importance of promoting a positive image of project team. To obtain recognition from outside and their leaders, team members are motivated to enhance their abilities and prove themselves. Theory and evidence are unclear concerning the link of leader demonstrating ability goal orientation and team performance. However, in a conceptual study, Dragoni (2005) proposed a positive relation between leader demonstration of ability orientation and group performance. Since leader goal orientation is viewed as a team-level variable, we expect some similarities between leader goal orientation and team goal orientation. Previous researchers have found that a performance climate could motivate team members to show superior accomplishments, such as project cost saving or early completion (Caniëls et al., 2019). Therefore, our hypothesis is stated as follows.

**H2:** Project managers’ demonstration of ability orientation is positively associated with project performance.

Project managers with an avoidance of failure orientation attain project objectives through managerial interventions which prevent from mistakes and errors. Less time and efforts are put on exploring new approaches to enhance performance. Also, they usually react negatively to challenging tasks. In their perception, ‘do things right’ weighs more than ‘do their best’. When such conservative leaders interact with team members, they may intentionally instil members with a value of avoidance and create a passive team climate (Huang et al., 2017). Team members realize that committing errors is not allowed, and thus, unwilling to engage in experimental activities. These could decline team efficacy and result in low capability for team members to cope with a complex project. However, current projects are more complex than before because clients are becoming more sophisticated and the required products are demanding for more innovation (Zhang and Ng, 2012). Project managers who simply focus on avoiding failure may not adapt to the changing environment. In fact, Huang et al., (2017) concluded that leader avoidance orientation was negatively related with overall team performance. Accordingly, we hypothesize in a project work context, project managers with an avoidance of failure orientation are likely to reduce project performance.

**H3:** Project managers’ avoidance of failure orientation is negatively associated with project performance.

The Mediating Roles of Team Cohesiveness and Knowledge Sharing

Research on team cohesiveness has shown its mediating effect on the relationship between leadership and team performance. Beersma et al., (2013) theorized that leaders’ achievement priority determined how team members interact, which in turn affected team cohesiveness and performance. Conforming to this argument, we posit that project managers’ goal orientation would nurture or weaken team cohesiveness, which, in turn, would influence project outcome. For leaders who rely on employee development approach, they help create learning mechanisms that collaboratively gather members together. By the virtue of uniqueness and temporality, project teams
originally are not equipped with sufficient knowledge and experience. In this environment, followers concentrate more on cooperation to tackle task problems. Learning therefore enhances the propensity of a project team to stick together and coordinate team efforts to achieve common project goals. Supporting these perspectives, Wang et al., (2006) verified that in an information system project team, commitment to learning can facilitate project success by augmenting group cohesion. For leaders who have a demonstration of ability orientation, a strong performance goal orientation enables team members to become more committed to their work and more unite to produce high performance. In comparison, for leaders who showing avoidance of failure orientation, they pay significant attention on members’ incapability. When project managers are consistent in their practices over time, team members become more frustrated and fear of negative evaluations by others. In this way, project managers inhibit morale building and break the cohesion in teams, and thereby lack the positive effects of project performance. Therefore, we proposed the following hypothesis:

H4: Team cohesiveness will mediate the relationship between project managers’ goal orientation and project performance.

Empirical studies have shown evidence that knowledge sharing could be a mediator in the leadership-performance model (e.g., Choi et al., 2016). It is obvious that leaders with developmental orientation help employees become knowledge seekers. Accordingly, these followers share task-related knowledge with their co-workers. The knowledge sharing behaviors in turn may promote team performance. Additionally, this type of leaders highlights the improved skills of team members. This increases the motivation for team members to share and acquire knowledge from their colleagues. Leaders with demonstrating ability orientation may provide opportunities for team members to prove themselves by sharing valuable knowledge. In this case, invalid information decreases and therefore contributes to informing correct project decisions. In contrast, leaders with avoiding orientation may facilitate self-protective processes that convert team members to knowledge hiders. This could inhibit knowledge sharing and consequently result in lower performance. On the other hand, project performance is affected both by leadership and knowledge sharing activities. Project team featured by heterogeneity requires team members to share their diverse professional skills and expertise to collaboratively seek effective solutions and enhance work efficiency. In the knowledge sharing process, project managers with an employee development or demonstrating ability orientation may play as a promoter, while an avoidance failure project manager may act as an interrupter. Their roles eventually influence team efforts toward project goals. Thus, we advance the following hypothesis.

H5: Knowledge sharing will mediate the relationship between project managers’ goal orientation and project performance.

Methodology

Data Collection

To test our research hypotheses, a questionnaire survey was employed to gather information from project professionals in the Chinese construction industry. This was based on a range of varied surveys developed by Dragoni (2005), Lee et al., (2011), Zhang and Ng (2012), and Demirkesen and Ozorhon (2017). We have distributed a total 310 questionnaires via social networking software. All the respondents were
required to have site experience, including project managers, project engineers, department managers, and skilled workers. A total of 256 responses were returned, representing a response rate of 82.6%. After eliminating questionnaires with the same answers or unmatched data, 226 were considered as usable and valid for data analysis.

**Measures**

All constructs were measured with validated multi-item scales derived from previous research and used a five-point Likert-type scale (1—“Strongly Disagree” and 5—“Strongly Agree”).

Project managers’ goal orientation incorporating employee development orientation, demonstration of ability orientation, and avoidance of failure orientation was measured with 13 items taken from Dragoni (2005). Team cohesiveness was assessed by using the 4 items from the Lee et al., (2011) scale. Knowledge sharing was measured by a four-item scale from Zhang and Ng (2012). Project performance was adopted by Demirkesen and Ozorhon (2017) which included 5 items.

**Common Method Bias**

Since the questionnaire employed were self-reported, common method bias may exist. We carried out a confirmatory factor analysis to compare the model fit of the original measurement model with the one where all observed variables loaded on a common latent factor (CLF). The results indicated that the original measurement model fit ($\chi^2=580.650$, df=284, $\chi^2$/df=2.045, CFI=0.927, IFI=0.928, RMSEA=0.068) was similar to the one-factor model fit (Model with CLF: $\chi^2=546.562$, df=283, $\chi^2$/df=1.931, CFI=0.935, IFI=0.936, RMSEA=0.064). Therefore, common method bias is not a serious concern in the present study.

**Reliability and Validity Test of Measurement Model**

As shown in Table 1, we used Cronbach’s $\alpha$ to estimate each construct reliability and the value ranges from 0.731 to 0.929, which are over the threshold of 0.70. The results imply a high degree of the internal consistency of the measurement items. We further assessed the convergent validity to evaluate the relative convergence among item measure, which is reflected by the value of standardized factoring loadings, composite creditability (CR), and average variance extracted (AVE). As reported by Table 1, all item loadings were greater than the benchmark of 0.70, the CR values for the six constructs range from 0.848 to 0.945, which satisfy the cut-off of 0.70. The AVE values for each construct range from 0.651 to 0.811, which are larger than the critical value of 0.50. The results confirmed a favourable convergence for all the constructs.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Loading</th>
<th>Cronbach’s $\alpha$</th>
<th>CR</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employee development orientation</td>
<td>0.761-0.864</td>
<td>0.910</td>
<td>0.930</td>
<td>0.690</td>
</tr>
<tr>
<td>Demonstration of ability orientation</td>
<td>0.782-0.866</td>
<td>0.822</td>
<td>0.883</td>
<td>0.654</td>
</tr>
<tr>
<td>Avoidance of failure orientation</td>
<td>0.748-0.868</td>
<td>0.731</td>
<td>0.848</td>
<td>0.651</td>
</tr>
<tr>
<td>Team cohesiveness</td>
<td>0.895-0.920</td>
<td>0.929</td>
<td>0.895</td>
<td>0.682</td>
</tr>
<tr>
<td>Knowledge sharing</td>
<td>0.864-0.915</td>
<td>0.922</td>
<td>0.945</td>
<td>0.811</td>
</tr>
<tr>
<td>Project performance</td>
<td>0.792-0.872</td>
<td>0.872</td>
<td>0.909</td>
<td>0.666</td>
</tr>
</tbody>
</table>
Hypothesis Testing

Prior to testing the hypotheses, we used goodness-of-fit indices to evaluate how well the model fits the data. Two absolute fit indices ($\chi^2$/df and RMSEA) and two incremental fit indices (CFI and IFI) were employed to assess the current model. The chi-square per degree of freedom ($\chi^2$/df) represents 1.726 ($\chi^2=609.281$, df=353), which is less than the stricter threshold ratio of 3.0. RMSEA is 0.057 and a value lower than 0.08 signifies a good fit. CFI and IFI are 0.940 and 0.941, respectively. A cut-off criterion of CFI and IFI is greater than 0.9. Therefore, our structural model is plausible for further testing.

As displayed in Figure 2, the results indicate that employee development orientation (Coeff. = 0.10, p=0.260), demonstration of ability orientation (Coeff. = 0.12, p=0.209), and avoidance of failure orientation (Coeff. = 0.07, p=0.357) do not directly affect project outcome. Thus, H1, H2, and H3 were not confirmed. In addition, we found that employee development orientation and demonstration of ability orientation have significant positive effects on team cohesiveness and knowledge sharing. In contrast, avoidance of failure orientation was found to have limited effect on team cohesiveness and knowledge sharing. The implication of the results also proves that team cohesiveness and knowledge sharing can significantly increase on project outcome.

Note: *p<0.05; **p<0.01; ***p<0.001; ns represents non-significant.

Figure 2: Results of the direct effects

Our mediation analysis followed the procedure of Zhao et al., (2010). Since the path coefficients of avoiding failure orientation, team cohesiveness, knowledge sharing, and performance were not significant, we discarded the antecedent of avoiding failure orientation. We further assessed the mediating effects through bootstrapping with 5000 samples and a 95% bias-corrected confidence interval. Bootstrapping is a powerful method for multiple mediators’ analysis, and it has no restrictions on the normality of the sampling distribution.

As can be seen in Table 2, the findings provide empirical evidence that team cohesiveness completely and positively mediates the effects on project outcome of employee development orientation (Coeff. = 0.255, p=0.012) and demonstrating ability orientation (Coeff. = 0.181, p=0.036). Therefore, H4 was partially supported. Additionally, the indirect effects of employee development orientation and demonstrating ability orientation on project outcome through knowledge sharing has
been proved not significant. Thus, the expected mediator of knowledge sharing for H5 was not substantiated.

Table 2: The results of testing mediation effects on project performance

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Indirect effect</th>
<th>P value</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employee development orientation→ team cohesiveness→ project performance</td>
<td>0.255</td>
<td>0.012</td>
<td>(0.066, 0.525)</td>
</tr>
<tr>
<td>Employee development orientation→ knowledge sharing→ project performance</td>
<td>0.066</td>
<td>0.151</td>
<td>(-0.02, 0.273)</td>
</tr>
<tr>
<td>Demonstration of ability orientation→ team cohesiveness→ project performance</td>
<td>0.181</td>
<td>0.036</td>
<td>(0.011, 0.500)</td>
</tr>
<tr>
<td>Demonstration of ability orientation→ knowledge sharing→ project performance</td>
<td>0.041</td>
<td>0.149</td>
<td>(-0.011, 0.217)</td>
</tr>
</tbody>
</table>

DISCUSSION

Theoretical Implications

The purpose of this study was to understand the effects of project managers’ goal orientation on project outcome. We did so by rigorously testing the measurement model and statistically analyzing the structural model. The findings provide answers we primarily proposed. First, we hypothesized that employee development orientation (H1), demonstration of ability orientation (H2), and avoidance of failure orientation (H3) would affect project performance. However, the results fail to validate any of these relationships. Second, we attempted to unveil the team process-mechanisms connecting project managers’ goal orientation and project outcome. Of the three dimensions of project managers’ goal orientation, employee development orientation and demonstration of ability orientation were found to have significantly positive effects on team cohesiveness and knowledge sharing which, in turn, influence project outcome. Consistent with previous findings of Beersma et al., (2013) and Lee et al., (2010), we provide support for the relationship of leader goal orientation with team cohesiveness and knowledge sharing in project settings. This indicates that team members are more likely to affectively or behaviorally interact with each other when project managers pay more attention on learning or proving. Such positive attitude transmits to team members and results in higher performance on projects. In contrast to our expectation, avoidance of failure orientation (H3) only has limited impact. This result contradicts with most of empirical studies. A plausible explanation is the discrepancy when western leader goal orientation theory applies into Chinese project context. Project managers in China are inherently conservative and they take avoiding failure as their basic job. Meanwhile, team members have already adapted to this goal orientation type before they join the team due to the Chinese culture. Therefore, it is not surprising that avoidance of failure orientation would not strongly affect team members’ feeling and action.

Second, we argued that there may exist two paths associating project managers’ goal orientation with project performance. The mediation analysis provides evidence that project managers’ developing employee orientation and demonstrating ability orientation enhance project performance by creating emotional interaction among team members (H4), supporting Wang et al.’s (2006) argument regarding the mediating role of team cohesiveness. Another team behavioral process does not pass the mediation test (H5). In sum, three antecedents excluding avoidance of failure orientation, when controlling for each other, impact project performance only through team cohesiveness. This implies that project managers with employee development
orientation and demonstrating ability orientation have the ability to generate beneficial outcomes by uniting and harmonizing team members.

**Practical Implications**

The findings of this study may provide a starting point for developing and improving the leadership competency of project managers. From a team management perspective, the choice of project managers is an essential factor when organizing a project team. The empirical results allow managers to evaluate and apply team management strategies appropriately to produce beneficial project outcomes. Our study confirms that managers who focus on employee’s learning and innovation ability should not be discounted because they could lead project team to high cohesiveness and performance. The more improvement of team members’ professional skills, the more intellectual capital of the superior organization to obtain. Although it may not be feasible to stress employee development in all projects, we recommend that managers could adopt flexible goal orientations. In addition, project manager should be aware of the importance of constructing team members’ sense of belonging, which can greatly boost project performance.

**CONCLUSIONS**

This study endeavours to investigate the relationship between project managers’ goal orientation and project outcome and how project managers orient team members to achieve project outcome through team processes in the Chinese cultural context. A sample of 226 questionnaires from the Chinese construction industry and SEM were used to examine the relationships among those constructs. Past studies proposed that leader goal orientation would be likely have a strong impact on team performance. Results in this study clearly substantiate the relationship between different goal orientations of leaders and team performance in project settings. The findings reveal that project managers with a strong employee development or demonstrating ability goal orientation can lead to improved project outcome albeit mediated by team cohesiveness. Nevertheless, project managers with avoidance of failure orientation tend to have less impact on project outcomes. These findings supplement goal orientation theory with different cultural contexts. Also, the current study deepens our understanding of the processes through which project managers’ goal orientation influence project outcome in the project environment. It provides a foundation for not only project management researchers in proceeding further study, but also practitioners in enhancing project outcomes.

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SUSTAINABLE OFFICE CONSTRUCTION PROCESSES AND PRACTICES: AN EXPLORATORY UK STUDY

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This working paper reports on a short project where researchers worked alongside teams actively involved in construction project delivery on two pioneering sites in Leeds, UK. This work forms part of an ongoing programme of academic-industry engagement on construction and city-wide sustainability action. The project aimed to identify the skills and processes required in the construction sector to achieve sustainable outcomes from building design, construction and use. An exploratory case study approach was taken to identify potential training opportunities and further research potential. Within the case study office projects, the local construction College and on-site apprenticeship trainers provided direct insights on additional training opportunity. Whilst lessons were learnt about required skills, equally important were the project processes that needed to function in order to deliver sustainable outcomes from the project. Sustainable construction can mean different things to each actor depending on their position in the project network. For example, funders require a focus on efficiency; design teams work towards standards, such as Design for Performance, focused on building performance and indoor environment quality; the technical advisers concentrate on optimising the efficiency of heat sources, water access and power provision; the project manager is concerned with organising materials to minimise waste; and the clerk of works pays attention to detailing on-site. Therefore, a co-evolutionary framework is used to understand the experiences of the construction teams engaged. Co-evolution acknowledges that innovation in technologies (sustainable materials and products) is co-dependent on institutions or norms (including policies and strategies), business strategies (including procurement routes of funders, design teams, technical consultants, project managers and clerks of works) and user practices (including design and build processes, plus operation of building controls for services such as heat and power).

Keywords: co-evolution, processes, sustainable construction

INTRODUCTION

Sustainable construction which minimises the negative environmental and social impact of the build, operation and end-of-life stages of buildings is vital. Within the broad area of sustainable construction, reducing the energy consumption of buildings, and therefore reducing carbon emissions from the built environment is key. Greenhouse gases emitted into the global atmosphere, contribute to the warming of the atmosphere and accelerate climate change (UNFCCC, 2018). Buildings account for 26% of UK CO₂ emissions (CCC, 2019). Of this sector, 25% is attributable to non-domestic operational carbon and 9% non-domestic capital carbon (GBC, 2013). Achieving decarbonisation of heat from buildings represents one of the biggest challenges in achieving zero carbon targets by 2050 (CCC, 2019). The

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construction sector is currently working towards Construction 2025 (HM Gov, 2013) which set out a plan to cut construction costs by 50% from 2009/10 figures and while reducing carbon emissions by 50% by 2025, from 1990 levels.

For a transformation towards zero-carbon new socio-technical regimes need to emerge around new design, and production solutions, with an understanding of the value of innovation to multiple stakeholders (Whyte and Sexton, 2011). However, the construction sector has been cited to suffer from a lack of collaboration, knowledge sharing, a high degree of fragmentation and low levels of innovation (HM Gov, 2013). The innovation of low carbon energy technologies related institutional practices and policies, their business strategies and, more recently user practices, or social processes, such as the training of skilled people, or knowledge sharing on technology use are crucial to the lower carbon industry transition (Foxon, 2010).

In Leeds, the City Council (LCC) voted in favour of declaring a climate emergency in March 2019, resolving to make Leeds carbon neutral by 2050 and calling on central Government for the funding to achieve this. LCC are working with academia through the Leeds Climate Commission to further develop plans (LCC, 2019). The transition to a more sustainable society needs technological changes, reforming of institutions, revisions to business strategies and changes in user practices, all elements which ‘co-evolve’ (Foxon, 2010). Three institutional factors appear to be required for sustainable innovation: the accumulation of both scientific and applied knowledge; allowing multiple parties to compete to find the answer; and motivational factors such as the drive to save energy, or towards self-sufficiency (Dosi, 1982: 160). The incorporation of knowledge and technology often lead to industrial growth, however highlighting the actors involved and the wider benefits to industrial innovation, such as in sustainability, may also accelerate motivation. Academia-industry engagement offers the ideal opportunity to capture, reflect on and assist in progress towards pioneering sustainable developments.

'Industry' is not a single entity. In practice it is a complex and fragmented network. The construction industry is vast and heterogenous, including a range of actors from micro to multinational sized enterprises with a range of purposes and motivations. Those actors collectively contribute skills and expertise relevant to their specialist roles in planning, designing, financing, constructing, occupying and maintaining buildings. The RIBA Plan of Work (2013), which is the industry accepted model for building design, construction and post-occupancy processes is being reviewed in terms of sustainability by a collaboration between RIBA and CIBSE (CIBSE, 2018). However, gaining and maintaining an understanding of the requirements takes time and there is a lack of expertise needed for complex work processes involved in low energy construction in the UK (Clarke et al., 2017). The UK construction skills challenges require an approach that facilitates better collaboration between industry, education providers, professional bodies and Government (UCEM, 2017). As such, a co-evolutionary framing is suggested to avoid focussing on only one part of the complex system.

**APPROACH**

An exploratory case study approach was taken to identify opportunities for both sustainable construction training and further related research. The case here being the situation, individuals, groups and organisations (Robson, 2011). An exploratory case study can lead to the development of a conceptual framework for future research (Yin, 2018), or where an appropriate framework already exists, this can be tested. Case
studies can be informal in their approach, allowing flexibility, if ensuring inappropriate impressions are not determined from the lack of formality. Within construction projects, informal interactions are essential mechanisms for information sharing and agreeing on the most appropriate action (Gorse and Emmitt, 2009). The present case study was developed from a project which put researchers into dialogue with potential research users without formal research design. The project aimed to identify the skills and processes required in the construction sector to achieve sustainable outcomes from building design, construction and use. These insights can guide further research and construction training strategies.

A co-evolutionary framing seeks to identify causal interactions between evolving systems of technologies, institutions, business strategies and user practices. This approach was originally proposed by Foxon (2010), building on the prior work of co-evolving systems by Kallis and Norgaard (2010) and sociotechnical transitions by Geels (2002), as a framework for analysing the transition to a low-carbon economy. One of Foxon's four proposed types of analyses is for the multi-level interaction of social and technological elements within potential transition pathways to a low carbon energy system; another includes detailed empirical analysis, both of which align with the current exploratory case study approach. Foxon's (2010) framework was adopted to analyse empirical evidence of innovation in sustainable construction, in particular in low-carbon housing renovation based on four previous studies (Killip et al., 2018). Whilst Killip et al., (2018) found the complexity of interactions between actors, specifically the way construction actors operated both as businesses and as technology user, was partly excluded from the framework, the approach was considered to analyse innovation within the sector fairly well. Foxon (2010) highlighted the value of the framework co-evolution approach in analysing the processes involved in technological and industrial change, influenced by wider factors. Co-evolution here refers to any two factors which have a "causal impact on each other's ability to persist" (Murmann, 2003; Foxon, 2011 and Killip et al., 2018).

The exploratory case study was centred on the actors involved in the planning, design and construction of two offices on two separate larger pioneering developments in the city of Leeds, UK, plus the connected training. Office A completed in 2018 and Office B was at design stage during early 2019. Both offices were designed to be innovative in terms of sustainability. Office B is targeted to be a base build within the 'Design for Performance' (DfP) approach (Cohen et al., nd). The Better Building Partnership (BBP) in the UK, chose to voluntarily adopt DfP for a more accurate simulation and measurement method of non-commercial buildings, recognising that without good measurement, legislating energy use is difficult to enforce and monitor (BBP, 2017). DfP is an industry-backed scheme adapted from the NABERS approach in Australia (NABERS, 2019), which rates office buildings on measured "base buildings", rather than modelled estimates, aiming to overcome the design-performance gap in energy performance (Young, 2018). In order to become a base build, the developers (funders) and their teams sign up to a 'Commitment Agreement protocol' to design, construct and manage new office buildings to agreed levels of actual in-use energy performance (Cohen et al., nd).

Design information for the site was provided by the Project Manager during the initial action project meeting and shared via email with the academic team shortly after. This included the Project Execution Plan and appendices, the sustainability strategy, the energy strategy and the Design for Performance document, which included estimates of energy performance for Office B (at July 2018) and the potential for the
build to exceed the ECON 19 (nd) Good Practice Benchmark by almost 50%, following further design revisions.

The engagement with the funder stems from an earlier academia-industry collaboration involving the research team, the developer for both sites, and local specialist construction College. Previous discussions focused on understanding what sustainable construction skills are required by construction stakeholders (Simpson et al., 2018). For this second stage, aiming to identify the skills and processes required across the project delivery network, the actors were identified through engagement with the construction project funder (a developer) and then snowball suggestions from each actor met. The local construction college, apprenticeship organisation and apprentices were all engaged in order to understand the practicalities of training provision and their perspectives on skills and knowledge needs.

**METHOD**

Information was gathered through a series of meetings with actors from across the network, most of which were held in the café at the completed Office A. Informal meetings, which construction teams are accustomed to in design and construction stages, allowed open discussion by the project actors on factors they considered to be most important in sustainable construction. Each meeting began with an introduction to the project; an outline of the previous project on sustainable skills which informed the work and led to engagement with the developer; and an overview of the underlying motivation informed by previous research, to address the building performance gap between designed and built. This was a shared motivation with some of the actors engaged and led to the Design for Performance approach adoption.

In each meeting, the participants were asked to identify what they thought were the sustainable skills required for project delivery, and who should have those skills. Each conversation began broadly to find out what sustainability meant to that actor, enabling them to lead the focus of discussion whilst probing questions were asked to ensure the meeting remained on the topic of sustainable construction and enabling teams involved to deliver. There is a gap in data collection from tradespeople as the action project took place post-occupancy for Office A and during design stage for Office B, so the main contractor was not yet appointed for Office B. Other actors were actively engaged in the design stage and were therefore active with the developer team and available to engage with late 2018-early 2019. Apprentices from the local College and industry are trained on-site as part of both Office A and Office B projects and this training was observed. This training was for the contractor 12 apprentices studying for their Level 3 Construction and the Built Environment Course (BTEC) and National Vocational Certificate in Construction Contracting Operations, during block week attendance in the on-site classroom. They were placed with organisations contracted by the funder, as part of their agreement.

The exploratory case study insights gathered were categorised into themes. The decision to adopt the co-evolutionary framework stemmed from a discussion on the findings between the authors. One author had previously adopted this framework and felt it was a good fit for what the author collecting, and processing information had observed. Therefore, the application of the theoretical framework was a result of explaining the past through abductive reasoning (Robson, 2011). The themes were then categorised to the nodes of the co-evolutionary framework encompassing technologies, institutions, business strategies and user practices, adapted from Foxon
Sustainable Office Construction Processes and Practices

(2010) and Killip et al., (2018). A summary of construction network actors engaged, and the office/s worked on, is shown in Table 1.

Table 1: The actors met and the case study office/s they worked on

<table>
<thead>
<tr>
<th>Construction network actors</th>
<th>Office A: Completed 2018</th>
<th>Office B: Design stage early 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funder</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Designer (and POE Researcher)</td>
<td>-</td>
<td>X</td>
</tr>
<tr>
<td>Technical consultant</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Project manager</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Clerk of works</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

FINDINGS

Insights

Constructing the case study revealed insights into sustainable skills and work processes across the network of actors. This network and the flows of information between each actor, as observed in the project teams, are summarised in Figure 1. Information may be shared through project meetings and project information, conversations or ongoing engagement (i.e. with Technical Networks and Civil Society Partners). Whilst other information transfer will likely occur between team members based on informal and personal connections, Figure 1 shows the formalised flows of information captured.

Figure 1: Network diagram of project actors with flows of information shown

The diagram includes actors who were not directly engaged in this action project; Main contractor/ Trades, Civil Society Partners (CSP's), Building Users (BU) and Technical Networks (TN), but whom were mentioned by actors during meetings.

The co-evolutionary framing highlights that innovation in technologies (sustainable materials and products) is co-dependent on related institutions (including local and national policies), their business strategies (for the funders, design teams, technical consultants, project managers and clerks of works) and user practices (including design and build processes, plus operation of building controls for services such as heat and power), as in Foxon (2010). The project insights are presented below using these co-evolving systems. Those who provided insights are indicated as follows: Funder (F), Project Manager (PM), Technical Consultant (TC), Clerk of Works (CoW) and Post-Occupancy Evaluation Researcher (RPOE).
Technologies

This includes the design software (such as dynamic thermal simulation, Building Information Modelling was at trial stage), physical construction materials, products and equipment specified for heating, ventilation, climate control and water. For the technical design process, the time to do a good job was considered essential for ensuring design data is accurate, so the building can perform as designed (TC, RPOE). In relation to construction technology and on-site processes, the CoW reported spotting "thousands" of small installation issues which could have led to problems with the building performance. TC suggested a CoW for Mechanical and Electrical (M&E) services would be beneficial in future, but to deal with this gap, CoW would photograph M&E queries and send to the TC for advice, then ensure it was rectified on site. Achieving sustainable outcomes here was clearly dependent on close collaboration between these actors. Post-build, TC and RPOE felt it essential to take time on the plant commissioning process. They emphasised that this can be rushed at the end of a contract, resulting in mistakes being made and switches left on (or off) resulting in energy wastage or faults. The TC highlighted the benefit of commissioning at each season of the year to ensure the systems are set up to cope with different climatic conditions efficiently.

Institutions

In co-evolutionary framing, “institutions” represent the wider policies, interactions and “rules of the game” which influence actors. This includes the Climate Change Act (2008), Leeds City Council's declaration of a climate emergency, the UK Building Regulations and the Design for Performance (DfP) guidance. Teams commented on the drive of the City Council in promoting sustainability and suggested this may serve as an additional motivation in going beyond the minimum requirements, particularly for the Funders. Working towards the Design for Performance approach required energy performance targets to be set early in the design process and collaborations between design teams to commence earlier than they would under a traditional contract. This approach requires post-occupancy evaluation for benchmarking.

Business Strategies

This encompasses the commercial, energy and sustainability strategies, in addition to wider social value strategies and procurement methods for contractor teams and connected organisations. The F recruited teams who shared this vision and felt it was necessary for everyone to understand what sustainability is and how it impacts on construction and development. For example, TC were based within an organisation which is striving to push industry boundaries in sustainability and were engaged in the pilot programme of DfP. The wider site influenced funder strategies, for example both case study sites are surrounded by areas which include many natural habitats important to wildlife; both are adjacent to a canal and one is close to woodland and parkland. Therefore, providing a built environment which is sympathetic to the natural environment may also attract tenants and generate commercial rewards.

The tender approach was highlighted (by TC, CoW and RPOE). This is because a Traditional contract does not formally allow engagement between the construction team and the user or operation manager of the building. A two-stage approach allows the contractor to begin work for a limited appointment in the first stage and then agree a fixed price for the contract in the second stage. This can allow engagement and knowledge transfer opportunities, enabling two-way discussion to overcome design challenges and ensure both parties understand the building and project aims. This is
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particularly useful for DfP. However, this is not always easy to do in practice as a two-stage tender process requires additional time (cost), as opposed to a Traditional contract in which the contractor is appointed once the design decisions are made. A two-stage process can incur additional risks for the contracted team due to added liability of being involved in design decision-making processes. However, it should lead to fewer misunderstandings than a Traditional contract approach and reduce the risk of missing designed targets for all parties.

User Practices

This encompasses both the professional practices of design, construction and building use, and the practices of the final users of the building, as they affect energy and resource consumption. A focus on sustainable and healthy, internal and external environments was considered important in shaping the teams’ professional activities (F, PM, TC, PROE). Being open-minded about integrating new ideas and technology was highlighted (by F, PM, TC, RPOE) as a need for team members at all levels. In order to progress in terms of sustainability, new methods and technologies must be trialled but investing and installing relatively new technologies carries risk for installer reputation, building performance and occupant satisfaction. Where contractors or contract teams can accommodate this risk, progress can be accelerated.

Employing a Clerk of Works to ensure designs were constructed accurately and with care on site was highlighted multiple times (by the TC, A, PN and DM) and is consistent with previous insights (Simpson et al., 2018). In addition, a clerk of works can assist in minimising on-site energy waste of plant on site through overseeing practices. For example, it was common to see generators used to power on-site machinery during construction on previous projects the TC had witnessed.

Ensuring positive communication between contract teams was highlighted (by TC, DM and A). This was achieved through ensuring defects are dealt with in a professional and considerate manner, direct with the contractor on a one-to-one basis, and generally communicating openly and regularly. The F organised socials for contractors so that teams could get to know each other. The architect highlighted the benefit of keeping contractors on a retainer agreement to ensure they have vested interest in doing a good job and an ongoing relationship with other teams.

Adapting to change was required by teams to ensure sustainable goals were met. For example, the site of office A flooded shortly pre-construction. This led to design changes in location of services to protect them from future flooding. This change led to a less efficient location and longer service runs, leading to more energy waste during transportation of heat and water around the building. Another unforeseen factor is often what type of fit-out future tenants will require. This leads to waste of fit-out products and materials once the tenant moves in and re-fits the internal space to their own specification. An office is advertised fitted-out as it is more attractive to tenants.

Both the TC and RPOE, plus the CoW, said it is important to engage users in how the building works, ensure they understand controls and allow them to feed back.

The results section ends with a summary on observations of on-site training, this is aside from the co-evolutionary framing for the construction processes but was considered to be an aid into the long-term development of sustainable practices.
**On-site Training**

The funder stipulated in the contract information that as part of gaining the construction contract, the winning contractors were obliged to take on a level 3 apprentice; emphasising the agency they have to enable change. This incentive created new jobs in the local area and boosted the social value impact of the construction project. The apprentices appeared to enjoy being based on a construction site and training in a Portakabin environment. Some of the contract teams had taken on a level 3 apprentice for the first time. Level 3 apprentices are usually aged 16-18, but these contractors were more accustomed to taking on graduates aged 21+; some of the contractors saw the younger trainees as a resource risk and were initially reluctant but did go ahead with the scheme. Table 2 outlines core skills required to achieve sustainable outcomes, captured throughout the project, which could be added to their existing training programme, in addition to on site meetings, or contract agreements.

**Table 1: Some of the core skills required to achieve sustainable buildings**

<table>
<thead>
<tr>
<th>Skills</th>
<th>For whom</th>
<th>How?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable understanding</td>
<td>All, from school onwards</td>
<td>Training/ on site</td>
</tr>
<tr>
<td>Minimising energy waste on site</td>
<td>Contractors</td>
<td>Training/ on site</td>
</tr>
<tr>
<td>Minimising material waste</td>
<td>Contractors and funders</td>
<td>Training/ on site</td>
</tr>
<tr>
<td>Dynamic thermal simulation</td>
<td>Designers</td>
<td>Training</td>
</tr>
<tr>
<td>Use of appropriate assessment and commissioning methods</td>
<td>Designers and technical consultants</td>
<td>Training/ team sharing</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The exploratory case study project aimed to use previous research as the springboard to identify the skills and processes required in the construction sector to achieve sustainable outcomes from building design, construction and use. Whilst skills could be improved, as recommended by Clarke et al., (2017) and UCEM (2017), the project environment and the processes which allow those skills to flourish must also be enabled for a productive co-evolution of technologies and practices (Foxon, 2010). The two offices’ wider sites are striving to be pioneering sustainable developments.

One of the biggest challenges raised was that the priorities of each actor vary since the funders have overall interest in the cost of the build and the satisfaction of the tenants occupying the office spaces. Sustainability was found to mean different things to different teams. Those involved in construction were concerned with minimising waste on site. Those involved in design were concerned with building performance and optimising the efficiency of the services. The funders can value both of those things but also recognise a need for the development to be sustainable in terms of protecting the local environment and through enabling sustainable transport. The apprentices training on site were not yet aware of the wider ambitions of the projects in becoming pioneering sustainable developments. Over time this is likely to be communicated as they were new to their positions. This on-site training appears to be a huge opportunity in equipping the next generation of construction professionals.

This project identified some required skills and processes to achieve sustainable office construction, which are being shared with the trainer and funder involved, potentially stimulating action. The short project duration limited the quality of information gathering but enabled an exploratory case study approach to inform a framework for sustainable office construction research. We suggest using a co-evolutionary framing for further research which both considers the motivation and agency of each actor and facilitates opportunity for them to act within that space.
CONCLUSIONS

The project aimed to identify the skills and processes required in the construction sector to achieve sustainable outcomes from building design, construction and use. An exploratory case study approach was taken to identify potential training opportunities and further research potential using a co-evolutionary framework (Foxon, 2010). Sustainable construction means different things to different actors, but some fundamental processes can enable sustainable skills and knowledge to be implemented, where a co-evolutionary framing is used to facilitate innovation, for each actor. These are working collaboratively and enabling this through the tender approach to achieve Design for Performance goals; ensuring individuals have a good understanding of sustainability and how their actions influence it on site (and beyond), being open-minded about integrating new ideas and technologies, ensuring funds and time are allocated for careful detailed design to be carried out, employing a Clerk of Works, enabling good communication so contractors understand sustainability and minimise energy and material waste, allowing careful plant commissioning at each season and engage users in the building operation post-occupancy while ensuring post-occupancy evaluation is carried out. Regular meetings and ensuring information sharing across the network is effective is essential for success. The factor of time was recurrent, either for design detailing, careful plant commissioning or allowing early collaboration, all of which can rushed but actors felt were essential to ensure a good quality and sustainable build. On-site training for apprentices appeared to be a success in terms of inspiring young people and forging closer connections with contractors through their training provision. This could be an effective avenue to integrate more sustainability training. This work has developed initial ideas for additional training and proposes using a co-evolutionary framework for further academia-industry engagement research on sustainable construction to accelerate meeting climate targets.

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INTEGRATIVE LEADERSHIP OF DESIGN TO FACILITATE IMPROVED ON-SITE PRODUCTIVITY

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In common with other industries, construction typically follows a sequence from design decision-making to implementation. Given this commonality, why does construction productivity apparently compare unfavourably? Despite academic understanding of low productivity and its causes, it remains stubbornly stagnant. This paper considers the apparent gap between academic knowledge and the industry’s performance in the context of international construction projects and forms part of PhD research into the impact of leadership behaviours on productivity. The review identifies that resources are commonly aligned at early stages of projects in anticipation of instigating, propagating or managing conflict relating to the causative potency of pre-site events on disruption to predicted productivity levels. Aspirations of collective working are discarded in favour of steps to manage the effects of low productivity, rather than their causes. Changing approach from reactive to proactive requires leadership, yet prevailing models of leadership were rarely found to reflect the reality of how international construction projects were procured, structured or managed, with inter-group behaviours and leadership models involving multiple groups separated by geography, discipline and contract being relatively under-researched. With a focus on pre-site activities the review combines a literature review of causative factors affecting productivity with analyses and observations of international construction projects to identify practical barriers to productivity improvements. The review sets out the future path of the research into integrative leadership behaviours of design which can support genuinely collaborative working between disparate stakeholder groups, to influence the manner in which design information is produced, with the aim of reducing inherent inefficiencies and supporting efforts to facilitate improved site productivity, all within prevailing contractual and risk distribution arrangements.

Keywords: disruption, integrative design leadership, inter-group behaviours

INTRODUCTION

The UK construction industry constitutes around 6% of GDP, contributing over one-hundred billion pounds to the economy annually and employing over one million people (ONS Q4, 2018). In developing economies, the relative contribution can be greater. The industry is however perceived to be a laggard in terms of productivity (Fulford & Standing, 2013) with UK government data indicating stagnant productivity growth (ONS Q4, 2018), a situation suggested to date back to the 1960s (Fox et al., 2002) and apparently replicated in the USA and Australia (Fulford & Standing, 2013). The challenges posed by a large industry sector with consistently low productivity has prompted interest and research into the causes of low productivity, and the consistency of findings indicates a reasonable understanding of what they are. Why
then has this body of research knowledge apparently failed to translate to productivity improvements, when other industry sectors have made significant progress?

Drawing on the author's research into productivity in international construction projects over the last decade, this paper explores the apparent gap between academic knowledge and performance, and examines some practical barriers encountered to improvement. The intended future path of the research is set out, with a particular focus on the leadership behaviours within and between design and other groups involved in pre-site / design activities, as a means of effecting change and facilitating improvement.

The Productivity Puzzle

The call for papers for the ARCOM Conference 2019 stated "…the problem of low productivity appears to be a perennial problem for the construction industry…". It is a view repeated in the Farmer Report (2016), which observed the industry's poor level of productivity when assessed against other industries, and the widening gap with them. Similarly, Green (2016) concluded that construction is little more productive now than it was many years ago. Such views are uncomfortable for the industry to face, concluding that it has consistently failed to improve productivity, when other industries have succeeded, and that it has failed to give effect to academic research which has identified, with consistency, underlying reasons for poor productivity. Therein lies the puzzle.

Both Farmer and Green cite data produced by the Office of National Statistics, which records UK quarterly productivity data across a number of economy sectors. Construction productivity is effectively unchanged for the last 25 years, whereas manufacturing productivity has increased by around 50%.

The ONS data records the value of industry output (in GBP) relative to worked hours. It is a macro-economic measure of the value of the industry to the economy (Yi & Chan, 2014). Relative to most other industries, construction produces less value per hour worked. This measure of productivity may be of utility for policy makers and economists, but is it appropriate in the context of what the industry itself requires to measure its performance? Increasing productivity by this measure could involve either increasing value (price) or reducing worked hours (employment) or a combination of the two (Green, 2016). Whilst superficially attractive, even if such measures were possible, would they really result in improvements in the efficiency of the way in which the industry delivers projects? Indeed, such macro-economic data may be an unreliable measure of labour productivity (Rojas & Aramvareekul, 2003). So, does the ONS data really tell us if the industry has poor and stagnant efficiency, over a period which has seen transformative change? Do we know if efficiency gains have been achieved, but have manifest in reduced tender pricing, thereby reducing value and hence productivity by the ONS measure? The data does not of itself allow this conclusion.

The reality of low margins, insolvencies, disputes and client dissatisfaction however indicate that the industry does not always deliver projects in an efficient way, and the generally held perception of poor and stagnant productivity may indeed be valid. So, whilst economic productivity is not necessarily directly related to contractors' efficiency, absent the ability to increase prices, reducing the effort required to achieve value is perhaps the only realistic option open.
This paper is thus concerned with construction efficiency on site as the basic building block of productivity, with a specific focus on the contribution pre-site activities make in determining on-site productivity. It summarises the initial stages of PhD research being undertaken at the University of Strathclyde, which seeks to identify the leadership influences on individual, intra-group and inter-group behaviours during design and other pre-site activities, assessing how such influences determine and facilitate productivity and how they serve (and can serve) to integrate performance with the aim of creating an environment of genuinely collaborative working.

**RESEARCH METHODOLOGY**

Following completion of a literature review of construction productivity research, which has been undertaken to identify causative factors affecting productivity, the research primarily relates to the views and opinions of key stakeholders involved in international construction projects regarding interactions and influences which take place within and between groups, and thus adopts a subjectivist approach.

The research method adopted consists of an ethnography of, principally, three live design and construct projects, in each of which construction activities had commenced, and into which the author became embedded within the contractors’ project teams. Project 1 is an airport development in the Middle East (c.AED 500m), Project 2 a healthcare project in Australia (c.AUD 2.5bn) and Project 3 a multi-site chemical manufacturing project (c.USD 15bn). The author was given extensive permissions to investigate project performance and to engage key stakeholders. Numerous discussions and data sharing took place regarding production, progress and productivity, together with identification of potential causes of disrupted workflows.

The approach facilitated investigation of both productivity and leadership influences on individual and group behaviours in a real-life context. Multiple unstructured and semi-structured interviews were conducted over periods ranging from three to nine months on each project, together with attendance at meetings and detailed reviews and analyses of project documentation. The individuals interviewed occupied managerial positions within contracting and consulting organisations, covering from mid-career site managers to CEO. Interviews were typically conducted on site or in site offices, or occasionally in off-site meeting rooms, with handwritten records of each interaction taken. Being embedded within the project teams afforded frequent opportunities to engage both formally and informally, and a circumstance was created in which information could be shared openly and freely, including frustrations, successes, interpersonal relationships and influences. Observation of interactions between individuals, within teams and between groups was carried-out on a daily basis.

**Literature Review of Productivity Research**

Lim (1996) described productivity as the relationship between the output generated from a system and the input used to create it, opining that labour is by far the most common form of input measured, calculating productivity as output over input. Thomas (2014) however considered that the most common and widely used measure of labour productivity in construction is the unit rate, defined as input over output.

The difference between 'output over input' or 'input over output' may be two sides of the same coin: at their root both approaches require output and input to be measured. From this data, productivity is calculated, either in units of output per worker-hour, or worked hours per unit of output.
Conceptually, the measurement of productivity is straightforward, however a further question arises regarding the input and output parameters to be measured. Tsehayae & Fayek (2016) set out a hierarchical scale of productivity measurement, starting at activity level and progressing through project, organisational, provincial, national to global. This paper relates to activity productivity and is concerned with the factors affecting the efficiency of labour utilisation in the performance of individual work tasks. It is an area in which interest in activity is growing (Yi & Chan, 2014).

A significant proportion of productivity research relates to the identification of the causes of low productivity and this has yielded lists of potential causes across cultural, jurisdictional and project types, with some consistency: Naoum (2016) considered the distinction between factors relating to pre-site activities and factors relating to activities during construction; in 'The professionals perspective on the causes of project delay in the construction industry', Agyekum-Mensah & Knight (2017) identified 15 causes of delay which contained a mixture of both pre-site and on-site events, the top 4 ranked causes relating to pre-site activities.

Productivity remains an active area of interest and research, in part because despite the consistency of findings, the body of research knowledge appears to have had little impact on recorded productivity, giving the impression of a gap existing between research knowledge and the industry.

Where the gap between academia and industry may exist is in the apportionment of liability for competing causes. The task of disentangling causation falls to the industry's well-rehearsed factual analyses and dispute processes. It may be that academia's theory-based productivity measurement methodologies and industry's fact-based analyses, undertaken in circumstances of multiple competing variables, is a gap which proves, as it has to date, to be incapable of practicable closure.

**Productivity in Practice**

Ethnography of the case study projects over periods ranging from three to nine months has identified that measurement of the variables used to calculate project productivity (output (value) and input (worked hours)) is undertaken routinely on projects of scale, primarily because they are used in recording progress and in calculating project margin. Productivity is also routinely calculated in scheduling software packages which use productivity factors to calculate labour resources and activity durations.

The challenge of productivity measurement in complex building projects, in which the labour component is high, the range of activities extensive, and their inter-relationships complex (and in part elective), makes practical measurement of productivity variables an effortful task. This effort vs. usefulness balance invites measurements to be elevated to a level which can be managed within acceptable parameters, so similar activities over a whole project may be taken rather than each instance of that activity. Whilst average productivity may be capable of being calculated based on that data, the need to do so is typically driven by a retrospective realisation that labour costs have exceeded predicted and or progress has not achieved planned. Any matters which have caused the lower-than-anticipated output, or greater-than-anticipated input, or both, are termed 'disruption' and become a focus for competing interests.

For practical purposes, the measurement of productivity is of secondary importance to production but is closely related to the measurement of disruption. The primary motivation for productivity measurement becomes the proving or disproving of the
Facilitating Improved On-Site Productivity

causes of productivity achieved below anticipated. To illustrate the point, three real-life examples of loss of productivity encountered are described below:

Example 1 - In an international airport project, service openings for sprinkler pipes differed between prospective sprinkler contractors. Known service penetrations could be created during the steelwork manufacturing process (at low cost) otherwise they had to be formed on site, requiring time-consuming and costly resources. The holes were the same, but the manner in which they were created resulted in inefficiency, cascading to other site activities. To avoid site work, a design solution was devised to create service penetrations for all the prospective contractor's technical requirements.

Example 2 - In the early stages of a building project in Australia, unknown ground contamination (a client risk) was discovered and treated by the contractor. The additional work delayed progress, but the time taken to secure a time extension (and the uncertainty of securing any), together with the rate of delay damages, meant the contractor chose to accelerate to try to meet the unadjusted completion date. The acceleration increased costs, negatively impacting efficiency and productivity.

Example 3 - A US petrochemical plant involved the design and construction of a pipe gantry, but the full extent of pipework was unknown at the time foundations and fabrication work was required to commence. To accommodate the uncertainty, the design adopted an increased factor of safety so that the foundations and steelwork were significantly over-engineered to accommodate any potential load combination. The procurement schedule and the uncertainty caused by incomplete design information resulted in an inefficient solution.

These examples, of which there may be many thousands in a project, perhaps demonstrate that the industry is skilled at devising solutions to problems which might otherwise negatively impact progress, but the solutions described do not represent optimal efficiency. Each resulted from a failure to fully identify the scope of work before site procurement and construction commenced. The inefficiency was recorded in construction, but it was caused by inherent inefficiency in pre-site information.

This identifies a significant challenge to improving construction efficiency: even optimal site efficiency would not overcome the negative effects of built-in inefficiencies created by pre-site processes. In practice, contractors make provision for their own predicted productivity (through pricing and scheduling, based on historic data) and then seek commercial recovery of any disrupting effects caused by others, through contractual routes. Resources are frequently aligned on both sides from an early stage for this purpose, creating an environment predisposed to conflict.

**Disruption**

Disruption is the difference between the contractor's intended productivity and that which was achieved. It is a relative term, requiring a comparison between intent and reality (Burr, 2016). Intended productivity is typically the baseline set by the contractor on what it considers could be achieved. Actual productivity rates are then compared to the intended and any derogation is the disruptive component.

Malisiovas (2010) lists six methods of project level productivity measurement: input / output; experience-based models; comparison with project milestones; activity model (work sampling); factor model; cost reporting model, and; programming software. Measuring productivity in projects with repetitive tasks, such as mining or bulk earthworks, is relatively straightforward, becoming more complex in civil engineering and building projects. Whilst it is possible to mathematically model such variations in
output and input, and their inter-relationship with predecessor and successor activities, in reality it is difficult and of limited practical value. In consequence, an average of anticipated outputs and (occasionally) inputs is typically set as baseline productivity.

Agreement of baseline productivity can be elusive, but once established, the contractor (and frequently the client team) must measure actual performance relative to predicted, to identify deviation. Cost reporting models are commonly used as an initial identifier of productivity loss, with input/output models adopted to prove achievability of intended levels of productivity and to quantify under-performance. In multi-activity situations in which activities are compromised upon commencement, demonstrating achievability can be challenging and the contractor must also prove causation, frequently in circumstances of competing causes. Productivity measurement thus becomes a reactive and negative concept focussed on blame.

Leadership and Productivity

Observed leadership behavioural contributors to low productivity

In addition to theoretical, event-based causes of disruption, participant observation of the case study projects suggests underlying leadership behavioural patterns which can also contribute to sub-optimal productivity, some examples of which are:

- Optimism Bias - When seeking to predict future events, individuals can be predisposed to optimism (Kahneman & Tversky, 1977). When scheduling a project, an optimistic duration creates expectations which invite inefficient use of resources;

- Delay Damages and Time Extensions - Challenges and uncertainty in securing time extensions effectively compels contractors to work (perhaps temporarily) to an unadjusted date for completion. The contractor must decide if it proceeds at its planned rate of progress in the hope of securing a time extension or seek to accelerate progress in order to meet the unadjusted completion date. The rate at which delay damages accrue can encourage contractors to focus on production, not productivity. In practice this means increased or earlier resources, resulting in more interfaces, stacking of trades, out-of-sequence working, pressures on supply chain and material management, etc all of which can negatively affect productivity. Low productivity becomes an acceptable sacrifice for reducing the risk of delay damages. Additionally, these accelerative measures can give the appearance of disorganisation, further reducing the contractor's ability to secure entitlement for client events.

- Procurement Strategies and Fragmentation - Common procurement routes for design and construction works can establish a hierarchy and power structure within the network of project organisations which fails to create an environment which invites collaborative working, or fails to provide sufficient time to allow the practical interaction of individuals and organisations necessary for collective knowledge to derive optimal solutions. Isolated working increases the risk of conflict and of sub-optimal solutions being devised with inherent inefficiency, to be resolved on site.

- Convenient status quo - Having a combination of causes of low productivity on site can be a convenient vehicle for each party to mask their own inefficiencies. Causation which is at least in part the responsibility of others provides a convenient basis for disputing liability for one's own contribution. A focus on production allows progress, but the measurement of causative impacts on productivity can take on a solely negative, reactive purpose, leading to a pattern of negative behaviours which are inconsistent with collaborative working. Challenging this status quo is the future aim of the research.
Facilitating Improved On-Site Productivity

The potential for positive integrative leadership
Leadership has been a topic of research for much of the 20th Century, during which period theories have evolved as social attitudes have changed over time. Northouse (2016) provides a useful summary of the development of leadership research, from 'Great Leader' to more recent Servant, Adaptive and Psychodynamic theories, defining leadership as a process whereby individuals influence a group of individuals into achieving a common goal.

Pittinsky & Simon (2007) describe an in-group / out-group trade-off, in which leaders sacrifice inter-group relations as a means of fostering strong in-group cohesion. Indeed, inter-group conflict is synonymous with strong intra-group bonds and can be used as a means of establishing leadership. Realistic Conflict Theory (Campbell, 1965) informs that negative inter-group behaviours can arise as a result of competition for scarce resources and followed Sherif et al.'s (1961) Robbers Cave study which sought to create conflict between groups, and to subsequently remove it, which was only partially successful. Group conflict is generally incompatible with collaboration.

It is known from productivity research that deficiencies in design information is a factor in causing reduced construction productivity (Abdulaziz et al., 2015), Hughes & Thorpe (2014), Naoum (2016) and Makulsawatudom (2003)) and a potential source of conflict. Given this knowledge, is it possible to 'do' design differently, so that the effects of late, changing or incomplete design information are reduced?

Design for productivity is concerned with providing design information to contractors in a manner which facilitates efficient construction work. The concept of designing for a specific purpose is familiar in the industry, for example, design for safety (CDM Regulations), or designers' duty to providing a design which can be built within the client's budget (clarified in Riva Properties Ltd v Foster & Partners Ltd [2017] EWHC 2574 (TCC), 175 Con LR 45).

Kotter (1990) suggests that leadership is about seeking adaptive and constructive change. 'Doing' design differently requires leadership. Integrative leadership, defined as that which fosters collective action across many types of boundaries in order to achieve a common good (Crosby, 2008), and references the formation of a superordinate group with a single over-arching objective (Crosby & Bryson, 2010).

Pittinsky & Simon (2007), suggest pathways to foster positive inter-group relations: increasing positive intergroup attitudes; promoting dual identities; promoting superordinate identities; managing resources and inter-dependencies, and; encouraging contact, all achieved through inter-group (integrative) leadership.

The concepts of inter-dependencies and collective action towards a common objective are significant as they best represent the reality of construction design, in which multiple groups are required to input into a single co-ordinated body of work. It is not unknown for projects to have over one hundred such design groups, frequently separated by geography, discipline, status, schedule, contract, law, culture, time-zone, disputes, language, etc. Not all of the groups' objectives are common, still less superordinate. The task of integrating the efforts such groups to create an environment of genuinely collaborative working is described by integrative leadership.

DISCUSSION
Research-based identification of the causes low productivity is of utility and given the commonality of findings from around the world, relatively uncontroversial. The effects of low productivity are readily observed in the performance of international
construction projects, which manifest as disruption, conflict and low margin. To that extent therefore there appears to be little gap between academic research and the construction industry. The gap in knowledge is perhaps what to practically do about it. How are competing causes of loss of productivity to be disentangled, so that contractors’ productivity can be stated with clarity, without the effects of inherent pre-site causes being collectively measured? The industry has responded by anticipating and accepting the inevitability of inherent inefficiency and by developing a culture of propagating arguments and counter arguments which deal with liability for any derogation of actual productivity levels from predicted. The variability of causative factors on projects of scale however may render consistent empirical data impossible to achieve and, in such circumstances, it is perhaps of greater utility to challenge the inherent reasons for loss of productivity and the barriers to implementing change.

Construction productivity is frequently viewed as a problem solely related to site operations. Contractor’s bear the brunt of the criticism, yet academic research has identified that pre-site activities also contribute to loss of site productivity (Naoum, 2016). A focus on the productivity of site works is important, but to do so exclusively, without also examining the manner in which necessary predecessor activities are performed, is unlikely to overcome the effects of inherent inefficiencies. Providing design information to contractors in a manner which facilitates efficient site working remains a challenge and a negative factor in productivity (Abdulaziz et al., 2015).

Farmer (2016) recommends a tripartite integrative leadership model involving government, clients and the industry. The industry, not just contractors, can however take a lead at project and corporate level, to demonstrate that it is capable of consistently delivering projects in an efficient way. Progress is being made, but the in-group / out-group trade off remains is one which is frequently made at the expense of inter-group relations. Whilst this may not be intentional, it is a potential source of conflict (Pittinsky & Simon, 2007) and is the antithesis of collaboration. It is not, however, inevitable: the human interactions and leadership behaviours necessary for genuine collaboration exist and remain a key area of research focus.

The next stage of the author's research will cover the behaviours of leaders (and followers) in the specific circumstance of international construction projects during the pre-site stage. What behaviours facilitate genuinely collaborative effort and what do not? What are the leadership behaviours which influence the behaviours of distinct or discrete groups such that the interactions within and between them allow their own objectives to be met whilst at the same time meeting the overarching project objectives? Can a culture of conflict resolution be shifted to a culture of conflict avoidance? What behaviours will create the political, corporate and project leadership required to provide the vehicle for change?

CONCLUSIONS

There is a broad alignment between academia and the construction industry in relation to the causes of low productivity at project level, which have consistently identified a combination of pre-site and on-site factors. The existence of pre-site factors which are outside the control or responsibility of contractors gives rise to well-rehearsed factual debate to establish liability, for which resources are aligned at early stages of projects in anticipation of instigating, propagating or managing such differences. Resolving liability however does not improve productivity.
The challenge for both academia and the industry is what to do about it. The ongoing research to which this paper refers suggests that the challenge of improving productivity could generally be approached by seeking to examine why the known causes arise, and how they can be reduced or eliminated at source.

Technology will inevitably play a part, but the research specifically focusses on pre-site design and sets out to identify the leadership behaviours necessary to integrate the often fragmented groups encountered in international construction projects, under the hypothesis that unless the manner in which pre-construction activities are collectively undertaken eventuate in facilitating optimal site efficiency, the value of any productivity measures of on-site productivity will be compromised by competing causes and liability, resulting in genuinely inefficient site practices being concealed by the effects of inefficiencies inherent in pre-site / design outputs.

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PROJECT PLANNING
INFORMATION REQUIREMENTS FOR THE USE OF 4D FORENSIC DELAY ANALYSIS ON CONSTRUCTION PROJECTS

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Delays are a familiar feature of construction projects, with ensuing claims and disputes about their causation and accountability. Forensic delay analysis is a discipline that investigates these issues using a variety of techniques and methodologies to support their resolution by judicial or other forms of proceedings. Inevitably, such analyses rely on information about what was agreed by the contracting parties, what actually occurred, and the intervening events, acts or omissions that may account for the difference between them. Obtaining and then verifying the relevant information has been a constant problem for the forensic delay analyst. The advent of building information modelling (BIM) offers analysts the prospect of more accessible, verifiable and illustrative information to support their arguments. However, as ‘information-rich’ as such models might be in theory, their value is dependent upon the data they contain and this in turn depends upon a level of mutual understanding between the model creators and the ultimate model users; in this case, the delay analysts. Working with delay analysts and using an action research approach with data collection by desk study, observation, software development and testing via user-evaluation workshops, the authors identify these information needs, discuss the implications of meeting them, and consider whether a solution can be reached and implemented.

Keywords: delay analysis, dispute resolution, 4D modelling

INTRODUCTION

Construction projects are vulnerable to schedule overruns: this fact has been highlighted on many occasions and over a considerable time and appears to be a continuing ‘global phenomenon’ (Adam et al., 2015). A report on the completion times of more than a thousand projects funded between 1974 and 1988 by the World Bank recorded frequent overruns of between 50% and 80% of their planned timescales (World Bank, 1990). The National Audit Office in the UK has reported that 70% of public sector construction projects suffer some degree of delay (National Audit Office, 2001). In a sample of high-rise buildings constructed between 2005 and 2008, the Chartered Institute of Building found that 13% were completed between three and six months late and 18% were completed more than six months after their original completion date (CIOB, 2008, 13). In the period since that survey, and despite highly-publicised efforts to control the problem, figures revealed by Gledson and Greenwood (2017: 951) show an increase in the proportion of UK construction projects between

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2007 and 2015 that were delivered outside their agreed completion dates. It has been demonstrated (by authors such as Bromilow et al., 1988, Kaka and Price, 1991, and Chan and Kumaraswamy, 1995) there is a clear association between project time and cost, in that delayed projects have a strong tendency to be over-budget as well. Aside from this, the delays themselves normally result in losses to the parties concerned: for example, the owner’s return on investment will be postponed while contractors will incur the extra time-related costs of completion. Standard forms of construction contract go some way towards apportioning the responsibility for delays and compensating for them (via liquidated damages, extension of time provisions, and compensations). However, as observed by Yogeswaran et al., (1998: 284) the generalities of standard clauses are insufficient for coping with specific situations and ‘most contractual regimes ... do not provide details of the principles governing the assessment of claims for extensions of time’. This has encouraged the production and use of industry guides and protocols, such as the UK-based SCL Protocol (Society of Construction Law, 2002; 2017; see also, Scott, et al., 2004) and in the USA, the Recommended Practice on Forensic Schedule Analysis (Association for Advancement of Cost Engineering International, 2007). However, even with such methodological guidance, the evidence required for demonstrating causation, impact and liability rarely exists and consequently disputes arise (Bilgin et al., 2017; Clay and Dennys, 2018). These disputes can add considerably to the cost and time of projects that have already deviated from original expectations. For example, the 'Contract Solutions Global Construction Disputes Report' has estimated that in 2017 the average value of disputes world-wide was US$43.4 million, and their corresponding average duration was 14.8 months (Arcadis, 2018: 8).

**Forensic Delay Analysis**

The combination of such high risks and the complexity of the process of dealing with them resulted in a business opportunity for specialist claims management and dispute resolution consultants (Kumaraswamy, 1997: 95). The specialist service of analysing construction delays is known in the USA as Forensic Schedule Analysis, or, more commonly in the UK, Forensic Delay Analysis (FDA). The FDA process comprises two distinct sub-processes (Parry, 2015: 32-35; Gibbs et al., 2013). The first is primarily quantitative and relies upon scrutinising work programs (schedules) using numerical methods such as critical path analysis. The second involves the collection and analysis of relevant supporting information from the construction process relating to a particular delay: this includes scrutiny and validation of correspondence, contractual documents such as change orders, diary entries, photographs, minutes of meetings, and interviews with project participants. The resulting analysis is primarily qualitative.

The critical path method (CPM) and related techniques have become a commonly-accepted basis for the quantitative forensic analysis of programmes of work (Wickwire and Smith, 1974; Wickwire and Ockman, 1999) followed by the use of computer-assisted delay analysis using CPM-based software products (Barry, 2009; Keane and Caletka, 2015). Despite the apparent reliability of such numerically-based tools there remains considerable uncertainty as to how to interpret them. There is no single standard method of analysis and the appeal of each of the variants depends upon a number of factors, including a basic decision as to which of the many possible versions of the project CPM to use as starting-point for analysis: that is, whether the 'baseline' critical path should be defined prospectively (i.e. as the work was originally planned), contemporaneously (i.e. at the time the delay occurred), or retrospectively.
(i.e. following the results of the delay). There have been several examinations of the commonly-used delay analysis methodologies (Bordoli and Baldwin, 1998; Bubshait and Cunningham, 1998; Ndekugri et al., 2008; Al-Humaidi and Hadipriono Tan, 2010; Al-Gahtani and Mohan, 2011; Keane and Caletka, 2015, Parry, 2015) and their relative acceptability is the subject of an on-going debate (see, e.g. American Association of Cost Engineering, 2011; Arditi and Pattanakitchamroon, 2006; Braimah and Ndekugri, 2008; Parry, 2015; Society of Construction Law, 2002; Society of Construction Law, 2017) that is beyond the scope of this paper. What should be emphasised, however, is that even the quantitative elements of FDA are inherently uncertain, and the results of related disputes have been unpredictable and inconsistent (Parry, 2015). As well as the variations in outcomes based on the different FDA methodologies adopted (Parry, 2015), there are persistent and long-term issues such as those of 'concurrent delays' and 'ownership of float' (Braimah, 2013). However, more fundamental to the uncertainty of outcome is the insufficiency and/or poor quality of project information upon which analysis relies (Gibbs et al., 2013:48).

The Potential for the Use of Building Information Models in FDA

According to NBS, Building Information Modelling (BIM) is ‘a process for creating and managing information on a construction project across the project lifecycle’ and can include ‘the digital description of every aspect of the built asset’ which in turn ‘enables those who interact with [it] to optimize their actions...’ (NBS, 2016). As Crotty (2012) points out, with BIM there is the potential for the information within the model to be of ‘far higher quality’ than that obtainable traditionally. Moreover, the digital format of this information offers the possibility of interfaces with other digitally-driven systems. This includes the integration of the 3-D model with computerized construction schedules in what is commonly referred-to as ‘4D BIM’ (the additional, fourth dimension being Time). The use of 4D BIM for planning construction projects is becoming widespread (Buchmann-Slorup and Andersson, 2010; Hartmann and Fischer, 2007; Gledson and Greenwood, 2017; Kassem et al., 2012; Koo and Fischer, 2000; Mahalingam et al., 2010; Trebbe et al., 2015; Wang et al., 2004). Other digital technologies offer automated tracking of progress in the field (Kim et al., 2013; Zaher, et al., 2018). Despite this, there is little evidence of the use of 4DBIM, or any digital technology, for FDA (Gibbs et al., 2013).

The visualisation or animation of construction activities in their time and space relationship does not per se rely on the use of BIM (see, e.g., Russell et al., 2009 and Huhnt et al., 2010). However, the use in BIM of a logical, semantic and object-based structure to define the elements in a constructed asset makes the addition of the time dimension increases its efficiency and fidelity. Returning to the two sub-processes involved in FDA, the prospects for the use of 4D BIM offers potential advantages for each. The first is to increase the plausibility of computerised CPM demonstrations using 4D presentation, particularly its visualisation capabilities: the second is the automation, through model data transfer, of some of the laborious tasks of collecting, validating and analysing project information that is currently at best dispersed and incomplete (at worst non-existent) but that could potentially reside in a digital model.

METHODOLOGY

The research was initiated as part of a Knowledge Transfer Partnership (KTP) grant to a host company active in the field of forensic delay analysis. The aim of the project was to develop a data-driven digital system for supporting delay analysis in
construction contract claims and dispute resolution. Empirical data collection was carried out by the KTP Associate, who was located at the premises of the host company for an average of four days per week over the two-year project duration.

The goals of the project were two-fold, namely: (1) to improve FDA output by exploiting the enhanced visualisation capabilities of 4D BIM; and (2) the automation, or semi-automation of time-consuming manual FDA workflows by utilising information that could reside in BIM models.

Given the above, and the nature of KTPs in general, the methodological typology of the work can best be classified as Action Research, which, according to Coughlan and Coghlan (2002: 220) is an approach that "aims at both taking action and creating knowledge or theory about that action".

The entire project involved four stages; these were:

- **Stage I:** Situational Awareness: acquiring an understanding of the context of the company and its business; its outputs and services; its customers and markets; the technologies it already used; and its workflows.
- **Stage II:** Discovery and Decisions: the development of initial solutions for integrating technology-enhanced workflows based upon example BIM models.
- **Stage III:** Implementation and Validation: the refinement and testing of the prototype technology-enhanced workflow solution.
- **Stage IV:** Commercialization and Embedding: the launch and roll-out of the new capability to customers.

Data for Stage I were collected by the KTP Associate, through personal observation and documentary evidence (such as timesheets and records of the host organisation's past projects). These sources were validated by semi-structured interviews with FD analysts, enabling the Associate to produce 'as-is' maps of the host company’s processes. In Stage II, the KTP Associate (an experienced data scientist) was involved in iterative software development, including the identification (or creation), testing, adaptation and modification of candidate software solutions. The ensuing functionalities were progressively evaluated with university supervisors and FD analysts in the host organisation. The work in Stages III (testing and refining of prototypes) and IV (commercialisation) has not been undertaken at time of writing and the following findings relate to Stages I and II.

**FINDINGS**

FDA work-flow can be simply represented by the two phases shown in Figure 1.

![Figure 1: Forensic Delay Analysis simplified work-flow](image)

The first (Analysis) phase determines 'when' and 'why' a delay has occurred; the second (Presentation) deals with how findings are demonstrated. FDA analysts concurred that former is the most difficult and time-consuming phase and, confirming the supposition noted earlier, involves two distinct process: the question "when?" involves comparative analysis (i.e. planned versus actual) of project schedules; the
question 'why?' requires exhaustive audits of the information available from the construction process and its participants. Observation, interviews and the review of documentary examples revealed that this part of the process currently relies on, at best, unstructured electronic data and in many cases, paper. This is a situation that has changed little from that encountered over ten years ago by Craig and Sommerville (2007) and one for which the advent of BIM holds considerable promise. In practice, however, there were challenges that became apparent in the next stage of the project.

**Challenges in Integrating Bim-Fda Workflows**

Stage II of the project was to enhance workflows by exploiting the potential for automatic data flow from BIM models to provide authentic and accurate information that was useful to the FDA analyst. The growing use of BIM software had resulted in the organisation holding a small repository of digital models that could be accessed.

**Challenges in the 'Analysis' workflow**

When attempts were made to extract data automatically from these projects several problems emerged. First, each typically comprised models created on a variety of software platforms that had not been federated properly, or in some cases at all. Secondly, when these were converted to a standard interchangeable format (i.e. IFC) there were inconsistencies that required extensive manual fixing. For example, 4D models had been produced with different nomenclature from 3D models, making the automatic matching of design elements to schedule activities impossible.

**Challenges in the 'Presentation' workflow**

The second set of challenges concerned the presentation of the analysis. Existing software products that support 4D BIM have been developed primarily for (prospective) planning purposes, and not (retrospective) FDA. There are consequently no 'off-the-shelf' products have been designed around the requirements of FDA.

**Understanding information requirements**

An obstacle to the use of BIM both the 'Analysis' and 'Presentation' aspects of FDA is that its success relies on an understanding of information requirements right at the start of and throughout the project. In the projects examined this had clearly not been the case. For example, there had been incomplete or imperfect data capture during construction. Constructors had failed to record completion of activities properly, so comparing planned with actual progress required manual intervention and inferences from incomplete non-digital records.

**DISCUSSION AND CONCLUSIONS**

These findings have implications for the goals of the project and more generally for the prospects for the successful integration of 4D BIM with FDA. Of the challenges identified above, some are technically resolvable. Others would require more radical and systemic change to the culture or workings of the construction industry.

**The automation of 'Analysis' workflows**

Two problems have been identified for automating the process of information retrieval, validation and analysis in FD workflows. The first related to the multiplicity of non-federated, or poorly-federated models currently encountered and the second to the ontological inconsistencies between these models. As the number of digitally-modelled projects increase an improvement in the quality of modelling can be expected. As the industry becomes more digitally mature an improvement in the quality and utility of modelling can be expected, enabling more effective sharing and
reuse of data and overcoming the inconsistencies of nomenclature and definition that currently exist between individual poorly-federated models (BEIS, 2015: 29-31).

**Presentation challenges**
The use of visualisations as supporting evidence has a growing acceptance in dispute resolution provided that their provenance, authenticity and fidelity can be upheld. However, current 4D software products have been developed for prospective planning, and not retrospective FDA. They can be and have been adapted to accommodate side-by-side planned-versus-actual animations, however, simply doing so may not enhance the understanding of complex arguments. Khacharem, et al., (2015) have suggested that animations offer no improvement in comprehension over static diagrams and that cognition can actually decrease when out-of-phase animations are shown side-by-side. This suggest the need for a radical rethink of how FD analysed are best presented: a split-screen or multi-screen approach, allowing the demonstrator to skip between views, could cater for this.

**Awareness of information requirements**
It is widely accepted that early identification of information requirements is essential for exploiting the full potential of digital models (Gu and London, 2010) however, procurement constraints, commercial considerations and convention have always conspired against this (Kagioglou et al., 2000). Even in terms of their construction BIM projects are still hampered by lack of early understanding of information requirements (Cavka, et al., 2017) despite the existence of guidance documents (such as PAS-1192(2) (BSI, 2013) and tools such as the NBS BIM Toolkit (Hamil, 2016). The problem is intensified when the information required is for FDA as its need is rarely recognised until a dispute arises. The need for a standard delay analysis ontology has already been identified (Bilgin et al., 2017). The creation of a standard set of minimum information requirements for FDA would be a valuable tool for the mitigation of the risk of disputes.

**CONCLUSIONS**
These factors may well explain the current status quo regarding the use of information technology in FDA: namely, that there is limited use of visual technologies to present findings or argue cases; limited use of BIM models (despite their increasing availability); and little or no use of digital data analytics. A fully-automated transfer of all required information from BIM models through the two main FDA workflows (of Analysis and Presentation) is currently not feasible. However, the goals of the project - to enhance FD presentations and to automate FDA workflows by utilising information that could reside in BIM models - are both attainable. By using a piecemeal and incremental approach to overcoming the identified barriers a semi-automated data-driven digital system remains is feasible.

**Limitations and Further Work**
Under Stage III of the project a prototype technology-enhanced workflow solution is being refined and tested. This will be reported in later publications. Stage IV is the embedding of a digitally-driven solution within the workflows of the host organisation and roll-out of a digitally-enhanced system to its customers. There are important matters of confidentiality, traceability and data integrity that have not been addressed here though they would be important in terms of a commercial service offering.
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PUBLIC PARTICIPATION SUCCESS FACTORS IN THE IMPLEMENTATION OF MEGA PROJECTS: GAUTENG PROVINCE CASE STUDY

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The delays and protests surrounding some very crucial mega projects in South Africa could be indicative of a weak consultation regimen. As a relative new democracy South Africa still has to consolidate and develop a robust legislative framework dealing with public consultation, but there is a consensus that things have to move fast in that direction. The new realization is that public consultation is no longer a public relations nicety but a critical implementation element that has to be contextually relevant and executed with adequate expertise and political smarts. Even in the current institutional shortcomings it appears that some projects are making headway in delving into the fundamentals of basic requirements by introducing innovative interventions to enhance the effectiveness of their consultation regimen. The study will seek to identify what could work in the country in this climate. Using three projects in Johannesburg in the transport sector—the Gautrain Metro rail Project, Re Ya Vaya Rapid Bus Transit System (BRT) and the Gauteng Highway Improvement Project (GFIP) an assessment was made on which approach is more effective in minimizing public resistance. The critical stakeholders were engaged with using interviews, online questionnaires and official project records. The data was basically analysed using thematic analysis for interviews and content analysis for the documents. It was found that adequate allocation of time to the consultation process and transparency with the stakeholder improves the project delivery. Without overhauling the legislative regimen, even some of the genuine strategies could be stymied by the sheer size of conflicting expectations as there are currently no prescribed benchmarks. The study could be useful to policy makers in appreciating the basic contextual requirements for operationalising consultation in mega projects. It is very instructive for other aspirant jurisdictions with weak legislative frameworks with regards to public consultation.

Keywords: consultation, mega projects, public resistance, legislation, interest groups

INTRODUCTION

With public transport demand expected to almost double by 2040, the City of Johannesburg is increasingly prioritising investment in public transport infrastructure and services across the metropolis. The Johannesburg Transport Department is making the use of public and non-motorised transport an increasingly attractive and viable option through strategic public transport infrastructure development and investment initiatives. According to the City’s 2017-2018 Integrated Development Plan (IDP), the public transport morning peak-hour demand is predicted to total 617 000 commuters by 2040, from 298 000 in 2010 (Mzamo, 2017). Johannesburg has come a very long way from the inception of the Johannesburg mining camp in 1886, through its evolution to village, town, city and metropolis (see figure 1). The main

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agglomeration of its retail and financial businesses and services has only initially been centrally located in the geographical sense of the word (Beavon, 2002). In 2018 it is different story as the city has expanded and there are a number of nodes that have to be connected by good public transport, as can be seen in figure 2.

![Figure 1: Area Growth of Johannesburg and the Central Witwatersrand 1900-1992](source: Whitlow and Brooker)

![Figure 2: The distribution of shopping malls (with a minimum size of at least 10,000m²)](source: Beavon (1995))

The advent of democracy has necessitated the need to adhere to democratic principles when implementing projects. Thus, community participation is paramount especially when it is done in a way that is just not purely compliant but demonstrates a desire to co-opt the community's sentiments (Lings, 2014). According to Ng, Li and Wong, (2012) the notable paradigm shift towards greater public participation in project planning, design, construction, and decision-making is not met with same ambience in some developing countries. It is still not considered valuable but rather a costly and time-consuming exercise.

The objectives synopsis (unpacked later) was to identify the modalities of conducting public participation, the specific outcomes and the probable long-term project cost savings associated with the exercise. A qualitative research methodology was used in three projects, data were collected by online small-scale survey and face-to-face semi-structured interviews from the three institutions’ project managers, cost consultants and stakeholder relations managers that were involved in the project including secondary data gathered from project reports. The report is presented in a linear analytical format from the analysed data where emerging themes and have been coded for a comparative report. The report is concluded by the research findings and areas for future research are also highlighted.

**LITERATURE REVIEW**

Public consultation is a means to improve democratic governance by helping governments consult their citizenry on the key public policy issues the government is facing. Public consultations are normally conducted with representative samples of the citizenry, using standard scientific methods of random sampling. A sample is chosen and subsequent weighted to reflect the population census on all major demographic variables, thus producing an accurate microcosm of the citizenry (publicconsultation.org, 2018). In the South African context public consultation is considered by Mautjana and Makombe (2014) as imperative because it offers different benefits for the project owner, individuals, community's organizations and the society as a whole when the processes are undertaken transparently. If undertaken early in the
project cycle and is inclusive. If it is transparent, representative of all stakeholders, a reasonable amount of time is given for participants to prepare based on clear information and there is prevalent effective two-way communication public participation would contribute towards conflict resolution, aid project implementation and conflict management (Choudhury, 2014). It is unmistakable that a clearly defined systematic process to public participation in infrastructure projects implementation is imperative.

**Public Participation in Infrastructure Provisioning**

The decision-making process in infrastructure provisioning requires an appreciation that multiple stakeholders should be included in the process towards managing risk governance and contribution to the final decision. Li, Ng and Skitmore (2012) postulate that the inability to appreciate the various interests of multiple stakeholders have resulted in the failures of some infrastructure projects and recommends a participatory approach to project decision making. Infrastructure projects are built with a primary objective to improve the living conditions of the people and enhance their quality of life. Ng et al., (2012) affirm that infrastructure provision is aimed at improving the well-being of society; thus, communities should be involved in the decision-making process. Communities provide labour and skills in projects which enhances the development of their wellbeing by creating jobs and distribution of wealth among other things (Kumar, 2016).

Infrastructure projects are representative of diverse interest groups referred to as stakeholders such as government, investors and community members. Ng et al., (2012) categorise these groups into four namely, "government as the project initiators for a public led project and the affected or those likely to benefit, the general public and users of the ultimate product, pressure groups and regulators. Erkul (2016) refers to project stakeholders as groups which are actively taking part in a project and whose interests are likely to be affected by the consequences of project implementation or completion. Ng et.al (2012) considers a comprehensive public participation framework to be one that is aligned with the entire projects cycle from initiation and throughout the projects cycle to implementation and close out. Li, Ng and Skitmore (2012) corroborate that the infrastructure sector is a technical environment and information presented at these sessions should be in an easily communicable manner, there should be a better timing of the process, methods used should be able to reach and efficiently gather inputs and stakeholders should be supported to participate meaningfully. The International Association for Public Participation (IAP2) has also developed a useful range of public participation processes - a 'spectrum' - that is becoming an international standard for practitioners in defining the public's role in the process. The spectrum has six categories that are as follows: inform, consult, involve, collaborate and empower (IAP2, 2019).

**Public Participation in South Africa**

Public participation as a concept and practice has a long history in Europe and other developed countries. An attempt at discussing the concept of public participation started in the USA in 1835 through the works of de Toqueville called Democracy in America (Toscano, 2015). It has been a regulated practice in countries like Canada as far back as 1960s and 1970s, because it is seen an important decision-making tool in the democratic and political aspect of the country. However, where there is little accountability to the general populace like Russia the paternalistic model of social organization means public consultation is not taken seriously (Li, Ng, and Skitmore,
Kar and Jha

2012). In China as in many developing countries the processes are not yet mature and the tokenistic approach is generally implemented to get cooperation and support for decisions already taken (Li, Ng, and Skitmore, 2012).

The Constitution of the Republic of South Africa (Act 108 of 1996), provides for the basic values and principles governing public administration by directing that ‘people's needs must be responded to, and the public must be encouraged to participate in policy making’. In 1994 South African political landscape transformed into a democracy which created opportunities for review and introduction of legislation aimed at promoting participatory democracy. The cornerstone of legislation in South Africa is the Constitution of the Republic of South Africa (Act 108 of 1996) which makes provision for public participation as a process to strengthen community involvement. Some of the legislative frameworks that emerged to govern public participation are:

- The Municipal Systems Act, Act 32 of 2000
- The Municipal Structures Act, Act 117 of 1998
- Intergovernmental Relations Framework, 2005
- Municipal Finance Management Act, Act 56 of 2003
- Public Participation Framework for the South African Legislative Sector, 2013

Unfortunately, all these pieces of legislation do not speak directly to infrastructure implementation, they are concerned chiefly with how new legislation gets disseminated before final promulgation. Currently in South Africa there is no prescriptive directive on how to conduct public consultation prior to infrastructure implementation.

RESEARCH METHODOLOGY

The study is based on a qualitative research methodology due to the fact that it is about how public consultation is practiced and experienced. According to Gray (2009) in qualitative research, the researcher aims to gain an in-depth understanding of the phenomena being studied within their context. A grassroots hands-on approach was adopted in line with Merriam (2016) assertion that in qualitative research the researcher is the primary source of data collection and analysis, the process is inductive, and the product is richly descriptive. Thus, research design is considered to be an actualisation of a logical process that entails a set of procedures that augments the validity of data for a given research problem (Hancock and Algozzine, 2017). The Saunders layered onion approach was adopted in this study which postulates that research goes through a systematic process of defined layers up to a result stage (Saunders and Thornhill, 2016). This layered process is cognisant of the various stages of research from the underlying philosophies to the last stage of data collection and analysis. Given the qualitative research methodology used in this research, the purpose of the research was exploratory, with the use of critical realism philosophical perspective. The critical realist view of research is focused on explaining what is seen regarding the underlying causal realities that shape what is seen. The underlying philosophy for this study is based on an epistemological assumption that the observed modalities of public participation in infrastructure provisioning of time and cost overrun and outward rejection of some projects may be a result of the lack of a clearly defined process.
Three projects were utilized as cases namely Gautrain rapid rail link, the Gauteng Freeway Improvement Plan and the Bus Rapid Transport system in Gauteng. A case study strategy was chosen as an appropriate strategy to gain a broader and generate in-depth understanding of project specific information of the selected case study projects, which will provide context from engagements and lead to rich and empirical descriptions and theory development (Saunders and Thornhill, 2016). On the other hand, Hancock and Algozzine (2017) affirms and denotes that there are three critical characteristics of a case study namely, it is a focused study on a phenomenon, and the phenomenon is studied in its natural form within a particular time. This allows the use of multiple sources of gathering data and direct quotes from participants and illustrations which provides for a diverse descriptive source of information. These scholarly affirmations of a case study strategy in research, affirms the relevance and appropriateness in this study and makes recommendations that have been adopted in this research. In that, in this study smaller sample size was chosen, multiple sources of data collection tools were used namely project reports, online survey and face to face interviews.

Primary data was collected by firstly, conducting an electronic survey distributed to a population of 20 participants' representative of project managers and professionals in the infrastructure sector from within and without the participant case study organisations, outsiders were helping in proving independent assessments of how the consultation processes were carried out. A purposive sampling technique was used to ensure that mostly project managers that were directly involved in the process throughout were used to provide relevant insights. Secondly, face to face semi structured interviews were administered to a maximum of two senior project managers and a stakeholder relations manager from each of the three participating agencies which proved to be a good source of primary data. Secondary data for the study was collected from project reports provided by case study organisations. In qualitative research, data analysis is continuous processing, comparison and an assessment procedure that starts when the researcher begins to collect literature on the subject or gets into the field to gather empirical data (Gray, 2009).

Thematic Analysis was used to analyse interviews. Thematic analysis is the process of identifying patterns or themes within qualitative data. The goal of a thematic analysis is to identify themes in the data that are important or interesting and use these themes to address the research or say something about the issue. Thus, a good thematic analysis interprets and makes sense of it (Clarke and Braun, 2013). A six-phase guide provided by Braun and Clarke (2006) was used as a framework for this study and the steps are as follows: 1) Become familiar with the data, 2) Generate initial codes, 3) Search for themes, 4) Review themes, 5) Define themes and 6) write-up. Inductive Content Analysis was used for analysing the documents. Content analysis is a research method for making replicable and valid inferences from data to their context, with the purpose of providing knowledge, new insights, a representation of facts and a practical guide to action (Krippendorff, 1980). The aim is to attain a condensed and broad description of the phenomenon, and the outcome of the analysis is concepts or categories describing the phenomenon. Usually the purpose of those concepts or categories is to build up a model, conceptual system, conceptual map or categories. This process includes open coding, creating categories and abstraction. After this open coding, the lists of categories are grouped under higher order headings (McCain, 1988). The aim of grouping data was to reduce the number of categories by collapsing those that are similar or dissimilar into broader higher order categories.
Abstraction means formulating a general description of the research topic through generating categories (Robson, 1993). Each category is named using content-characteristic words. Subcategories with similar events and incidents are grouped together as categories and categories are grouped as main categories (Dey, 1993). The abstraction process continues as far as is reasonable and possible. The two methods discussed above serve two distinct purposes, Content analysis describes the characteristics of the document about who says what, to who and with what effect whereas on the other hand Thematic analysis is method of identifying, analysing and reporting patterns within data.

The Gautrain: Case 1

The Gautrain Rapid Rail Link is the first rapid rail link in Africa. This network consisting of ten stations with 80 kilometres of railway lines was procured using the Public-Private Partnership (PPP) model and it cost more than 24 Billion Rand (~1.8$USbn) and its operations commenced in 2010 on the Sandton OR Tambo International Airport route. The Gauteng Provincial Government was the primary public partner including the other strategic partners. The project is considered to be amongst the most successful rapid rail mega transport infrastructure schemes located in South Africa. Because of its sheer size, multiple stakeholders with competing priorities and expectations were involved from the political, financial, technical and environmental sectors and had a say on how the project was to be implemented.

The Gauteng Freeway Improvement Project (GFIP): Case 2

The Gauteng Freeway Improvement Project (GFIP), was implemented by the National Government (Department of Transport) which appointed South African National Roads Agency Limited (SANRAL) as an implementing agent. The scheme comprised of 561 kilometres of national and provincial roads transferred to SANRAL consisting of the first phase of upgrading and lane additions on existing freeways (185 kilometres), future upgrades on existing roads (223 kilometres) and new freeways (158 kilometres). Apart from widening of the freeways, the GFIP project will also ensure that bottlenecks at interchanges are resolved. For the first phase of the GFIP, 34 interchanges are significantly upgraded. Furthermore, median lighting and an Intelligent Transport System (ITS) consisting of cameras, electronic notice boards and other traffic management features along the national routes will be provided. Electronic tolling was designed to be used to recoup the costs of the project.

The Bus Rapid Transport System (BRT)

This project was approved in 2006 by the City of Johannesburg (COJ) to implement the project in phases to transform Johannesburg's public transport to world standards. This paradigm shift in upgrading the Strategic Public Transport Network (SPTN) into a higher-quality public transport system utilised an approach known as Bus Rapid Transit (BRT)-Rea Vaya. The project was regarded as an opportunity of empowerment and transformation of the previously disadvantaged public transport operators, particularly minibus-taxi and small bus operators. For the commuters the project offers a car-competitive alternative, a much-hoped-for shift to public transport, and at the spatial restructure the City along transport nodes. The long-term vision is for 85 percent of Johannesburg’s population to be within 500 meters of a Rea Vaya trunk or feeder corridor (COJ, 2006). The project was implemented towards the 2010 world cup build up and the rollout of some routes commenced in August 2009 and the second phase thereafter.
FINDINGS AND DISCUSSION

For a data analysis and presentation and in attaining a logical case study comparative analysis, the systematic, participatory framework for highly sensitive Public Infrastructure Projects recommended by Ng et al., (2012) was used. This framework is based on the principles that there is a relationship between public participation and the success of the implementation of infrastructure projects (Ng et al., 2012). The framework postulates that the impact caused by infrastructure projects necessitates that participatory activities should be an integral part of the plan from inception to construction. The process should carefully select participatory techniques, allow a reasonable time for engagement, ensure that project information is communicated to relevant stakeholders and feedback is collated. The project stages as per the systematic framework will be utilised to guide the comparative analysis and they are listed below (see table 1 below):

Project Initiation: this stage in the framework requires that the public be involved in developing a participatory strategy, making inputs into the project and also strategies of how to manage their expectations.

Project Planning: At this stage the revision of the project plans if necessary are made to accommodate the community's inputs, as the social and environmental impact is very important. And the communication techniques used are focus group meetings, face-to-face interviews and public forum meetings.

Project Design: here the designs have been fully developed and public concerns should result in altering the original designs if necessary, the expectations of the public should carefully be managed.

Project Construction: It is at this stage that the community should be continuously consulted on issues that emerge at construction including the evaluation of the participatory programme. The framework suggests that this shall be embarked upon with all stakeholders that have been involved in the project utilising public briefing meetings.

The findings will be further discussed vis-à-vis the objectives of the study.

1) The relationship between public consultation and project commencement-the Gautrain took the longest because the EIA was combined with extensive public consultation process that took eight (8) years. People were mostly worried about tunnels running below their properties. The implementation was never a big problem. The GFIP did not go far enough in consultation, and the result is the refusal of the public to pay their e-tolls and hence the stifling of the project revenue stream. The BRT project was met with a lot of resistance from the taxi and bus industry stakeholders but the offer of the shareholding in the BRT Company to the taxi and bus owners led to a breakthrough among other challenges that were encountered. Respondents to questionnaires (80%) appear to agree that given enough time most misgivings can be dealt with and the interviews revealed similar patterns that are aligned with Ng et al., (2012) position.

2) The Timing of the Consultation process-the three projects showed that timing has to be commenced very early before a lot of money could be spent on other project related initiatives. Gautrain took the longest time and consultation was ongoing throughout the project implementation. The other two projects took under two years to engage in consultation initiatives and there were met with different levels of resistance. It is clear from the foregoing that the consultation process must run its
course. There is strong sentiment among respondents (65%) and all the interviewees decrying that sometimes a lack of support from the politicians lead to mishandling of the process.

Table 1: Stage-by-stage Approach Undertaken on Each Project

<table>
<thead>
<tr>
<th>Project stage</th>
<th>Gautrain</th>
<th>GFIP</th>
<th>BRT (Rea Vaya)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Initiation</td>
<td>Concept development and sharing with strategic stakeholders (enabling).</td>
<td>Consultation guided by NEMA, EIA and issuing of notice of intent for comments.</td>
<td>The critical stakeholders consulted - the taxi industry and bus industry.</td>
</tr>
<tr>
<td></td>
<td>Inputs were gathered from stakeholders</td>
<td>A notice of intent was published in an official gazette for a 30 days circulation</td>
<td>Public engagements undertaken</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A technical steering committee established (national, provincial and local government tiers)</td>
<td></td>
</tr>
<tr>
<td>Project Planning</td>
<td>Consultation with the public was undertaken for a period of not less than 8 years</td>
<td>GFIP Project steering committee representative of strategic stakeholders.</td>
<td>A study tour with taxi and bus industry and some community members was taken.</td>
</tr>
<tr>
<td></td>
<td>Extensive consultations delayed progress</td>
<td>A gazette on the notice of intent was issued including print media advertisement</td>
<td>Stakeholders were engaged and led to the revision of originally planned routes.</td>
</tr>
<tr>
<td></td>
<td>Communication was through Public meetings and broadcast and print media.</td>
<td></td>
<td>Public meetings and print and broadcast media was used for communication</td>
</tr>
<tr>
<td></td>
<td>Stakeholders were identified and classified according to their level of influence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Design</td>
<td>Noise concerns led to redesigns of some stations</td>
<td>Inputs on noise barriers on the freeway were considered and revisions of designs were done</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The EIA was further revised with inputs from stakeholders</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Disagreements referred to tribunal and/or litigation in a court of law.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Construction</td>
<td>Construction progress updates were provided through media</td>
<td>Construction progress updates were provided through media and stakeholders were kept informed</td>
<td></td>
</tr>
</tbody>
</table>

Source: Author

3) The adequacy of the consultation process--The appropriateness of a process in the context of this research is measured by the extent to which it complies with legislative provisions and the extent to which all properties of a project have been clearly communicated and the response of stakeholders taken into account. The consultation process undertaken by GFIP with its limitations was only compliant to the current legislative provisions on engagements with interested and affected persons. There is no evidence of any innovative far reaching ways of gathering public sentiments. On the other hand, Gautrain's processes with its attention to detail were faced with some level of dissatisfaction which dissipated with time. Rea Vaya projects identified critical stakeholders and engaged them continuously throughout the implementation process. Although nobody wanted to commit to what is adequate it is clear that each project dynamics should be considered when estimating the resources allocated to the process. The effective way is to follow the empowering principles promulgated by IAP2 (2019), which was not the case especially with the GFP.

4) The type of public consultation model used -- the various consultation approaches utilised could not be linked to a clearly defined process whose efficiency can be measured. In keeping with the global paradigm shift of actively acknowledging and
involving communities in critical decisions on infrastructure project implementation a clearly defined process embedded in a model is imperative. Such a model is recommended to draw reference to the systematic, participatory framework by Ng et al., 2012 which postulates that, participatory activities should be built into every stage of the project from inception to construction. The lack of legislative prescriptiveness in is cited by interviewees as the main source of mishandling consultation in the projects.

**CONCLUSIONS**

The consultation process for infrastructure projects in South Africa is not properly articulated in the legislation. However, it has been shown in this study that if there is a genuine intention to solicit the sentiments of the general populace there will always be ways that could be found to elicit cooperation of the masses because of that will. The time has been established as an element of immense importance when it comes to public consultation, enough time should be allocated in order to allow people to understand and have realistic expectations of the deliverables of the project. Identification of critical stakeholders' organizations is important as they are generally observed in South as being on the side of the people and they are not regarded as being 'captured' by the corporate interests. In South Africa currently there is no indigenous model that has emerged and that should be direction that future studies should take.

**REFERENCES**


HYBRID ORGANISATIONAL ARRANGEMENTS AND THE ROLE OF MULTIMODALITY

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Hybrid organisational arrangements experience interest among scholars and practitioners due to increasing prevalence of pluralistic institutional environments in modern societies. Hybrids are perceived to do well in such environments because of their ability to combine institutional logics and thereby address a wider set of institutional referents compared to non-hybrids. Besides the growing attention to hybrids, a yet neglected but nascent interest on organisations’ use of multimodality to communicate, compete, form identities and organise activities is rising. In this paper, we consolidate the growing interest on hybrids and multimodality by studying the role of multimodality in a strategic partnership, which we define as a hybrid combining institutional logics. The theoretical approach consists of concepts from the literature on institutional organisational analysis that is considered suitable for a study of multimodality in hybrids. The analysis is organised in a prelude and three organisational narratives based on data collected during 2018-19 through observations and qualitative interviews. The analysis provides insights into the development and mobilisation of multimodalities in the investigated hybrid. Furthermore, the analysis illustrates how material and visual multimodalities influence the shaping of internal and external hybrid relations. This includes for example the development of a hybrid practice that eliminates criticism from organisations outside the hybrid, a portfolio office that enables the shaping of a hybrid identity and a standardised budget form that constitutes a basic scheme for organising action across divergent social parties in the hybrid. This paper contributes to the growing literature on hybrids and multimodality with novel insights from a strategic partnership operating in the construction industry.

Keywords: hybrid organisations, institutional logics, multimodality, strategic partners

INTRODUCTION

Hybrid organisational arrangements (or simply 'hybrids') have in recent years experienced interest among scholars and practitioners because organisations in modern societies increasingly are confronted with competing institutional demands (Kraatz and Block, 2008). Hybrids occur for example as public-private partnerships, social enterprises and venture philanthropy organisations (Ocasio and Radoynovska, 2016), and are considered an effective way to pool competencies, practices, artefacts, etc. across private, public and non-profit sectors (Doherty et al., 2014). Hybrids are thus supposed to effectively address 'complex problems' related to competing institutional demands that cannot be solved by drawing narrowly on a single logic but require attention to the plurality of institutional environments that organisations operate under (Jay, 2013; Pache and Santos, 2013).

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In this paper, we examine a strategic partnership between a public client and a private business unit to build cost effectively and deliver increased public value. We consider the strategic partnership as a hybrid represented by the public sector that traditionally is guided by principles of public benefit and collective choice, and the private business unit that traditionally is guided by market forces (Doherty et al., 2014). From a construction management perspective, Barraket and Loosemore (2018) argue that there is little understanding of how private firms collaborate with non-market entities in meeting new goals, and of the institutional and organisational factors shaping new practices. This has been discussed extensively in research on social entrepreneurship, where hybrids, however, have been treated as predominantly verbal and written achievements, and where explanations of hybrids’ mechanisms have largely neglected the material and visual modalities that are also found in contemporary organisations (Boxenbaum et al., 2018). Recent research streams even proclaim that material and visual modalities constitute organisations and institutions (e.g. Meyer et al., 2018). Construction industries are rich in examples of visual images (technical drawings, organisation charts, diagrams, etc.) and material objects (building materials, instruments, tools, etc.) that reify logics of action and patterns of organisation as material facts (Jones et al., 2017; Boxenbaum et al., 2018). Such materialisations enable ideas to endure over time and provide a source of institutional stability that constitutes a critical challenge for attempts to promote and manage change in the industry. Organisations' and in particular hybrids' efforts to address competing institutional demands thus also depend on their ability to mobilise and manage material and visual modalities from the plurality of environments in meaningful ways.

The objective of this paper is to explore the role of multimodality (multiple sources of modality) in a hybrid organisation with a special focus on material and visual modalities. We consolidate the growing interest on hybrids and multimodality by highlighting how a hybrid develops and mobilises particular multimodalities and how these affect activities in the hybrid. In doing so, this paper also contributes to the debate on materiality in construction management scholarship as advocated by e.g. Styhre (2017) and Sage (2017) by providing novel insights about the role of multimodality in a hybrid operating in the construction industry.

Institutional Organisational Analysis

In this section, we present a brief overview on the literature of hybrids and multimodality in institutional organisational analysis.

Hybrid organisational arrangements and the multiplicity of institutional logics

The growing occurrence of hybrids can be explained by an increasing prevalence of pluralistic institutional environments in modern societies (Kraatz and Block, 2008; Thornton and Ocasio, 2008) characterised by the presence of multiple, competing, and often contradictory institutional logics (Ocasio and Radoynovska, 2016: 287). Organisations embedded in such environments are exposed to multiple and sometimes contradictory institutional demands (Pache and Santos, 2010), which can be addressed by establishing hybrids (Greenwood et al., 2011). Hybrids are supposed to do well in pluralistic environments because of their ability to address a wider set of institutional referents compared to non-hybrids (Pache and Santos, 2013). They do so by combining and reconfiguring institutional logics in an effort to achieve hybrid identities, hybrid logics, hybrid organisational forms and hybrid practices (Greenwood et al., 2011). Institutional logics guide legitimate behaviour and prescribe taken-for-granted conceptions of goals that are legitimate to achieve (Pache and Santos, 2013).
Additionally, institutional logics provide a link between actors' cognition and behaviour and the socially constructed institutional practices and rule structures guiding the actors (Thornton and Ocasio, 2008). The combination of institutional logics in hybrids is thus a way to reach specific goals leading to unique organisational arrangements (Kraatz and Block, 2008; Battilana and Dorado, 2010; Pache and Santos, 2013). In addition, hybrids must deal with both competing external demands and internal identities forming organisational life that potentially trigger conflicts as well as innovation (Jay, 2013).

Hybrids' entanglement with multiple institutional logics in search for hybrid characteristics is, however, not only a matter of cognition or linguistic/verbal components of logics. It is also about which multimodalities are mobilised and how these allow or hinder the creation of hybrid characteristics (Greenwood et al., 2011), affect community and individual agency (Styhre, 2017) and shape organisational goals and ambitions (Tryggestad et al., 2010). In a construction management perspective, institutional organisational analysis has recently been acknowledged as an absent but valuable approach to highlight change in construction industries (e.g. Barraket and Loosemore, 2018; Chan, 2018). However, this has been without elaborating the material side of construction practice, which otherwise plays an important role in understanding conditions for change (Harty and Whyte, 2009).

**Multimodality**
In recent years, scholars have given attention to multimodalities and their ability to ensure community action in organisations (e.g. Croidieu et al., 2017; Zilber, 2017). The term multimodality refers to verbal texts such as written documents, oral recordings and videos but also to material and visual artefacts such as building materials, charts, images and symbols, which shape, translate and stabilise ideas, beliefs and values across time and space (Boxenbaum et al., 2018; Meyer et al., 2018; Jones, 2019). The 'material and visual turn' in organisation studies arose due to an acknowledgement that contemporary organisations increasingly rely on multimodal sources to communicate, compete, form identities and organise activities, and that these sources often are of material and visual characters (Boxenbaum et al., 2018). Nonetheless, the role of material and visual artefacts has been largely neglected despite such multimodalities frame how actors and organisations act as well as facilitate institutionalisation processes (Meyer et al., 2018).

Within institutional organisational analysis, it is widely recognised that actors and organisations are strongly influenced by institutional pressures in search for legitimacy. However, institutions' underlying logics are rendered visible through material and visual artefacts (Jones et al., 2017) as logics reciprocally bridge the macro structures of institutions and micro processes of individual and organisational action (Thornton and Ocasio, 2008). Croidieu et al., (2017: 38) even argue that institutions are maintained by utilising and combining multimodal resources and that multimodality can highlight “…how community members employ linguistic, visual, and material resources, which shape their experience of institutions”. Individuals and organisations' activities and their mobilisation of multimodalities are thus guided by logics referring to institutions (Jones, 2019). Moreover, institutions are also multimodal achievements influenced by the multimodal presence and effort to ensure for instance stability or transformation through certain activities (Meyer et al., 2018).

Hybrids mobilise several multimodalities to address demands from the plurality of institutional environments (Jay, 2013) in order to achieve legitimacy (Pache and
Santos, 2010) as well as to develop and maintain hybrid characteristics (Greenwood et al., 2011). Multimodal resources can therefore be considered assets that maintain institutions as multimodal achievements, influencing actors and organisations through all senses (Croidieu et al., 2017).

**RESEARCH DESIGN AND METHODS**

This study examines the strategic partnership between the public client, Aedificare, and the private business unit, Fiducia, comprised of six companies from the construction industry of Dania. Aedificare is anchored in the Finance Administration of Hafnia and manages building projects for Hafnia's seven administrations. From primo 2017 to ultimo 2020, Aedificare has tasked Fiducia with a portfolio of 40 new-built and refurbishment projects of schools and day-care institutions worth €320M.

We collected data from the examined strategic partnership over a one-year period starting from spring 2018. The data was collected through participant observations and qualitative interviews. The observations covered several kinds and numbers of meetings such as development meetings, dissemination meetings, orientation meetings, onboarding meetings, steering group meetings, as well as observations at the common portfolio office three-four days a week to reveal 'on-site' communication and ongoing discussions (Pink et al., 2010). The qualitative interviews were conducted with informants from Aedificare and Fiducia. Each of the 17 interviews lasted 45-60 minutes and was audio recorded and transcribed. The setup of the interviews was explanatory, and the interviewees were all informed about the scope of the study.

The analysis is organised in a prelude and three organisational narratives providing insight into the use of multimodality in the investigated hybrid. Organisational are temporal, discursive constructions that introduce the reader to individual, social, and organisational sensemaking and sensegiving (Vaara et al., 2016). Such narratives allow us to explore and understand the multimodal role in the hybrid's effort to ensure transformation and stability under pluralistic influence (Vaara et al., 2016).

**ANALYSIS**

A prelude and three organisational narratives are presented in this section. The prelude outlines the current situation in Hafnia and the institutional demands experienced by the hybrid. Each of the narratives demonstrates the hybrid's mobilisation and use of multimodalities to redeem certain outcomes such as legitimacy and stability by addressing institutional referents and development of hybrid characteristics.

**Prelude**

In 2015, the City of Hafnia released a brand-new municipal plan describing the city's situation and visions for the coming years. The plan predicted a population growth of 100,000 citizens towards 2027 which would increase the pressure on the public services, such as schools and day-care institutions. Besides the expected population growth, the municipal plan also described a need to strengthen the city's green profile and welfare system thus constituting an effort to pursue and address multiple societal agendas. The multiple agendas, however, represented a complexity of competing institutional demands that generated a pressure on Hafnia as prioritisation of schools and day-care institutions for example would slow the green transition and vice versa.
Due to the experienced pressure, in 2016 Hafnia commissioned a report from a consulting firm, which recommended means to navigate through the complexity. The report argued that long-standing droves of plans, policies, strategies and guidelines had established and maintained a high but expensive one-of-a-kind architectural standard in Hafnia, which impeded productivity and buildability. On this basis, the report's recommendations were to downgrade the architectural ambitions in Hafnia and to open up for strategic partnership tenders based on portfolios in order to spur learning loops and repetition effects. Furthermore, the report described strategic partnerships as a multifaceted approach with the ability to address the need for more schools and day-care institutions in Hafnia in such a way that financial latitude was made for e.g. the green transition. Strategic partnerships were thus stated as a catalyst to address multiple competing institutional demands.

Narrative 1: Creating 'the Sitting Box' as a hybrid practice
Five months after receiving the commissioned report, Hafnia's client organisation, Aedificare, announced a tender for a framework agreement on two strategic partnerships worth €400M. The objective was to reduce the city's building expenses with at least 10% without compromising quality. Aedificare also wanted to use the strategic partnership tenders to strengthen their role as public client by developing new principles for how to manage tender processes in the most economically advantageous way. Aedificares' focus on economy was, however, subjected to harsh criticism by the Association of Architectural Firms that used the media to proclaim that the quality would suffer because of the strategic partnership model's focus on rationalising construction processes at the expense of aesthetics. The media coverage reflected the concerns with contributions about the strategic partnerships that would "change Hafnia's appearance the coming years", while the economic rationales behind the tenders were masked. The media thus ended up as a forum where the strategic partnerships were discussed as a matter of economy vis-à-vis a matter of aesthetics.

Fiducia took notice of the criticism and realised that the strategic partnership from the very beginning would experience resistance from the industry if the criticism was ignored. Therefore, they developed a concept named 'the Sitting Box' that aimed at strengthening the link between Fiducia and the industry thereby eliminating the criticism. The Sitting Box was in the bids described with a twofold purpose. First, it ensured the incorporation of competencies, knowhow, tools, etc., from outside organisations, meaning that the industry was given the opportunity to contribute in the development. Second, it ensured that valuable learnings and developments not only provided benefits for the organisations in Fiducia, but also for the industry in general. The Sitting Box allowed Fiducia to adopt a strategy of selective coupling, enabling the hybrid to manage the incompatibility between logics (Pache and Santos, 2013). Fiducia hence used the Sitting Box to position itself in a situation where they selectively could decide what practices and professional logics from outside organisations the strategic partnership wanted to hybridise with (Thornton and Ocasio, 2008; Greenwood et al., 2011). Fiducia e.g. used the Sitting Box to mobilise architectural competencies from outside the strategic partnership.

Narrative 2: Shaping a hybrid organisational identity through the portfolio office
In autumn 2016, Aedificare announced that the consortium Fiducia was awarded the larger of the two strategic partnership tenders. During the preparation of the bids, Fiducia described a common strategic partnership office as a necessary platform for collaboration and a prerequisite for a successful strategic partnership. Therefore,
employees allocated to Fiducia were moved from their respective organisations into a strategic partnership office with no existing company-specific rules, norms or identity.

In effort to avoid subgroup identities and tensions between logics in the strategic partnership (Battilana and Dorado, 2010), Fiducia wanted to foster a common organisational identity and commitment to the strategic partnership across all project members. Hence, the portfolio office was identified to become the main reactor to spur common organisational identity. Organisational identity can be defined as the "...attributes that define the organization as different from other organizations - especially those sharing the same institutional category" (Greenwood et al., 2011: 347). Promoting a certain organisational identity allowed Fiducia to guide behaviour in order to prioritise responses to the competing institutional demands related to multiple professional logics (Kraatz and Block, 2008; Greenwood et al., 2011).

The operational management in Fiducia adapted an organisational structure based on 'soft values' such as collaboration, mutual recognition, transparency and trust to create an organisational identity that allowed project members to work as one common unit. A meeting policy was furthermore implemented requiring that all project members should carry out their daily work at the portfolio office and participate in certain meetings such as onboarding meetings and dissemination meetings. The onboarding meetings introduced new project members to Fiducia's core story and how to behave as a part of the strategic partnership. The dissemination meetings worked as 'spaces of negotiations' (Battilana et al., 2015) allowing project members from distinct groups of the strategic partnership to discuss the trade-offs related to the portfolio projects despite their organisational placement.

Several symbols supporting soft values were also implemented at the portfolio office and in the project members' daily routines e.g. semiotic signs on the walls guiding how a project member in Fiducia should act, a 'hall of fame' section at the intranet where project members of Aedificare and Fiducia were mentioned and the Wi-Fi password 'collabor8'. The portfolio office thus became subject to materialisation of soft values (Boxenbaum et al., 2018) as material and visual artefacts and hidden cognitive messages guided project members in how to behave as a part of Fiducia, thus constituting a common organisational identity balancing the different logics present in the strategic partnership (Battilana and Dorado, 2010; Jones et al., 2017).

**Narrative 3: Developing the 'budget front' as a public-private boundary object**

In autumn 2017, Fiducia delivered their first strategic partnership project worth €1,400M. The impressions from the client organisation, Aedificare, and Fiducia were that the project was cheaper than expected and delivered on time. They even reported to the media, Construction Today, that the strategic partnership model had "proven its worth". Nevertheless, data reported to an external benchmark operator, Benchmark Centre for the Construction Sector, told a less romantic story, with a budget overrun of 40% and a schedule overrun of 60%. The overruns meant that project data were revisited by the two poles of the strategic partnership. This revealed the use of two very different calculation traditions. For Aedificare, a project price included building expenses as well as assurances, building site consumption, client access to the software platforms, consultancy, land purchase, mains water installations, rehousing, etc. For Fiducia, however, a project price only included building expenses related to their delivered services without special client deliveries and Aedificare's internal project-specific expenses. Furthermore, Aedificare reported expected time and prices to the benchmark operator in the early stage of the project while Fiducia reported time
Hybrid Organisational Arrangements and the Role of Multimodality

and prices when the project was completed. During the project period, Aedificare, however, requested extensions in the project which meant that the reported data included different attributes and reflected time and prices differently. Respectively, reported data reflected the planned project from Aedificare's perspective and the realised project from Fiducia's perspective. Aedificare and Fiducia thus agreed to test their different calculation traditions on a reference project born outside the strategic partnership, which Fiducia had completed for Aedificare earlier. This allowed a comparison of the two calculation traditions. Aedificare's calculations on the reference project estimated a square meter price of approx. €3300, while the contractor from Fiducia stated a square meter price of approx. €4100. According to the Head of Fiducia, the differences were a threat to the strategic partnership model's legitimacy as it exhibited Fiducia as an unserious partner due to the vague explanations of the economic variations.

Aedificare and Fiducia agreed on developing a standardised calculation method that could bridge understanding and couple different calculation practices. The new calculation method was named 'the budget front' and represented a material manifestation that enabled Aedificare and Fiducia to translate the calculations from the strategic partnership into the calculation traditions found in their respective organisations. In the creation of the budget front, it was also decided that site-specific costs such as site pollution should be calculated separately from building expenses because two identical projects otherwise could show two different prices. Furthermore, Aedificare and Fiducia agreed on a calculation practice where project overruns in the budget front only could happen in two circumstances. The first circumstance was if Aedificare would acquire an extra service that expanded a project's scope but also added value. The second circumstance was if Fiducia would be unable to deliver on time and to price, which would decrease the value on a project. The budget front thus appeared as a boundary object between public and private social parties (Star and Griesemer, 1989) allowing Aedificare and Fiducia to maintain their traditional calculation traditions on strategic partnership projects without conflicts. It furthermore marked the need to uphold collaboration to ensure stability and legitimacy in the strategic partnership (Jones et al., 2017).

DISCUSSION

In the analysis we have identified three different multimodal sources mobilised in the investigated hybrid. A yet underexposed but highly relevant discussion that we will illustrate in this section is how the mobilised material and visual multimodalities reify distinct logics of action in the hybrid in an effort to achieve certain outcomes such as legitimacy, stability or hybrid characteristics. In the first narrative, the Sitting Box was developed as a response to criticism from the industry. According to Ocasio and Thornton (2008), market reactions to certain corporate practices are influenced by the prevailing institutional logic in the specific field. In this particular narrative, the hybrid's desire to reduce building expenses, thereby meeting the client organisation's demands, conflicted with practices on aesthetics found in the industry. The Sitting Box therefore functioned as a hybrid practice that eliminated the criticism from the industry by combining an administration logic, represented in the hybrid by Aedificare, and prevailing professional logics from outside the hybrid.

In the second narrative, the portfolio office was identified as the main reactor to spur common organisational identity, which was seen as essential for the success of the hybrid. Members of any organisation tend to defend the institutional logic they
themselves are socialised into (Pache and Santos, 2010). However, hybrids are by definition composed of multiple internal identities (Jay, 2013) meaning that tensions are likely to occur because of identity claims shaped by different professional logics (Kraatz and Block, 2008). Hybrids thus create a common organisational identity to strike a balance between the logics the organisation combines (Battilana and Dorado, 2010). The investigated hybrid created a common organisational identity by mobilising soft values into the portfolio office and in the project members’ daily work routines at the portfolio office. A result of this was that activities in the portfolio office constantly demanded presence of project members affiliated to different organisations with different organisational identities carrying diverse professional logics (Battilana et al., 2015). Hence, project members in the hybrid were forced to prioritise the common organisational identity over individual identities as it was necessary to avoid mission drift and maintain a productive collaboration between the involved organisations. The portfolio office therefore ensured the creation of a common hybrid organisational identity shaped by a community logic encoding and combining the professional logics in the hybrid.

Finally, in the third narrative, the budget front was introduced as a boundary object bridging understanding and couple different calculation practices in the hybrid. The different calculation practices in Aedificare and Fiducia gave rise to uncertainties regarding costs and efficiency in the hybrid, which potentially could delegitimise the strategic partnership. The hybrid therefore agreed on developing a standardised calculation method. However, the hybrid, which operates in a pluralistic environment, experienced conflicting demands imposed by their institutional environments (Pache and Santos, 2010). Aedificare experienced demands on reporting specific data to other departments in the public system, which meant that price data had to be handled in a specific way and form. Fiducia, on the other hand, could not incorporate expenses that were not construction related in a competitive market as prices would become non-comparable to other construction projects in the industry. Aedificare was thus influenced by an institutionalised practice in the public system guided by an administration logic, while Fiducia was under influence by an institutionalised practice guided by a market logic. The budget front was therefore framed as a novel calculation practice functioning as a boundary object, allowing the addressment and maintenance of both logics as well as legitimising the projects in the portfolio. An overview over the three multimodalities presented in the narratives and their characteristics is shown in Table 1.

Table 1: Overview over the three multimodalities and their characteristics

<table>
<thead>
<tr>
<th>Narrative/Multimodality</th>
<th>Functions between</th>
<th>Mobilised because of</th>
<th>Occurs as/Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The Sitting Box</td>
<td>The hybrid (administration logic) and the industry (professional logics)</td>
<td>Pressure from the industry</td>
<td>A hybrid practice eliminating criticism and maintaining legitimacy</td>
</tr>
<tr>
<td>2. The portfolio office</td>
<td>The involved organisations in the hybrid (several professional logics)</td>
<td>Presence of multiple organisational identities</td>
<td>A hybrid identity combining several identities</td>
</tr>
<tr>
<td>3. The budget front</td>
<td>The private (market logic) and the public (administration logic) parties in the hybrid</td>
<td>Different calculation traditions</td>
<td>A boundary object allowing the addressment of conflicting institutional demands</td>
</tr>
</tbody>
</table>

CONCLUSIONS

As shown in the analysis, the establishment of hybrids across public and private sectors is not just a simple and smooth way to address multiple competing institutional
demands. It penetrates and relocates existing institutionalised practices, organisational identities, organisational structures, etc. The establishment of hybrids, however, provides an opportunity to foster novelty across highly institutionalised fields and material and visual multimodalities play an important role in this pursuit. The mobilisation of material and visual multimodalities with certain characteristics facilitates the development and maintenance of a hybrid nature, handling tensions between logics internally in the hybrid and between the hybrid and logics found outside the hybrid.

In this paper we have illustrated how a hybrid develops and mobilises material and visual multimodalities to combine institutional logics in the midst of pluralistic environments to achieve hybrid characteristics, legitimacy and stability. On this basis, we conclude that material and visual multimodalities play an important role in hybrids as a facilitator, enabling hybrids to combine multiple institutional logics and institutionalised organisational structures and practices in search for a hybrid nature.

REFERENCES


DUTCH WATER BOARDS AS A CONSTRUCTION CLIENT

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Unlike other countries such as the United Kingdom, water boards in the Netherlands are part of the government and are independent public entities with democratically elected officials. For their task in water management such as protection against the water and purifying wastewater they publicly procure construction projects. This paper shows that by adopting a fit-for-purpose procurement strategy, the Dutch water boards can contribute to effective client-contractor relations. The research question is: What characterizes Dutch water boards as public clients on the construction market, and which challenges and opportunities do they face? Desk research was performed into the characteristics of the Dutch water boards, such as the size and complexity of their portfolio, their organizational structure, and the productivity of their projects. Then 9 project managers of different water boards and 9 project managers from industry were interviewed to explore the issues and best practices in Dutch water board projects. Public clients and their private contractors both stated that procurement strategies regularly not match project needs. Contractors thereby notice that they regularly cannot sufficiently apply their innovative capacity in projects, or on the contrary that the required project delivery methods are too complex. The findings show that tender timing related to contractor availability, and reducing tender costs are important elements of the procurement strategy. The data also shows that there are challenges in fostering project productivity. Informal aspects of client-contractor relationships such as regular communication, guided by planned work meetings, are being regarded as crucial elements that get too little attention in projects.

Keywords: client-contractor relations, public procurement, project management

INTRODUCTION

There is no contemporary research done on the Dutch water boards as a construction client. The purpose of this research is to fill this knowledge gap. This research aims to provide a basis to compare the Dutch water boards with other clients in the Netherlands, and to compare the water boards internationally. The first objective is to clarify the position and portfolio of the water boards. The second objective is to provide insights for practitioners to improve client contractor relations in the hydraulic engineering market, and by this to contribute to the construction sector. The research question is: What characterizes Dutch water boards as public clients on the construction market, and which challenges and opportunities do they face?

The Dutch water boards have a unique position in the Netherlands and the world. This is because unlike other countries such as the United Kingdom, water boards in the Netherlands are part of the government and are independent public entities with

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democratically elected officials. The Dutch water boards are with 940 million euros invested each year responsible for 35% of the total hydraulic engineering market in the Netherlands. In this sector the water boards are even a larger client than the central government. The Dutch construction sector, and specifically the hydraulic engineering market, is therefore inextricably linked with the Dutch water boards as a public client. This contains an opportunity to understand and improve works in this sector.

In recent years procurement has become an emerging field of interest. Several authors provided a definition of procurement such as: “procurement refers to the function of purchasing goods or services from an outside body” (Arrowsmith, 2008), and: “public procurement is the acquisition and utilization of goods and services required by government institutions.” (Manunza and Schotanus, 2018) (Callender and Matthews, 2002). But there is more to procurement than meets the eye, procurement has to be done following public procurement rules and taken subsequent process steps. van der Puil and van Weele (2014) developed a procurement process model accordingly. The procurement model in this paper acts as a guideline to address the research question, and to organize the findings. This not only provides insights into the water boards, but also where the challenges and opportunities lie in the process. In this way the findings can be related to the relevant scientific literature, and it becomes possible to compare the Dutch situation in an international context.

The first part of the procurement model is related to the two mandatory phases under the Dutch public procurement act: selection phase and award phase. The first part of the procurement process is also about selecting the right procurement procedure (open procedure, restricted procedure, etc.) and choosing the right contract model (traditional contract, integrated contract, life cycle contract). The second part of the procurement process covers the operational elements, this is where the actual work is executed. For this inductive research empirical data is reflected on through a 'partnering in construction' perspective (Bygballe, Jahre, and Swärd, 2010), including elements such as project characteristics (Beach, Webster, and Campbell, 2005), tools and techniques (Bresnen and Marshall, 2002), and social aspects (Lau and Rowlinson, 2009).

**METHODOLOGY**

To define the position and portfolio of the Dutch water boards in the Netherlands desk research was done to position the water boards as a public organisation. Publications and internal documents of the water boards were studied. Publications from central government and the association of water boards were reviewed, and also publications from other relevant organisations such as the Dutch economical institute for the built environment were examined. For the second part of this research a grounded theory approach was used based on the work of Glaser and Strauss (1967) and more recently, Strauss (1993). This method relies on comparison of data and theory, beginning with data collection (Eisenhardt, 1989). A more recent and detailed description of grounded theory is given by Saunders, Lewis, and Thornhill (2016). Saunders et al., (2016) describe grounded theory method as theory inductively developed from a set of data: “the aim is to ‘discover’ or generate theory grounded in the data produced from the account of social actors”. Limitations of grounded theory can be found in its inductive character, and a perceived lack of anchoring in literature. For this explorative research empirical data gathering was entered with no previous conceptualisations. Through coding and integration analysis allowed for the
emergence of topics and themes. Subsequently the emerged elements were related to theory as presented here.

18 semi-structured interviews were conducted with 9 project managers from water boards, and with 9 project managers from their main contractors. Not only clients but also contractors were interviewed to explore both their expectations (Newcombe, 2003) in order to understand the complete picture. The interviewees were selected for their involvement in hydraulic engineering projects with the water boards as a client. The interviews where not about a specific project but referred to ‘water board client projects’ in general. All interviewees were involved in at least one water board project at the time of the interview. But they were also specifically asked about their experiences in all water board projects they were a part of in general, including recent previous projects they participated in. This approach was chosen to obtain a wide view, without narrowing the findings to a specific project. The interviewees therefore had the opportunity to reflect on the water boards as a public client from a project-transcending perspective. For the explorative character of this research in-depth interviews where applied, ranging between semi structured and unstructured. The main questions guiding the interviews where about the challenges and opportunities Dutch water boards face as a construction client. After 18 interviews data saturation was accomplished as interview data started replicating the same information, with new information no longer emerging from the interviews. All interviews where analysed through open coding and integration (Corbin and Strauss, 2008), which led to the emergence of two main themes: procurement strategy and project management.

FINDINGS

The Position of the Dutch Water Boards

Unlike other countries such as the United Kingdom, water boards in the Netherlands are public entities part of the government structure. In the Netherlands there are 4 layers of government, from which three are geographically divided. As in many other countries the government is divided into the central government, 12 provinces, and 355 municipalities. The fourth layer of government consists of the water boards. The water boards are democratically elected, and therefore also have positions similar to a municipality, such as a mayor (dijkgraaf), alderman (heemraden), and councilors (hoofd- ingelanden).

In the Netherlands there are 21 water boards, each responsible for their own geographically defined area. These 21 areas’ in total cover the whole of the Netherlands, therefore there is a functional separation with central government. The Ministry of Infrastructure and Water (central government), by means of the agency of Rijkswaterstaat, is responsible for larger water surfaces such as the sea and rivers, for instance by providing protection against the water from the sea by maintaining dikes. The water boards on the contrary are responsible for local water surfaces such as canals, and for water protection in their own territory. In addition, the water boards are also responsible for other tasks such as water treatment and providing sufficient water for Dutch agriculture.

Traditionally the water boards emerged from self-organisation of citizens and farmers in order to manage water issues. Therefore, the water boards in most cases are geographically delimited along canals and lands. Because municipalities and provinces are not limited by the same natural boundaries, they in multiple cases overlap. One water board could therefore for instance have to deal with the central
government, 3 neighbouring water boards, 3 municipalities, and 2 provinces. As this example shows, water boards operate in great administrative complexity.

The Portfolio of the Dutch Water Boards

The water boards describe their own responsibilities along three themes: water safety (primary flood defences such as dikes and locks), water systems (i.a. dredging and damming), and water quality (surface water) also including purifying wastewater from households and businesses. They do this by purchasing these works and services from industry. The gross domestic product (GDP) in the Netherlands was 725.4 billion euros in 2017 (CBS, 2019). The construction sector was responsible for 4.5 percent of the gross domestic product in that year (Bouwend-Nederland), and this percentage has been fairly stable over recent years. Hydraulic engineering in the Netherlands had a total market size of 2.7 billion euros in 2017. The most important clients in hydraulic engineering are the Dutch water boards, responsible for 35% of the market. Closely followed by Rijkswaterstaat (central government) who is responsible for 30%, and provinces and municipalities together responsible for 18% (Groot, Stiemer, and Visser, 2018).

For the past year (2018) the volume of the hydraulic engineering market was expected to increase with 6.5%, provisional realisation figures show an actual increase in 2018 of 6%. For 2019 the volume is expected to increase even further with 3.5%. Medium term forecasts show that the total size of the hydraulic engineering market in 2019 will be 2.8 billion euros. For 2020 and 2021 a decrease is expected to the level of 2017 with 2.7 billion euros per year. Long term forecasts show a stable hydraulic engineering market up until 2028 (Groot et al., 2018). Under influence of the completion of multi-year programs such as the high-water protection program, the share of the water boards in the total hydraulic engineering market is expected to be slightly lower for years to come. This is compensated by higher investments made by Rijkswaterstaat (central government). The contribution of the water boards is expected to drop to 850 million euros in 2021, which then is 31% of the total hydraulic engineering market in the Netherlands (35% in 2017).

Water board projects are all very different in size and form. This is driven by the fact that project characteristics differ, but also because the fact that there are 21 different water boards. The Dutch economical institute for the built environment did some research into project characteristics (Groot et al., 2018) and found that water safety projects such as dikes and locks have an average project duration of 21 months, and that water purification projects such as purification plants and pumping stations have an average duration of 18 months. Also on average the Dutch water boards publicly procure around 70 projects per year according European procurement law.

Within the hydraulic engineering market several contract types are used. Chao-Duivis, Koning, and Ubink (2013) distinguish three main types: traditional, integrated and life cycle contracts. Traditional contracts have a clear separation between the design, construction, and operation phase. Integrated contracts are characterized by the integration of phases, for instance when design and construction are the responsibility of one party, examples are design and construct and engineer and construct. The third main type is life cycle contracts which integrate also other aspects such as operation and for instance financing. Examples of life-cycle contracts are design-build-operate and design-build-finance-maintain (Chao-Duivis et al., 2013). Within the Dutch hydraulic engineering market integrated contracts are used.
most (65%) followed by traditional contracts (30%), life cycle contracts are hardly applied at all, as presented below in figure 1.

*Figure 1: the hydraulic engineering market by share of contract type (2017). Source: Groot et al., (2018)*

**Procurement Strategy**

Related to procurement strategy in general, project managers from water boards stated that by their opinion they made optimal use of different procurement strategies. For instance, one project manager stated: “we always choose the strategy that is best-for-project”. And one other project manager stated: “we always think carefully about the type of contract, and all related aspects”. Water board project managers stated that in recent years there was a strong drive to use integrated contracts to a level at which integrated contracts were used as standard, at the expense of traditional contracts. Water board project managers also stated that after several years of an integrated contract focus, now a more balanced approach begins to emerge.

Regarding the water board project managers this led to a two-fold problem: projects that could have benefitted from traditional contracts became expensive and over-complex, and integrated projects became managed by project managers that where schooled and experienced with traditional contracts. The second element is a problem because integrated projects became supervised as if they were traditional contracts. In that way beneficial elements of integrated projects such as risk division, innovation, and capacity are cancelled out. Which in several cases, even led to an aversion to integrated projects for the wrong reasons.

Another finding is that clients choose their strategy based on other elements such as: technical knowledge of client-staff, client-contractor maturity barriers, and anticipated cultural differences. Clients take these elements into account in different phases of the procurement process. As an example: one observation is that when client staff is technically knowledgeable, they tend to prefer traditional contracts over integrated contracts regardless the project characteristics. When asked about this practice one client stated: “We have the attitude that we cannot learn much from the contractor during repetitive work, we just do it as we always do”. This is a different rationale for contracting then that used in existing models.

Contractors stated that they appreciated the general transformation to a more integrated-minded client. The interviewed contractors all chose a contract-related strategy. One contractor stated: “since a few years my company only participates in integrated contracts, traditional contracts are no longer interesting for us.” Several other contractors used a mixed-contract approach, for instance stating: “we will
always need traditional contracts, the tender time is very short so you can get to work quickly.” The interviewed contractors all stated that the water boards had a drive towards integrated contracts in recent years, but that the balance was not found yet. Sometimes leading water boards to use over-complex methods for simple projects, or still using simple methods for projects that could have benefited from more innovation. One contractor stated: “I simply cannot apply my innovative capacity, or add any value to the project, if the specifications are cast in concrete. I would like to see more integrated contracts such as design and construct.” Another contractor stated: “when the project is simple and straightforward, you should only use traditional contracts.”

In general contractors stated that the use of integrated contracts for ‘traditional contract projects' leads to increased tender costs and low profit margins, ineffective project management, and therefore low quality and poor client-contractor relationships. Another finding is that multiple contractors noted tender timing issues related to contractor availability. Within a complex administrative environment with multiple (semi-)large public clients, sometimes several projects are published at the same time. This leads to over- or under capacity. This is bad for the continuity of work, with negative effects to competition, employment, project costs, and more. Contractors proposed that public clients should communicate and align project timing with other public clients. Some contractors even experienced tender-timing issues within different departments of the same client, so there is a long way to go to resolve the issue of tender-timing related to contractor availability.

**Project Management**

The second theme that emerged out of the interviews was that more attention is needed for informal aspects of project management. However, these informal aspects can be formalized as well. Project managers from the water boards as well as from the private contractors stated that they paid very little attention to these aspects, but at the same time they acknowledged that these aspects influence project result in terms of quality, time and money. For example, when the relationship hardens, contractors state that less effort is being made to deliver the best quality. In response, clients then spend more time, effort and money checking that quality. When relationships get worse, this leads to legal disputes and lawsuits, which leads to an increase in costs for both parties and delays project delivery. Based on these interviews, it can be stated that a lack of attention to informal aspects, such as mutual understanding and good communication, leads to higher total costs, extended deadlines, and lower quality.

Regarding the informal aspects, and the investments made in good relations, both clients and contractors stated that for short term or low prize contracts they made no investments at all. One client stated: “For a three-week job we obviously don’t invest any time or money in the relationship with the contractor. This phenomenon is also found in literature, for instance Beach *et al.*, (2005) questioned if a concept of mutual trust and collaboration could even be supported in an environment characterised by one-off contracts and short-term gains. They even stated: "in many respects project environments represent the antithesis of current thinking in partnership development" (Beach *et al.*, 2005).

But even for larger projects often times limited to no investments are made to enhance the relation. One large contractor stated: “We expect that our employees know how to ‘deal with people’ we don’t train them to do that. We only talk about it with our employees when things really go wrong”. Some teams who work in high visible large
projects in the Netherlands use profile-matching techniques. People are assessed on their skills and characteristics, and then client and contractor teams are matched accordingly. When asked about this practice the water boards and their clients stated that this was not common practice in the hydraulic engineering sector. Only one client and one contractor, out of 18 interviews, commented that they had experience with these techniques. Exemplary for the interviewed population one contractor stated: “we are plan-driven, by which I mean that the selection of people for the project only depends on their availability. We never match anyone based on their match to the client's team or based on personality traits”.

Client and contractor project managers stated that communication in projects was sometimes poorly structured. Both clients and contractors acknowledged that they themselves paid too little attention to this aspect of project management. Clients and contractors noticed improvements in recent years, for instance start-up meetings are organized, and often times follow-up meetings are scheduled. One water board project manager stated: “since a few years we now use start-up meetings for every project”. But as projects are being executed, meetings are being cancelled or poorly visited. Evaluations are not performed or inadequately held, or if done properly not being regarded in future projects. One water board project manager stated: “evaluations are often seen as a burden”, and a project manager from industry stated about evaluations: “the actual recording and implementation of the points for improvement still needs attention”. Another exemplary statement of a water board project manager consisted the following: “the evaluation of projects is no common practice at the water board I work for, the same goes for giving feedback to each other”. The interviews showed that evaluation and/or feedback models are rarely used. Conflict escalation models (who to go to in case of a conflict / dispute) are being used more often.

CONCLUSIONS

Several conclusions can be made along the procurement process model (PPM) (van der Puil and van Weele, 2014). The PPM distinguishes six phases, which can be divided into two parts, the pre-contracting and the post-contracting phase. Pre-contracting consisting of specification, selecting, and contracting. Post-contracting consists of ordering, expediting and follow-up. The pre-contracting phase is about procurement strategy. This research shows that parallel to the PPM also other elements influence project decisions. The specification phase is also guided by staff competences. Technical trained staff tend to choose traditional contracts where they can apply their technical knowledge more than in integrated contracts. And in selecting an appropriate construction partner not only project specifications, but also maturity and culture plays a role. On the contrary in the contracting phase there needs to be more attention to environmental factors. Market conditions and contractor availability should influence tender-timing.

Post-contracting is about project management, or productivity in projects. This research shows that more attention to project team selection, and attention for matching different cultures can positively influence project management throughout the process. This is found in other research as well, as Wood and Ellis (2005) stated about partnering: "this is the most significant development as a means of improving project performance". This research also shows that planned meetings and sufficient attention to communication is needed to improve project results. The benefits of tools and techniques such as planned work meeting, conflict escalation models and others
are widely recognized and researched. For instance, by Bresnen and Marshall (2002) who call these "formal mechanisms for 'engineering' collaboration". Another interesting finding from this research is that project results are influenced by softer aspects of project management such as mutual understanding. Hughes, Murdoch, and Champion (2015) already stated that: "the level of understanding is often less than desirable". In recent years work on these 'softer aspects' has been done, sometimes referred to as 'the working relationship' or 'moral and social goals' (Lau and Rowlinson, 2009), and some scholars even concluding that 'the social' can be of greater influence and importance than 'the material' (Pitsis, Clegg, Marosszeky, and Rura-Polley, 2003). This knowledge is not reflected in Dutch water board practices, and therefore gives an opportunity to improve the Dutch hydraulic engineering market.

REFERENCES


Dutch Water Boards as a Construction Client


EVALUATING THE NON-COMPETE PROVISION IN PUBLIC-PRIVATE PARTNERSHIP: PUBLIC BENEFITS PERSPECTIVE

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The debate on the inclusion of non-compete provisions in a PPP contract has long existed. Recent PPP projects that run into controversy primarily due to such provisions, e.g. Midtown Tunnel in Virginia, reinitiate a discussion on the protection of public interest from an inclusion of the non-compete provision. Early studies largely investigated the financial impact of the non-compete provision with an objective to ensure the attractiveness of PPP contracts to private entities. A comprehensive evaluation of the provision especially from the perspective of public benefits, however, has not been conducted. This paper addresses this knowledge gap by incorporating public interest measured with passenger utility function into the analysis framework. The model features a balance between the protection of public benefits and private interest through dynamic tolling behaviours. The paper uses the I-77 project in North Carolina to demonstrate the analysis and offers insightful results. A strict non-compete provision often worsens congestion and public benefits, therefore should be avoided in the PPP contracts. A better solution leading to a win-win solution to both the public and private can be the inclusion of a compensation provision that eliminates the monopoly but offer damage compensation when a competing facility is built. The results of this study can provide practical managerial implications for a better design of the non-compete provision in PPP contracts.

Keywords: contract design, non-compete provision, PPP, public interest

INTRODUCTION

Public-Private Partnerships (P3) have been increasingly utilized as a mechanism for closing the gap between revenues and expenditures in transportation mega-projects (Zhang et al., 2015, Wang et al., 2018a). Private equity investment in US greenfield transportation PPP projects has amounted to $ 6.56 billion from 1993 to 2017 (Poole 2018). Comparing with traditional project delivery method, the private sector needs to undertake more risks under the P3 delivery method, which may influence the private investor’s confidence in investing in infrastructure projects, particular those transportation mega-projects with uncertain revenue (Liu et al., 2014, Moore et al., 2017). In order to attract private capital or foreign investment to fund the development of transportation mega-projects, the government may provide guarantee provisions for the private investor in the contract, e.g. the minimum revenue guarantee and the non-compete provision or the restrictive competition provision (Ashuri et al., 2011, Sun and Zhang 2014).

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However, there has long existed the debate whether the non-compete provision should be included in the P3 contract (Harrison 2015a, 2015b; Laris 2016). In this aspect, a painful lesson can be learnt from the Dulles Greenway project in Virginia, in which no non-compete provision was included in the agreement and Virginia government was free to increase capacity on VA Route 7, an un-tolled parallel facility (Persad et al., 2005). Eventually, the concessionaire began to default shortly after the project opened due in part to lower than anticipated toll revenues (Persad et al., 2005). On the other hand, a non-compete provision may become a heavy burden for the government to further improve the transportation system during the concession period. For example, in the case of State Road 91(SR-91) project in California, due to a non-compete provision which prohibited increasing capacity within a 1.5-mile corridor surrounding the project, the public sector was forced to buy back the project in order to expand merge lanes from SR-91 to a competing toll road (Garvin and Bosso 2008, Iseki and Houtman 2012). Therefore, there come some questions whether the non-compete provision should be provided in the PPP contract, and how to properly evaluate the value of the non-compete provision. This study tries to explore these questions by evaluating the non-compete provision from the perspective of public interest, so that a benchmark can be provided for the government to judge whether the non-compete provision should be included in the P3 contract.

LITERATURE REVIEW

An abundant of researches have been conducted to investigate the government incentive in the PPP contract. While most of these researches focused on evaluating and how to better arrange the government guarantee, particularly the minimum revenue guarantee (e.g. Li et al., 2017, Wang et al., 2018b). Brandão and Saraiva (2008) and Brandão et al., (2012) evaluated the minimum traffic volume guarantee and the minimum demand guarantee respectively with the real-options method. Ashuri et al., (2011) proposed a risk-neutral pricing approach to evaluate the minimum revenue guarantee in Built-Operate-Transfer projects. To counterbalance the effect of the guarantee, e.g. the private sector gains too much excess earnings, some complementary agreements were proposed from point of view of contract design, such as setting the maximum revenue limit and the maximum expense limit (Park et al., 2012), using the dynamic revenue insurance contract (Chiara and Kokkaew 2013), and applying the royalty fee mechanism (Sun and Zhang 2014). The warranty provision in the PPP contract had also been studied. Cui et al., (2004) analyzed the advantages and disadvantages of warranty provisions, and a warranty option approach was proposed to increase the value of warranty provisions. Moreover, Cui et al., (2008) investigated the value of the warranty ceiling clause in the New Mexico Highway 44 project using a Binomial Lattice model. They found that the expenditure ceiling clause is costly and suggested that the government should determine a favorable ceiling value before including a ceiling clause in the warranty.

From the above literature review, it can be seen that the minimum governmental guarantee provision has been widely investigated, but the non-compete provision related research is scarce. A recent seminal research about the non-compete provision came from Liu et al., (2014), which evaluated the option value of restrictive competition provision in PPP projects in case of an increased market demand. Nonetheless, Liu et al., (2014) mainly analysed how much value the non-compete provision can bring to the private investor, how the non-compete provision influences public interest is still not studied. It is necessary to further analysis the non-compete provision from the perspective of the public interest, because the non-compete
provision may bring profits for the private investor at the cost of public interest, as is shown in the case of SR-91. To fill up the research gap, this study proposes a quantitative method to evaluate the public interest value of the non-compete provision. The travelling cost of passengers is formulated by a utility function and the dynamic optimal tolling behaviour of the private investor is considered. A criterion is proposed to judge whether the non-compete provision should be provided. The results of study can help the government to better arrange the non-compete provision in the PPP contract.

**METHODOLOGY**

The form of the non-compete provision has evolved from the strict non-compete provision to the competing facilities and compensation provision. The strict non-compete provision prohibited the government from constructing the competing facility, while the competing facilities and compensation provision allow the government to construct the competing facility but needs to compensate the private investor its revenue loss. The following section will investigate these two provisions respectively.

**Strict non-compete provision**

As in the case of State Road 91 project, in order to increase the traffic capacity and release the current traffic congestion, the government may promise a strict non-compete provision in the PPP contract to attract the private investor to build a new toll road. However, from the perspective of public interest, although the new toll road can release the current traffic congestion problem and reduce the travelling cost of the passenger, the non-compete provision constrains the managerial flexibility of the government to further improve the traffic system. That is to say, although the non-compete provision can bring public interest currently, it may become a burden for the public 20 years later. Therefore, the government needs to trade off the cost and benefits of the non-compete provision within the concession period to decide whether the non-compete provision should be provided. Figure 1 shows the estimation of public interest brought by the strict non-compete provision.

In order to evaluate public interest brought by the new toll road, the user cost of passengers should be determined first. In this study, the user cost of passengers is formulated as the following utility function:

$$U = k \bar{t} \left(1 + a_0 \left(\frac{q}{V}\right)^{b_0}\right) \quad (1)$$

Where $k$ means the time value of the passenger, $\bar{t}$ means the free-flow travelling time, $q$ means the traffic volume, and $V$ means the traffic capacity of the road; $a_0$ and $b_0$ capture the traffic condition of the road.

Suppose there exists a general-purpose road (the traffic capacity $V_1$ and free-flow traveling time $\bar{t}_1$) which is free for the passenger from the city A to the city B. Due to the increased traffic volume, the congestion problem is increasingly exacerbated. Suppose there are $N$ types of passengers with different time values $k_1, k_2, \ldots, k_N$, satisfying $k_1 < k_2 < \ldots < k_N$, and the number of them are $q_1, q_2, \ldots, q_N$, respectively. Based on formula (1), the total travelling cost of the passenger (the social cost) on the road can be calculated by the following equation:

$$TC_1 = \sum_{i=1}^{N} U_i q_i \quad (2)$$
When new toll lanes are built by the private investors, the traffic capacity of the road can be increased by $V_2$. The passengers will compare the user cost on the toll lane and the toll-free lane to decide which lane they should use. Because the maintenance cost of the private investor is increasing with the number of passengers on the lane, the private investor needs to properly set the toll rate to adjust the number of passengers on the toll lane. Under the optimal pricing strategy of the private investor, the user cost of passenger on the toll lane and the toll-free lane can be calculated with equation (1), and the total user cost $TC_2$ can be estimated.

When the total traffic volume is increased, the private investor will increase the toll rate. Besides, the congestion will emerge, which further increases the user cost of passengers. Under this situation, the total user cost $TC_3$ and $TC_4$ can be calculated respectively by the equations (1)(2). Then, the public interest brought by the non-compete provision can be estimated with $TC_2 - TC_3 + TC_4$. The precondition that including a strict non-compete provision in the PPP contract is that the public interest brought by the provision should be positive.

**Competing facilities and compensation provision**

Under the competing facilities and compensation provision, the government can increase the traffic capacity of the toll-free lane but needs to compensate the private investor its revenue loss. Figure 2 shows the process to evaluate public interest brought by the competing facilities and compensation provision.

It can be seen that comparing with the strict non-compete provision, there is an added value for the competing facilities and compensation provision, which is exactly the value of the flexibility provided for the government. On the other side, the government has to compensate the private investor for the toll revenue loss. It can be derived that the earlier the government increases the traffic capacity of the toll-free lane, the larger the public interest value, but the larger amount of compensation the
government should pay the private investor. Therefore, the government needs to decide when to increase the traffic capacity of the toll-free lane in order to maximize the net public interest.

Figure 2 The public interest analysis of the competing facilities and compensation provision

Several factors can also influence the decision making of the government. The first one is the capital cost of expanding the toll-free lane ($I$). When the capital cost is relatively large comparing with the benefits it brings to the public, the government should not expand the toll-free lane. The second factor is the financial budget pressure of the government. When the financial budget of the government is tight and there are some other more important projects that wait in the queue, the government should not spend money to expand the toll-free lane either. Moreover, due to the pervasive view that the private sector gets a better deal with the competing facilities and compensation provision, the government gets pressure to compensate the private sector, which also influence the timing of expanding the toll-free lane. By taking all these constrains into consideration, the precondition that the government expands the toll-free lane needs to satisfy:

Public interest, $t_0 > B \times P_0 + I_o$ (3)

The left side of the inequation is the added public interest value by expanding the toll-free lane. The right side is the total cost, where $B$ ($B \geq 1$) reflects the pressure of the government to expand the toll-free lane, including the financial pressure and the social pressure; $I_o$ means the annual capital cost apportion from time $t_0$ to $T$, which can be estimated with $I_o = \frac{1}{T-t_0}$. The government should not expand the toll-free lane until the added value of expanding the toll-free lane is larger than the total cost.

CASE STUDY

The NCDOT (North Carolina Department of Transportation) decided to develop express lanes on I-77 with PPP model to release the congestion problem in November 2011. The overall length of the project is 26 miles from the Brookshire Freeway (Exit 11) in Mecklenburg County to N.C. 150 (Exit 36) in Iredell County. The total investment amounts to $636 million, in which the private equity contributes $248 million. A competing facilities and compensation provisions were included in the PPP contract that has been criticized because the feeling that the private sector was getting a better deal was pervasive.
Data and parameters of the project

1. The traffic flow forecast conducted by C&M is shown in Figure 3. Trucks make up about 15 percent of the total transactions.

2. The speed limit is 55 mph on the toll-free lane, and 70 mph on the toll lane. Given the percentage of trucks and the speed limit on the road, the traffic capacity of the toll-free lane and the toll lane can be estimated: 1,960 vehicle per hour per lane for the toll-free lane (4 lanes) and 2100 vehicle per hour per lane for the toll lane (4 lanes).

3. The passengers on I-77 can be roughly classified as two categories: high time value passenger (Light truck) and low time value passenger (Private car), and the time value of them are $20 per hour and $15 per hour, respectively.

4. The travelling time on the toll-free lane and toll lane are estimated as 0.82 hour and 0.4 hour, respectively.

5. The traffic condition parameters are set as $\alpha_0 = 0.15$, $\beta_0 = 2$. The maintenance cost parameter is assumed to be $a = 0.0002$. Since it is hard to evaluate non-social benefits, we suppose $\lambda = 0$, and only focus on the travelling cost here.

6. The capital cost for the government to double the traffic capacity of the toll-free lane is supposed to be $700 million ($I = 700$).

7. The discount parameter is assumed to be $r = 0.05$.

Cost and benefits analysis of the non-compete provision

From the perspective of public interest, releasing the congestion problem on the road by introducing the toll lane is a main concern. However, since the private investor only concerns its profits, the purpose of releasing the congestion problem may not come true. Actually, based on the optimal tolling analysis, the private investor will increase the toll rate from $6.2 to $12.4, which leads to the low time value passenger more and more reluctant to use the toll lane. If no competing facility is built, the congestion problem on the toll-free lane will still exist. Figure 4 shows the percentage of low time value passengers on the toll road every year under the optimal toll pricing of the private investor.

It can be seen that the percentage of the low time value passenger on the toll lane is decreasing. That is to say, the function of the toll lane to release the congestion...
problem existed on the toll-free lane is diminishing. This result reflects that it is necessary for the government to keep managerial flexibility to expand the toll-free lane when the congestion problem is serious. Otherwise, if a strict non-compete provision is provided, the public interest of the strict non-compete provision can be derived as $-13.54$ billion. It can be seen that it is costly for the public if including a strict non-compete provision. Therefore, the strict non-compete provision should not be provided in the PPP contract.

Actually, a competing facilities and compensation provision was provided in the PPP contract.

![Figure 4: The percentage of low time value passengers on the toll lane](image)

*Figure 4 The percentage of low time value passengers on the toll lane*

Based on the evaluating method proposed in the above section, the added value and cost of the compete facilities and compensation provision every year can be estimated, as is shown in Figure 5.

![Figure 5: The added value and cost of the competing facilities and compensation provision](image)

*Figure 5 The added value and cost of the competing facilities and compensation provision*

From this figure, it can be seen that the more traffic volume on the road, the more added value for the public by expanding the toll-free lane. Therefore, the government will have more motivation to expand the toll-free lane. The timing of expanding the toll-free lane depends on the financial budget pressure of the government and the capital cost of the expansion. In this case study, when the pressure of the government is small ($B = 1$), it will be better for the government to expand the toll-free lane as early as possible. However, when the pressure of the government is relatively large ($B = 1.5$), it is unnecessary for the government to expand the toll-free lane in the early two years and the last three years. The intuition behind this finding is that expanding the toll-free lane in the early stage can increase the amount of compensation for the private investor, which explains the reason why the government should not expand the
toll-free lane in the early two years specially when the financial budget is tight. Besides, because the project will be transferred to the government soon, expanding the toll-free lane in the later stage is costly (a high annual capital cost), so the government should not expand the toll-free lane in the last three years.

DISCUSSION

It is not uncommon for the private investor to negotiate with the government to include a non-compete provision in the PPP contract (Liu et al., 2014). However, if the non-compete provision is not properly arranged, either the public or the private investor may suffer a great loss. As is shown in the case study, the potential loss of public interest can reach up to $13.54 billion if a strict non-compete provision is included in the PPP contract. As a matter of fact, the private investor will increase the toll price with the increasing traffic volume (the toll price is increased from $6.2 to $12.4 in the case study), which makes those low time value passengers are more reluctant to use the toll lane (the percentage of low time value passengers on the toll lane even decreases from 70% to near 0), so the congestion problem on the toll-free lane may be worse and worse. In practice, the SR-91 project is a hard lesson that the government had to buy back the project from the private investor with high price due to the strict non-compete provision in order to expand the traffic capacity of the road. Therefore, the strict non-compete provision should not be provided in the PPP project from the perspective of public interest. This result indicates that when designing the non-compete clause, the government should keep some flexibilities which has also been emphasized in the study of the minimum revenue guarantee (Cui et al., 2008, Chiara and Kokkaew 2013).

On the other hand, if no guarantee provision is provided in the PPP contract, the government can build a competing facility at any time and do not have to compensate the private investor. The results show that the government should expand the traffic capacity of the toll-free lane as early as possible. However, expanding the toll-free lane at the early stage makes the private investor lose its 70% toll revenue, which will lead the private investor to go bankruptcy. Such high revenue risk will deter the private investor from participating in the PPP project eventually.

In order to attract the private investor and meanwhile maintain the government’s flexibility to expand the traffic capacity, the compete facilities and compensation provision is used in practice, e.g. the I-77 project, which can be a win-win solution for both the government and the private investor. The case study verifies that the benefits of the private investor is guaranteed with the compensation provision. Liu et al., (2014) also pointed out that the compensation provision can add up about 10% of project NPV (net present value) for the private investor. Additionally, the government can expand the toll-free lane when necessary, which can save almost $7 billion travelling cost for the passenger.

Two main limitations should be highlighted. First, when evaluating public interest, the travelling cost of passengers is focused on in this study. Actually, building a new road or expanding an old road may also influence the price of real estate or other business activities in the area. Further study can be conducted to properly quantify those influence to better evaluating the public interest, so that the government and the private investor can make more sound decision. Second, the potential renegotiation between the government and the private investor is not considered in this study. Due to the incomplete characteristic of the PPP contract, it will be more efficient for the government and the private investor to renegotiate the improper original contract...
provision than put the project in jeopardy. Future research can further add a renegotiation option in the model and investigate how much public interest that the renegotiation option may bring.

CONCLUSIONS

This study quantitatively evaluates the value of the non-compete provision from the perspective of public interest. The I-77 project is used as a case study to illustrate the evaluating process, from which several important insights can be derived. First, the strict non-compete provision should be avoided in the PPP contract since this provision may cause a huge cost for the public during the concession period. The government should keep some managerial flexibilities in the PPP contract to deal with the uncertainty and protect public interest. Second, the result manifests that the competing facilities and compensation provision can be a win-win solution for the public and the private investor. The timing of constructing the competing facility is influenced by the magnitude of the financial budget pressure of the government and the capital cost of the competing facility. The result of this study can help the government to better arrange the non-compete provision in the PPP contract.

REFERENCES


PUBLIC PARTICIPATION IN NHS CONSTRUCTION PROJECTS

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Despite the prominence of public participation in built environment projects and National Health Service (NHS) activities in the United Kingdom there has been little attention on the role of public participation specifically in NHS construction projects, and which actors are engaged in those activities. The aim of the paper is therefore to reflect into the rationales, practices and impacts of public participation on NHS construction projects. The research presents a case study of an NHS construction project. The case study is positioned within an analytical framework based on the rationale behind, and the practices of, public participation. The actors’ rationale for public participation is placed along a continuum between ‘consumerist’ (public participation as a means to an end) and ‘democratic’ (public participation as an end in itself). The practice and effects of public participation are placed along a continuum which runs between ‘rhetoric’ (no transfer of public participation claims into practice) and ‘substantive’ (public participation impacts the project). Drawn from secondary data, the findings highlight that the public participation on the NHS construction project was conducted principally via intermediary or ‘secondary actors’. There is a lack of evidence to show any significant impact of public participation on the NHS construction project; instead, the focus for the project was on the selection of appropriate public participation methods, documentation and demonstration of the event. Finally, public participation is often politically motivated, with local councillors and MPs using specific issues in these construction projects as a broader political platform.

Keywords: National Health Service, NHS, public participation

INTRODUCTION

The use of public participation (sometimes referred to as engagement or involvement) can be identified throughout the history of the UK National Health Service (NHS), with a clear presence in its politics and policies (e.g. NHS England, 2017). With such well-established principles it might be expected that NHS construction projects would also utilise public participation (PP) and be influenced by its outcomes. However, there is little evidence of the impact of PP in NHS construction projects. There are three potential problems of this lack of explicit research into public participation in NHS construction projects. First, research into PP in construction tends to focus on generic construction projects (e.g. Xie et al., 2017). Second, most studies carried out on NHS PP focus on healthcare services quality and provision (e.g. MacDonald and Taylor-Gooby, 2010). Finally, there is little evidence about whether or not PP has any perceptible impact on healthcare service (e.g. Mockford et al., 2012). The aim of this

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paper is to focus on the key actors’ understanding and views on the definition of, and approaches to, public participation in NHS construction projects, and how they influence the practices of public participation being operationalised.

LITERATURE REVIEW

Defining Public Participation (PP)

Public participation (PP) has grown in different domains. Accordingly, understandings of the PP concept evolved, and within different frameworks each has its own nature. Considerable amount of literature asserts that there is no clear definition of PP (e.g. Harrison et al., 2000). In general, the basis on which PP has been defined has followed three different routes. The first route considers PP is about public empowerment and public control of decisions or resources. This understanding of PP is mainly influenced by a classic and prevalent model presented by Arnstein (1967) known as the ladder of participation. Arnstein (1969: 216) claimed that PP “is a categorical term for citizen power” and public participation is a conduit for “the redistribution of power that enables the have not citizens, to be deliberately included in the future”. Such views consider ‘gaining power’ by the public is the main objective and motive for the public to participate. The second route refers PP as a shared decision-making process between the public and the organisation / authority (e.g. Skeffington, 1969). This means carrying out PP ‘with’ the public, not ‘by’ or ‘for’ the public. The public is an active part of the decision-making process, in deciding how to respond to the public feedbacks / concerns, and of the final decision of the plan / project. The Director of Involve defines PP as “citizens interacting with and receiving information from government all the way through to citizens having a collaborative approach with government and actually developing services with them, consultation sits somewhere in the middle” (House of Commons, 2013:9). The third route considers PP as consulting the public on an already-drafted plan or decision. The consultation focuses on providing the opportunity for the public to participate, and to recognise the public’s views; but the assessment of the public feedback, how to respond and the final decision usually remains in the domain of the authority / organisation. The International Association for Public Participation (IAP, 2007), for example, considers PP as the process by which an organisation consults with interested or affected individuals, organisations, and government entities before the organisation makes a decision. These three routes in defining PP arguably were influenced by two broad aspects which are discussed below.

Public Participation Theory and Practice

Public participation theory - democratic and consumerist approaches. Since the 1990s two distinctive PP rationales have been predominant: the consumerist and democratic (e.g. Beresford, 2002; Lupton et al., 1997). Public participation has been rationalised either from a political point of view - the public participate to exercise their citizen rights; democracy principles; or from a public service improvement point of view. Under the consumerist approach members of public are consumers who provide feedback on the quality of services, to be improved accordingly. Under the democratic approach the PP is an aim and an end in itself (Oakley, 1991). For the consumerist rationale contemplates PP as a tool to improve the quality and efficiency (Cornwell, 2002). The democratic and consumerist approaches meet at some points even when they can be mostly viewed in contrast. Beresford (2002:96) summarises this view by commenting “… at points the two approaches … may blur into each other with overlapping interests and objectives, they can also be seen to be based on
distinct and different philosophical and ideological approaches”. In general writers (e.g. Florin and Dixon, 2004) consider each of the consumerist and the democratic approaches implies different objectives and implies different methods to achieve them. This study suggested that the two rationales are not mutually exclusive, but extreme ends of one range.

Public participation practice - rhetoric and substantive. PP practice does not necessarily (or always) match up with the organisation’s public claims and expectation. Such a situation might lead to tensions (Martin, 2009). Although there is insufficient evidence to support this, there are different reasons that could lead to such a stance - a gap between theory / claims and the actual practice. This could either be done intentionally or be due to internal or external factors (e.g. financial constraints, lack of trained staff, the public mistrust or lack of interest). In theory this may vary from a full transfer of PP definition claims into practice, to no transfer of the definition or claims into practice at all. The former can be referred to as substantive practice, and the latter as rhetoric practice. Accordingly, a continuum can be suggested as an indicator of the participation practice. This continuum runs between two extremes of the rhetoric and substantive participation practices.

The Impact of Public Participation

PP impact can be on a project decision/plan itself or on the project outcome. Each of these impacts is difficult to measure or define. The classic mentality of ‘Doctor Knows best’ (e.g. Mooney 2014) in the NHS is still dominant. This view resonates with Powell and Seale (2016:1) who argued that “[t]he access to information and knowledge by patients eager to share in the decision-making process is restricted to the medical profession. This colludes with the ability for the powerful expert to remain powerful”. In respect of the claimed benefits of PP, Burton et al., (2004: 40) noted that “benefits [of public participation] cannot be easily quantified or associated causally with particular forms of involvement”. Furthermore, there is insufficient evidence to confidently support the claimed positive impacts that have been associated with public participation practice. Indeed, there is a noticeable relative shortage of studies on the impact of PP in general (Oliver, 2008), no studies have shown how the degree of PP impacts changes on services (Harrison et al., 2002). Haworth (2011) concluded the above view by arguing that more research and evaluation is required to inform and improve impact of

Summary

The above discussion raises two broad aspects. The first aspect is that PP’s definition; rationale and / or practice are directly determined or influenced by those actors involved in the PP process. This is not necessarily based on how the literature (or even the policies) defines and rationalises Consequently, this raised the necessity to define the project key actors’ responsibilities, obligations and positions within the project and if they influenced their understanding and practice of The second issue is to explore if PP has an impact on the projects as per the claimed virtues for its practice. The aim of this paper is therefore to focus on the key actors’ understanding and views on the definition of, and approaches to, PP in NHS construction projects, and how they influence the practices of PP being operationalised. Accordingly, five research objectives were developed around the key actors involved in PP and what impact PP has on the project decisions and outcomes (please see ‘discussion’ section where each of the five objectives had been addressed).
RESEARCH METHODOLOGY

Research Approach
Case study approach (Yin, 2018) was adopted. Except for the studies that focused on the validity of public participation in principle and its philosophical or political position, public participation studies seem to be conducted as a specific case study or use a specific case study to prove a theoretical deduction, evaluation or assumption associated with public participation (e.g. Arnstein, 1969). A single local NHS construction project, Springfield University Hospital, was selected based on two main criteria. First, the project is a local NHS construction project. The NHS construction projects are usually developed within a defined local authority and specific location, to facilitate healthcare services to a defined deanery or catchment, it is hardly to argue that there is NHS healthcare projects that be consider as a national NHS (for example) hospital service wise; with the exception of some highly specialised Hospitals. Second, the complexity, data availability and accessibility of the project itself. Springfield University Hospital has been a mental health hospital in Tooting since 1840. In 2004, South West London and St George’s Mental Health Trust (SWMT) assigned Urban Strategies Inc. (a planning architectural practice firm) to develop a strategy for the future of the Springfield University Hospital site. They suggested three alternatives for the hospital site: selling the whole site, selling part of the site, or creating an integrated development at Springfield University Hospital. The outcome of suggestions was summarised in what was called the ‘Vision and Masterplan’ published in 2005.

Data Collection
The research is based upon secondary data. The rationale is that the time scale of PhD in respect of NHS construction projects can be problematic, i.e. the chosen case study extended over eight years, exceeding the duration of the PhD. The main data for Springfield University Hospital Project included (1) Planning application 2008 by South West London and St George’s Trust, (2) 3 planning applications 2010 by South West London and St George’s Trust, (3) Neighbourhood of Springfield objection to 2010 Trust planning application, (4) Local Member of Parliament objects to 2010 Trust planning application; (5) 2 Statements of Community Engagement for 2008 and 2010 Trust planning applications), (6) Objection letters to the Council for allowing the Trust appeal on 2010 applications, (7) The local Guardian and other local press, (8) South West London and St George’s Trust and NHS websites, (9) Local MP’s website, (10) Wandsworth London Borough Council website, and (11) Neighbourhood of Springfield website (https://sites.google.com/site/neighboursofspringfield/). The study looked into: how the project PP exercise data was collected; who the public of the study was; if there were any other objectives other than of the original PP conducted; if there were any public response categories for each PP survey / feedback question; and, if there were any public stratification been created or were already exist when the PP took place that might affect the analysis. The secondary data also allowed a longitudinal vision of the complete PP process as it took place over many years for the same construction project. This provided a massive time and cost effectiveness. There are two factors influenced the data status for this study. First, PP is a legal requirement for planning applications. Accordingly, the NHS authority, the private developers and the local authority properly documented evidence of their PP activities. Second, PP
understanding, and practice of the local NHS and the local authorities are broadly defined and directed by national and local policies guidelines.

**DATA ANALYSIS**

The data analysis is based on an analytical framework for PP that has been developed (see Figure 1). It has four variables, of which two signify two terminals of a continuum representing PP theory rationales: the consumerist rationale and the democratic rationale. The other two variables are the two ends of a continuum representing PP practice rationale: rhetoric and substantive practices. Table 1 below shows the main indicators and their definitions for these variables for the analytical framework for public participation.

![Figure 1: Analytical framework for public participation](image)

<table>
<thead>
<tr>
<th>PP theory rationale</th>
<th>Rationale and definition</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumerist</td>
<td>the definition, claim and / or objectives consider PP as a tool or mechanism to achieve an end, typically efficiency, effectiveness or quality.</td>
<td>Market competence, Efficiency and quality, Marketing research, Individual needs, Feasibility-driven decisions, The public are consumers</td>
</tr>
<tr>
<td>Democratic</td>
<td>the definition, claim and / or objectives consider PP as an end and aim in itself. It is a citizen rights and public empowerment.</td>
<td>Citizen right, Democratic methods, Collective view, The public are citizens</td>
</tr>
<tr>
<td>Rhetoric</td>
<td>the details and events of an actual case of practice of PP do not indicate the proper transfer of its definition, claim or objectives.</td>
<td>Absence of public participation, Inappropriate opportunity, Lack of update / transparency, Lack of drive, Decision- making exclusiveness, Insistancy / ignorance, Already taken decision</td>
</tr>
<tr>
<td>Substantive</td>
<td>the details and events of an actual case of practice of PP confirm or indicate the proper transfer of its definition, claim and / or objectives.</td>
<td>PP presence, Appropriate opportunity, Transparency, Decision- making inclusiveness, Acceptance or consideration</td>
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**Key Findings**

**Public participation in the project**

While the public perceived the hospital project mainly as a redevelopment their healthcare provision quality; for SWMT the project was part of regeneration for Springfield area as whole. Therefore, SWMT’s response to the public concerns was based upon weighing the benefits of the project for the catchment in general.

SWMT indirectly excluded PP feedback as an element in its decisions. First, despite opposition to the three planning applications for the redevelopment of Springfield University Hospital, councillors, the public and the MP, SWMT insisted on appealing against London Borough of Wandsworth Council’s (LBWC) refusal decisions. Second, SWMT considered that its responsibility towards the patients only (not the public) position it to support the planning application. The Director of Nursing and Operations at the Trust, commenting that “it is our overriding responsibility to ensure that patients are cared for in modern, purpose-built facilities … For this reason, no change on the Springfield Hospital site is simply not an option" (Guardian, 2011).
The Planning Inspector on her written report, published on 21st June 2012, remarked that “there can be no doubt about the strength of objections to the proposal”, but maintained that the local community has every right to voice its objections. However, the significant benefits of the proposed scheme … clearly tip the planning balance in its favour, even in the face of the harm ... feared by local people” (LBWC, 2012).

The Head of the Council commented that "in our view [referring to the councillors, the public and the MP] the transport shortcomings of this scheme should have led to this appeal being dismissed. Unfortunately, the inspector chose not to give these arguments the weight and importance we believe they merit” (LBWC, 2012). The Secretary of State’s rationale for the allowance of SWMT’s appeal against LBWC for the 2010 planning application noted that “the adverse effects of the proposed scheme … should be weighed against the cumulative benefits.”

SWMT narrated in its policies that “we must develop effective ways of making sense of the [public] feedback we receive and acting on it to improve services, and then demonstrate that we have listened and show how that feedback has led to improvements”. SWMT’s reports on the project PP are heavily focused on the methods it used and the opportunities it had created for the public to participate, but not on how they reacted to or evaluated the public feedback and why.

In 2012 SWMT’s final planning application was eventually approved from a national level. Such approach to endorse the local planning application resulted in frustration being expressed by the public. The Council Leader commented "this … a bitter blow to the many local residents … community are strongly in favour of providing better clinical facilities … this could have been achieved without a redevelopment on this scale and without creating the kinds of problems … Regrettably residents … have to live with the consequences of this flawed decision" (LBWC, 2012). The MP commented that “unfortunately, many of the concerns raised were ignored by the Trust” and “Springfield Hospital … should develop a plan that local residents can support - not bulldoze through this unpopular planning application …” (Guardian, 2011).

**Project public participation position within the analytical framework**

Although there were several key factors involved at different stages in PP, the Trust was the key actor who was the meant body to create the opportunity for the public to participate. Despite the several interactions and responses between the Trust and the public, the main indicator across the case was the persistence of the Trust on its views and positions against the public stance.

Acceptance or consideration. It can be argued that LBWC took into consideration the public's concerns to the project. LBWC rejected all three planning applications lodged by SWMT. Although LBWC did not rationalise its rejection of the planning applications in terms of the public objections.

Insistency or ignorance. SWMT did not reject the public feedback altogether but it was selective in what to accept, reject or change. The Trust accepted reducing the buildings’ heights, from 8 to 4 storeys; and the number of housing units to be built, from 1,200 to 839. But the Trust had been persistent in its view on the project’s impact on traffic, contrary to the public’s, the local councillors’ and the MP’s views.
DISCUSION

Identify the Key Actors Involved in PP for NHS Construction Projects

The primary key actors involved were South West London and St George’s NHS Trust, the public, the local MP, Wandsworth London Borough Council and the Planning Inspector; while the secondary key actors were Soundings (stakeholder consultation specialist) and the Secretary of State for Communities and Local Government.

Identify the Key Actors’ Responsibilities and Obligations Within PP

Each of the key actors, except the public, positioned with specific responsibilities in respect to the project. Accordingly, the obligations and objectives of the key actors varied. SWMT was responsible to provide standard quality services efficiently. This responsibility allowed it to accommodate the public’s views, but only to a limited extent. This limit was determined by whether SWMT evaluated that the public’s feedback was feasible to be adopted or accepted. The Council was the body that had the power to endorse or reject the planning application. Therefore the Council’s responsibility placed it in a ‘referee’ position rather than a key actor that was required to influence the plans directly. The local MP, he had no official responsibility or obligation to get involved or conducts PP for the project. However, he still became involved, and act as ‘a public representative’ in regard to the project directly and through the Neighbourhood of Springfield group.

Identify the Key Actors’ Drivers and Rationales for the Involvement in PP

On SWMT planning application for the project the explicit rationale noted for PP was to conform to the Council’s planning permission requirements. On the Council Statement of Community Engagement there were several benefits claimed for PP but there were no details on how these benefits were determined or how they could be achieved, measured or how it affected the decision on the planning application. The local MP’s drivers or rationale were not clear, but publicly advocated PP as a public right. The main feature that the MP’s involvement, comments, and actions were well recorded publicly, easily accessible and well published in the local media.

Analyse How the Key Actors’ PP Practices Reflect Their Understandings of the PP Concept

None of the key actors showed any renunciation to the public right to participate but beyond this basic agreement, their acts indicated a different perception and understanding of the concept. The public responses reflect the perception that the public views should be the major element to evaluate and to decide on the planning application. For the Trust, PP meant establishing the opportunity for the public to express their view. It was almost the same understanding by the Council: it is a public right for the public to participate, but it remains the Council’s power to decide to accept or not the public feedback through its endorsement or rejection of the planning application even base solely on the council technical, environmental and safety requirements.

Analyse the Impact of PP on Projects

PP had a kind of impact on the first plan produced for the project when SWMT accepted and responded to some of the public’s feedback. Therefore PP could not have a direct impact on the project plans if it did not infiltrate through the SWMT selective mechanism towards what to accept (reject or ignore) from the public’s
views. The impact of PP on the plan or decisions themselves was totally determined by SWMT. Public participation also had an impact on the second proposed plan, when SWMT decided to consider certain issues raised by the public on the first plan. The plans were accepted through an appeal, and finally by Secretary of State, while the public still hold major objection against it. Little is known about the impact of the PP on the project quality or efficiency.

CONCLUSION

Despite the prominence of public participation (PP) in both built environment projects and NHS activities there has been little attention on the role of PP specifically in NHS construction projects, and which actors are engaged in those activities. Drawing on secondary data from a single case study, it was found that there is insufficient evidence to support the impact of PP on the NHS construction project. Furthermore, London Borough of Wandsworth Council (LBWC) rejected all three planning applications lodged by St George’s Mental Health Trust (SWMT). Although LBWC did not rationalise its rejection of the planning applications in terms of the PP feedback and SWMT did not reject the public feedback altogether, PP process was selective in what to accept, reject or change.

Empirical Contributions

The findings provide three empirical contributions. First, the prevailing literature focus is more on the PP rationale and on the appropriateness of methods. The case study results indicated that PP impact on the project decisions should have been the main issue. How the NHS agents and the local Council evaluated, processed and responded to public feedback, irrespective of the PP rationale adopted or the methods used. In respect of PP impact on project quality, efficiency or outcomes there was no related study or discussion and therefore there was clear lack of evidence or findings that could confirm such claims or not. This finding resonates with Madden and Speed’s (2017) remarks that the empirical evidence-base demonstrating the worth and impact of PP remains poor, and with Mockford et al.’s (2012) assertion that there is a need for the development of an PP evidence base particularly around guidance for the reporting of impact. Another major issue was that the public had been invited to participate in already taken decisions or formed plans. The NHS agents produced detailed plans that were ready for submission, and this is only when the public been offered to participate. Second, the literature repeatedly confirmed that ‘the public’ can be defined or classified in different ways and from different perceptions. The key actors from the case study did not define what is ‘the public’ they are targeting or how ‘the affected members of the public’ was defined and on what basis. The local MPs were primary key actor, and created a public group based on his political party to ‘represent’ the neighbourhood but is this means the MP define the public as his political party supporters? For MP involvement in the PP, their motive could be perceived as a political or strategic movement, as the MP was not required or initially expected to be a major PP key actor in the project. The MP reporting of the events was more focused on what was their own supportive activity to the public rather than on the development of the events in general. Interestingly, what they had done was very well documented and publicised. The only clearly reported rationale for PP by the NHS Trust agents was to conform to local authority and / or planning legislation. Though it is a public right is more in the background policies. Finally, the findings highlight that the PP on the NHS construction project was conducted principally via intermediary or ‘secondary actors’. ‘The public’ and the ‘NHS Trust’ were expected
to be continually one of the primary key actors. But the NHS Trusts’ agents and not the trust itself were the primary key actors. The public were represented by a public group which politically based. The committee members of this group might lead or influence ‘the public’s’ view, prioritise or be selective on what to accept or reject of the public’s views / concerns. There are questions about how effectively the public were represented in these practices, and the extent to which the NHS Trusts, and their priorities around service provision, were accommodated into these construction projects.

**Contribution to Public Participation Theory**

The NHS PP analytical framework (see Figure 1 and Table 1) served to reflect the primary key actors involved in the case study in terms of their PP rationale, and practice, and impacts, and shifts. The analytical framework provided a ‘range’ instead of mutually exclusive positions for each of the primary key actors’ PP practice. Such a framework helped to represent more the actual position of the primary actors’ practice, rather than forcing it to be placed within the limits of the fixed moulds of being entirely or perfectly consumerist, democratic, rhetoric or substantive. The analytical framework also facilitated reflecting simultaneously the rationale and practice of Therefore the position of any of the primary key actors within the framework represents both the theory and practice, instead of positioning each independently. This enabled the strength of the relationship to be assessed between the primary key actors’ PP rationale and actual practice.

**Limitations and Further Studies**

There were three main limitations to this study. First, it was based on secondary data. In a further study, in addition to obtaining the secondary data, deploying primary data from interviews with key actors and / or observations of PP activities would help to examine in more detail individual views on both the value of, and motivation behind, Second, the chosen case study extended over eight years, exceeding the duration of the PhD. This is partly mitigated by the PP documents used for this study, which covered a wide range of time. However, further research over a longer time period could produce longitudinal studies that may reveal further insight and more critical analysis of the fine details of PP in NHS construction projects. Finally, this research is aware of that the conclusions from a single case study have limited generalisability. This research adopts the position set out by Stake (2005) in that real-world studies are valuable for refining theory and suggesting complexity for future direction.

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A REVIEW OF UNSUCCESSFUL TRANSPORTATION P3 PROJECTS IN THE US

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Public-private partnerships (P3s) have become increasingly popular in the US transportation industry. Although enabling P3 success is important, unsuccessful P3s have received little attention. This paper distinguishes unsuccessful P3s from P3 failures with the former encompassing all cancelled P3s and projects whose private partner declared bankruptcy. The latter means projects that have been terminated after contracts are signed and the bankruptcy cases. This paper tries to understand P3 failure from both the public and private sectors’ perspectives and explain the reasons why sometimes P3 endeavours become unsuccessful. The research team examined in depth 26 unsuccessful transportation P3 projects in the US to determine the types and drivers of unsuccessful P3s. A two-tiered driver framework is developed and presented in this paper through an iterative process of qualitative analysis. In particular, the framework includes six Tier 1 drivers. From the most common to the least common, they are; lack of Value for Money, low revenue, lack of public support, inviable project, stakeholder misalignment, and poor project governance/management. Optimism bias and poor financial viability stand out as the most and the second most Tier 2 drivers. The paper finally presents the lessons learned and calls for better project governance and stakeholder management to prevent early termination of contracts. The study also concludes that low revenue is the main reason for private sector’s failure, which may not be a public loss.

Keywords: public-private partnership, failure, bankruptcy, value for money

INTRODUCTION

Public-private partnerships (P3s) have gained traction in the US transportation market in recent years, as the public sector is attracted by the off-balance sheet (i.e., the asset is recorded in the private partner’s balance sheet, so is the liability) and risk transfer benefits and the private sector is drawn to the potential revenue-generating assets with long-term payoff. Being one of the most cited P3 databases, the Public Works Finance Major Project Database compiled 58 closed P3 deals over the past thirty years in the US transportation industry. Those projects, with a total value of approximately $45 billion, covers a variety of P3 models, including Design-Build-Finance (DBF), Design-Build-Finance-Maintain (DBFM), real toll or availability payment-based Design-Build-Finance-Operate-Maintain (DBFOM), and long-term lease. As of August 2018, 36 states, as well as the District of Columbia and Puerto Rico, have enacted horizontal P3 authorization legislations (FHWA 2018).

With the popularity and prospect of P3 as a project delivery method high, little attention is paid to the unsuccessful cases - at least in the academic world. An executed P3 project may yield undesirable outcomes (e.g., significant cost overrun and delay). An example is the US 460 Corridor Improvement project, which was
cancelled after the contract was signed. The cancellation is due to the project sponsor, the Virginia Department of Transportation, failing to secure environmental permits from a federal agency, the Army Corps of Engineers, over impacted wetlands. The cost to the state of Virginia is $210 million which was paid to the contractor, plus $50 million for bond cancellation and $42 million for project development (Ress 2015).

Such failures create public distrust towards the government and discourage the agency from using P3s on future viable projects. However, there are projects that are unsuccessful P3s, but not P3 failures. In fact, many times as a result of the planning and development process, agencies chose other procurement types over a certain P3 model or decided not to build the project at all. An example is the Parallel Thimble Shoal Tunnel project. The Chesapeake Bay Bridge and Tunnel Commission decided not to consider the unsolicited DBFM proposal submitted by the Parallel Crossing Consortium and moved on with a Design-Build process because the authority had not received a competitive bid within the 90-day bidding period. Another example is the Ronald Reagan Parkway Extension (RRPE) project in Georgia. With the Skanska team being the sole responder to the RFQ, the owner, Gwinnett County commissioned a feasibility study with Skanska USA Civil Southeast and split the cost 59% on the county and 41% on the firm. The report recommended against building the toll road because of the low traffic volume, which resulted in the county shelving the project (Young 2009).

With the UK discontinuing their PFI program in 2018 following the collapse of Carillion, it seems timely to discuss unsuccessful P3 projects. Understanding what constitutes unsuccessful P3 projects and why those projects have become what they are in terms of project status affords important lessons. On one hand, the study helps agencies avoid making mistakes that could lead to public losses. On the other hand, the private sector could better assess if and when they should get involved in a P3 project. The three-member research team examined relevant news articles for 26 unsuccessful transportation P3 projects, to which each person independently assigned types and drivers. Then the team discussed the results to reach a consensus. Through this exercise, the authors developed a two-tiered driver framework.

**Sectoral Views of P3 Failure**

For those projects that are P3 failures, how is P3 failure defined? The authors tried to interpret P3 failure from the partners’ perspectives. In a P3 deal, partners may have different or even conflicting goals. A failure for one partner is not necessarily a failure for the other. This complexity poses a challenge to define a P3 failure clearly. The rational-choice theory in the PPP literature hinges on each party attempting to maximize its utility by exchanging resources (Angerer and Hammerschmid, 2005). This study follows the rational-choice theory to classify P3 failure into two groups: state failure and market failure, as explained below.

**State Failure: A Public-Sector Perspective**

State failure, according to Jessop (1999), relates to what is called substantive rationality (i.e., the belief in serving the ultimate values). In the world of P3, a state failure occurs when a project is not delivered, or the project has not achieved its intended objectives using P3. The primary criterion for identifying a state failure is effectiveness, rather than efficiency. However, efficiency (e.g. Value for Money and cost saving) is a factor gauging public sector success. In other words, as long as the facility was delivered and useful in solving the government’s problems, irrespective of what happened during the process, the project is not a P3 failure from the public
sector’s perspective. In the case that the project delivery would have been more efficient had it been done otherwise; we could question it being a successful P3. This is not to say that state failure has nothing to do with inefficiency. Procedural hindrances (e.g., poor project planning and lack of transparency) to conscientious governance could well lead to state failure.

**Market Failure: A Private-Sector Perspective**

Market failure revolves allocative efficiency (Wallis and Dollery, 1999). Jessop (1999) asserted that market failure is predicated upon procedural rationality, which is the outcome of appropriate deliberation. The consideration can come from either the public or the private sector and should result in an action that represents a significant setback in the firm’s pursuit of profit. Such actions include the private partner declaring bankruptcy. Take the South Bay Expressway project for example. In May 2010, the Special Purpose Vehicle (SPV) filed for Chapter 11 bankruptcy to consolidate their debt. The 9.3-mile toll road in San Diego County, California had been haunted by low revenue since the opening in November 2007: 22,600 average daily traffic in 2009 vs. 60,000 projected daily traffic. Another reason for declaring bankruptcy was the burden of claims by Fluor/URS, the design-builder in the project (Tanner 2010).

**Early Studies on P3 Failure and Unsuccessful P3s**

A complete literature review was conducted to understand the existing knowledge and potential gap on P3 failure and unsuccessful P3s. This section discusses the previous research on two topics: P3 failure types and P3 obstacles.

Soomro and Zhang (2011) identified six types of P3 failure: 1) Value for Money not achieved (the government did not get the Value for Money promised in P3), 2) concession cancelled (the concession contract was cancelled by the government), 3) concession tender cancelled (P3 was cancelled during procurement), 4) project nationalization (the government took over the project during construction/operation phase), 5) project halted (the contractor stopped working), and 6) contract suspension (the government suspends concession rights of the SPV). Regarding the first failure type, the research team argues barring an ex-post evaluation, one cannot confidently suggest if Value for Money has been achieved. Concession tender cancelled does not fit into either P3 failure definitions discussed earlier, hence the research team argues it is not failure type. Project nationalization is a special case of early termination. The fifth and sixth types are temporary statuses, and the research team believes that failure should be a definite and ultimate effect. Therefore, the research team considers that only two failure types are valid: Early termination and, based on the previous discussion, SPV declaring bankruptcy.

Multiple studies involve the topic of P3 pitfalls. Tam (1999) investigated three unsuccessful Build-Operate-Transfer projects in Thailand to find out the following issues: SPV financial problems, public sector’s inaction/delayed action, slow and hindered construction progress, cost escalation, incomplete contract, lack of political champion, cardinal change during construction, interfering with toll pricing, changing regulations, and expensive land acquisition. Bacheva-McGrath et al., (2008) identified critical issues in central and eastern Europe transportation projects to include optimistic traffic projects, lack of competition, inappropriate risk allocation, and low revenue. Through examining the London Underground P3 project, Williams (2010) pointed out poor governance of SPV, lack of governmental control, high private financing cost, incomplete contract, selection of unsuitable subcontractors, and
poor communication to be problems. Soomro and Zhang (2013) presented 31 failure drivers by project phases and responsibilities of the parties. Rahman et al., (2014) had low revenue, dispute between partners and weak economy as failure reasons for the Kuala Lumpur LRT project. Soni (2015) propounded public sector inaction/delayed action, dispute between partners, problematic land acquisition, and lack of approvals as P3 failure reasons in India. Adarkwa reviewed five P3 bankruptcy cases in the US and identified optimism bias, low revenue, and weak economy as the common themes in those projects. Kurihara (2017) mentioned optimism bias, SPV financial problems, low revenue, dispute between partners, weak economy, and high leverage as P3 failure causes. These P3 obstacles provided a starting point to analyse the unsuccessful P3 cases in the US and develop a driver framework.

RESEARCH DESIGN

Based on the potential unsuccessful P3 drivers that were identified in the literature review, the team members individually reviewed and assigned drivers to the cases. The team then discussed the drivers that apply to each case, before checking all drivers across all cases to ensure consistency of the meanings and avoid redundancy. The process is summarized in Figure 1.

Figure 1 Research Process

The research team searched the IJGlobal and InfraPPP databases for cancelled transportation P3 projects in the US to get more than 20 results. Added to the list are bankrupted P3 projects searched from the web. In total, the team investigated 26 unsuccessful P3 projects that either had been cancelled or filed for bankruptcy (The original SPV of the Pocahontas Parkway project surrendered its ownership to the creditors, a move similar to bankruptcy except the liquidation process is not court-supervised.)

This paper distinguishes unsuccessful P3s from P3 failures with the former encompassing all cancelled P3s and projects whose private partner declared bankruptcy. The latter means projects that have been terminated after contracts are signed and the bankruptcy cases. Hence, P3 failure types include early termination and SPV filing for bankruptcy. The types of unsuccessful P3s include two other types as well: Project cancelled during planning and project cancelled during procurement.

Driver Framework for Unsuccessful P3s

Through an iterative process of independently identifying the drivers for unsuccessful P3s and discussing the differences until reaching a consensus, the research team was able to develop a two-tiered driver framework (Table 1). Tier 1 drivers are the main reasons why P3 projects became unsuccessful (i.e., cancelled or filed for bankruptcy). Twenty-three Tier 2 drivers are the contributory factors for the six Tier 1 drivers.
Table 1: A driver framework for unsuccessful P3s

<table>
<thead>
<tr>
<th>Tier 1 Drivers</th>
<th>Tier 2 Driver</th>
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<tr>
<td>Low revenue</td>
<td>Competing facilities</td>
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<td>Weak economy</td>
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<td>Poor project governance/management</td>
<td>Optimism bias</td>
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<td></td>
<td>Selection of unsuitable subcontractors</td>
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<td>Cost overrun</td>
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<td>Schedule delay</td>
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<td>Poor quality of work</td>
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<td>Financial problem with concessionaire</td>
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<td></td>
<td>Interfering with toll pricing</td>
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<tr>
<td>Lack of public support</td>
<td>Community opposition</td>
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<td></td>
<td>Lack of political champion</td>
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<tr>
<td>Stakeholder misalignment</td>
<td>Dispute between stakeholders</td>
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<td></td>
<td>Poor communication/relationship management</td>
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<td></td>
<td>Inappropriate risk allocation</td>
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<td></td>
<td>Lack of permit/approval</td>
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<td></td>
<td>Incomplete contract</td>
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<tr>
<td>Lack of Value for Money</td>
<td>Lack of competition/no bidders</td>
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<td></td>
<td>High private financing cost</td>
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<td></td>
<td>Poor financial viability</td>
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<td></td>
<td>Changing project scope</td>
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<tr>
<td>Inviable project</td>
<td>Poor/expensive preliminary design</td>
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<td></td>
<td>Limited economic impact</td>
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<td></td>
<td>Lack of public fund/credit assistance</td>
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</table>

The most common Tier 1 driver is lack of Value for Money, which applies to nine projects. Under this driver, the most common Tier 2 driver is poor financial viability, meaning the project cannot sustain itself financially. Ballati and Robinson (2014) recognized implementing P3 on unsuitable projects as a pitfall. An example is the Iliana Expressway, a 47-mile, $1.5 billion toll road that would connect I-55 in Illinois with I-65 in Indiana. The project failed to get an investment grade rating from Fitch as the rating agency questioned the reliability of traffic projection. In June 2015, Illinois governor Bruce Rauner axed the project. In the same month, a federal judge ruled that the federal approval of the Environmental Impact Statement was invalid as the study assumed the same traffic growth with or without the new road and consequently, exaggerated the demand. In September, FHWA dropped its appeal of the verdict and Indiana followed suit (Leone-Cross 2015). The second most common Tier 2 driver under the Tier 1 driver is lack of competition or no bidders. Chan et al., (2010) regarded it as a P3 obstacle and put it under high transaction costs and lengthy lead times, which Meaney and Hope (2012) and Rahman et al., (2014) considered as a P3 limitation. Another factor that could potentially deter bidders is high risk exposure. An example is the First Coast Outer Beltway in Florida. The original plan was to build a 46.5-mile toll road from I-10 in Duval County to I-95 in St. John’s County. But it turned out that no firms would DBFOM the $1.8 billion road. The private firms expected more public subsidy/guarantee considering the revenue risk. The state scaled down the project to a 15-mile section and had the Florida Turnpike Enterprise to finance it (Hannan 2011). High private financing cost applies to five projects and ranks third from the top. Macário et al., (2015) regarded it as a P3
weakness from the Portuguese experience (35). An example where this driver kicks in is the Accelerated Regional Transportation Improvements (ARTI) project in Los Angeles County, California. The project is a combination of several projects including addition of HOT lanes and a makeover of the existing lanes on I-5 North, expansion of a segment of SR 71, and building some sound walls. The Los Angeles Metropolitan Transit Authority and Caltrans, both public sponsors, cancelled the project in light of high private financing cost (P3 Bulletin 2014).

Low revenue is the second most common Tier 1 driver and applies to eight projects. The most common Tier 2 driver under low revenue is optimism bias. The Camino Colombia is a 22-mile bypass west of Laredo, Texas from the Mexican border to I-35. The original SPV was betting on an increase in truck traffic, provided that the US would allow through-trucking (without changing tractors) across the border under NAFTA, which did not come true. In the first three years of operation, less than 100 trucks travelled the road on an average day compared to 1500 projected, and the overall traffic was 13% of what was expected. Annual toll revenue was about $500,000 compared to 9 million expected. In January 2004, the project was sold at a foreclosure auction for $12 million to its lender, John Hancock Life Insurance Co. A second example is the Foley Beach Express Bridge in Baldwin County, Alabama. Opened in June 2000, the 1-mile DBFO bridge was initially contracted with the Baldwin County Bridge Company. In December 2005, American Roads acquired the concession of the bridge and the immediate approaches. In July 2013, American Roads filed for bankruptcy, citing low revenue, which is largely due to the BP oil spill bringing down traffic (Finch 2013). Another Tier 2 driver under low revenue is competing facilities, which also applies to the Camino Colombia project. The toll free World-Trade Bridge, being the competing facility to and opened around the same time as the road’s Colombia-Solidarity Bridge, attracted most of the traffic in the region (Toll Road News 2004).

Seven projects have lack of public support as a main driver, making it the third most common Tier 1 driver. Community opposition is a Tier 2 driver and apply to four projects. One of them is the Columbia Pike Streetcar project in Virginia. A candidate opposing the streetcar was elected to the Arlington County Board in November 2014. The board took this as a message that the popular opinion disliked the $358 million, 7.4-mile transit line - there was a cheaper bus rapid transit option ($67 million) and decided to abandon streetcar and evaluate alternatives to improve the corridor capacity (Thompson 2014). The other Tier 2 driver is lack of political champion, which affected four projects. The Indiana Commerce Connector would be a 75-mile toll road connecting I-69 with I-70 around Indianapolis. The project was conceived together with the Illiana Expressway to help fund I-69 construction using toll proceeds. In March 2007, Governor Mitch Daniel, the mastermind of the plan, withdrew his support of the project in the face of strong community opposition (Shaver 2014) which includes NIMBY, environmental concerns, the non-compete clause, etc. Another project that lacked political champion and got cancelled during the planning phase is the Tampa-Orlando High Speed Rail in Florida. The 84-mile link would cost $2.7 billion to build. The federal government would pay $2.4 billion, leaving a $280 million gap to be covered by the private sector. In February 2011, Governor Rick Scott rejected the federal funds, citing high risk of cost overrun and inflated ridership projection. The money was rescinded despite some lawmakers’ effort to salvage the plan (Poole 2011).
The next in line is inviable project, which involves five projects. Under this driver, lack of public fund/credit assistance ranks the first with 3 projects. The driver played a role in the cancellation of the Baltimore Red Line project. In June 2015, Maryland Governor Larry Hogan announced that he would not build the $2.9 billion, 14.1-mile east-west light rail but would support the $2.45 billion Purple Line. The reasons are 1) the state did not have the money and 2) poor design with lack of connection with the existing transit network and the $1 billion downtown tunnel (Dresser and Broadwater 2015). Reason No. 2 was poor/expensive preliminary design in our framework (also under inviable project). The other Tier 2 driver is limited economic impact, which applies to the Knik Arm Crossing project in Alaska. The connection between Anchorage with Mat-Su Borough got off the ground with a federal earmark of $231 million. The initial construction would cost $782 million ($894 million including contingencies). A 2011 article reported 89,000 residents living in Mat-Su and that the bridge could save 12 minutes on a commute from Wasilla, a population Center, to Anchorage (Boaz 2011). In June 2013, the project received the Golden Fleece award for wasting the taxpayers’ money. In June 2016, Governor Bill Walker shut down the project.

Stakeholder misalignment is a Tier 1 driver that appeared in four projects. Ranking #1 within this Tier 1 driver is dispute between stakeholders. An example is the SR 91 Express Lanes in Orange County, California. This 10-mile 4-lane toll road opened in December 1995. There was a non-compete provision in the contract that bans major improvements to 30 miles of general-purpose lanes through 2030. Facing mounting pressure to upgrade and increase capacity on the freeway, in January 2003, the project sponsor, OCTA, bought back the road for $207.5 million (Weikel 2002). Lack of permit/approval is another Tier 2 driver that falls within stakeholder misalignment. An example is the US 460 project, which was early terminated from a switched from a 63-20 DBF concession.

The last Tier 1 driver is poor project governance/management. Within this driver, financing problem with concessionaire is the highest-ranking Tier 2 driver, which applies two cases. One of the cases is the I-69 Section 5 Upgrade in Indiana. Construction was delayed four times and nearly two years behind schedule. The design-builder, Isolux Corsan, was delinquent and unable to pay its subcontractors. In August 2017, the state terminated the contract with the SPV, I-69 Development Partners, took over control of the project, and agreed to reimburse the private activity bondholders $246 million by issuing highway revenue bond. With the settlement, the project cost was estimated at $560 million in 2017 dollars, compared with the $325 million bid price in 2014 dollars (Lange 2007). The other project whose SPV had financial problems is the Indiana Toll Road. In June 2006, the Indiana Toll Road Concession Company (ITRCC), the original SPV, paid the state $3.8 billion upfront for the right to operate the 157-mile interstate for 75 years. ITRCC also pledged to spend more than $200m on capital improvements over the first three years and upwards of $4.4 billion over the life of the lease. In September 2014, ITRCC declared bankruptcy due to low revenue and delinquent financials, which were burdened by $2.15 billion interest swap liability (Bloomberg News 2014).

CONCLUSION
This paper reviewed 26 unsuccessful transportation P3 projects in the US while acknowledging that not all unsuccessful P3s are P3 failures. The authors discussed sectoral views of P3 failure and the types and drivers for unsuccessful P3s. The paper
Unsuccessful Transportation P3 Projects in the US

presented four types of unsuccessful P3s: Project cancelled during planning, project cancelled during procurement, early termination, and SPV filing for bankruptcy. Only the last two types are P3 failure types. The team has worked individually and collectively on deriving the failure drivers and assembling them into a two-tiered framework. Validation of the findings can be explored in future studies.

While successful P3 projects create the best practices to follow, failed P3s can help both public and private organizations understand and avoid potential failure. This study reports several critical observations and lesson learned for future P3 implementation.

- An unsuccessful P3 may not be a public loss. When a P3 is cancelled due to project feasibility or lack of value for money, one can argue that the failure reflects sensible governance for the public agency. An SPV bankruptcy does represent a wipe-out of private equity, or a loss to the equity investors. But the facility remains in operation and open to the public. The public sector does not have any liability to cover the loss of the equity investors.

- An SPV failure may demonstrate the P3 advantage in risk transfer. If an unsuccessful project has low revenue as a driver, that project most likely has declared bankruptcy. This means the public agency has passed the revenue risk onto the private sector. Public agencies should be careful not to allocate too much risk to the private firm.

- P3 does not save a bad project. If a project has inviable project as a Tier 1 driver, it is most likely that the project got cancelled or contract terminated, although P3 has been advocated all along.

- Better project governance and stakeholder management could help prevent early termination of contracts. Stakeholder misalignment appear as a Tier 1 driver for US 460 and SR 91. Poor project governance/management is the only Tier 1 driver for I-69 Section 5. Those three projects are failures and their contracts have been terminated. And the two drivers are areas that can be improved.

- Lack of Value for Money is the main reason why P3 procurement got cancelled. P3 procurement cannot sustain if the value of the P3 does not beat the value of non-P3s from the beginning. It is also noted that if Value for Money is an issue, P3 is most likely killed before or during procurement.

- Low revenue is the main reason for private sector’s failure. This is true for all private sector’s failures for the projects except for I-69 Section 5, whose early termination indicates both failure from both public and private perspectives.

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Unsuccessful Transportation P3 Projects in the US


STRATEGY
CONSTRUCTING ARCHETYPES: MAPPING BUSINESS MODELS IN THE CONSTRUCTION VALUE CHAIN

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Construction value chains are characterised by institutionalised roles, such as architects, engineering consultancies, contractors, and material suppliers. These roles constitute an important reference point in an industry like construction, where few processes are standardised, and few projects are repeated. However, as these roles rely on different business models, and as most construction projects are organised in a cross-organisational way, the construction of buildings tend to be a matter of coordinating and aligning different business models. Recent research shows a rising interest in business models of construction. However, the differences between construction business models are underexplored. The purpose of this paper is to investigate the archetypical business models in construction. The aim is to create a foundation from which further business model research can be conducted. It presents findings from a series of workshops and interviews with companies representing the whole construction value chain. Building on an analytical framework, we explore archetypical characteristics of different business models found in the construction industry. This includes identifying the priorities (value proposition and profit formula) and capabilities (resources and processes) of companies representing different institutional roles. We identify four business model archetypes, which utilise three distinct profit formulas. The findings show that professional service providers, like architects and engineering businesses, build on a profit formula concentrating on selling hours to cover high variable costs; general contractors build on a sustained cash-flow model to cover high variable costs and contractual risks; and material suppliers sell products and optimise the capacity of their production facilities to cover high fixed costs. Each business model is sustained through unique capabilities in the form of resources and processes, which support a specific value proposition. The identification of business model archetypes represents a platform for further research and discussions on how new technologies and changes in boundary conditions influence different types of construction businesses.

Keywords: business models, capabilities, archetypes

INTRODUCTION

The construction industry is often criticized for being less productive than other industries and being conservative and slow, when it comes to implementing innovation. The systemic challenges pointed out in Egan (1998) and Dubois and Gadde (2002), coupled with the reports published by government agencies in other countries, including Denmark, show that this criticism seems legitimate. An example of this is Nielsen et al., (2010), who show that the index adjusted construction cost in Denmark has doubled in the last 50 years, and this cannot be explained by an increase in quality of construction. Despite the increasing costs, an analysis made as part of

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this project (see Methodology) based on financial data from Danish trade publication (Asmussen, 2018) about companies in the construction industry show that companies' ability to make a profit is very different through the value chain. While large Danish main contractors in 2017 had EBIT margins (Earnings Before Interest and Taxes divided by turnover) of 8.5% to -7.3%, in the same period several large developer companies were reporting EBIT margins in the +20% range. The analysis showed that the companies in both ends of the value chain have a reasonably healthy business with a steady income, whereas companies in the centre of the value chain, i.e. contractors and professional service companies, are struggling to create a decent profit.

According to Ballard (2012), the challenges of the construction industry stem from the fact that construction production differs noticeably from repetitive manufacturing, mainly because of the nature of the product and the role of the customer. The product of a construction process is arguably unique and as such, measures and techniques from repetitive manufacturing does not apply. In the construction project, the customer has a special place as the product is made to a specific customer and not a customer type.

The construction industry hosts the typical examples of project-based organisations (Chinowsky, 2011), working in dynamic environments and short-term collaboration patterns. Eriksson (2013) argues that due to the project-based nature of the industry, project teams tend to focus on short-term results and move on to the next project without the opportunity for reflection, thus resulting in discontinuities in the knowledge flows and learning. After construction projects are terminated project teams are usually dissolved (Bower, 2003) and therefore the transfer of the valuable experience gained during the project execution is limited.

The construction value chain is organized around institutionalised roles, such as architects, engineering consultancies, contractors, and material suppliers. These roles constitute an important reference point in an industry like construction, where few processes are standardised and few projects are repeated (Thomasson, 2004). However, as these roles rely on different business models, and as most construction projects are organised in a cross-organisational way, the construction of buildings becomes a matter of coordinating and aligning different business models.

Research on aligning business models in construction has been ongoing for the last couple of decades, with searches for integrated models that span the entire construction value chain (Brady et al, 2005). This vertical approach has a counter point in models, where a supply chain is looked at as a business network, and where alignment happens, not in a common business model, but by aligning the individual business models towards a common goal (Bakhtiyari, 2016). Regardless of viewpoint on integrated or business network model, it is necessary to have an understanding of the current prevailing business models found in construction, if we wish to advance.

The purpose of the paper is to identify distinct archetypical business models in the construction value chain. This will form the basis for improved understanding of incentive structures and collaboration patterns in construction.

Conceptualizing structures and patterns of the business models of construction will enable a better understanding of how different institutionalised roles act and interact and open an agenda for improving their relationships (e.g. through strategic partnerships or in other ways). This could lead to improved productivity and innovativeness of the construction industry as a whole.
While not specifically addressing the combination of business models, this paper aims to contribute with an understanding of the archetypical business models of construction. We start by reviewing literature on business models in construction and present a theoretical frame for understanding different types of business models. Hereafter, we present the applied methodology, the findings, the discussion and conclusion.

**Business Models in Construction**

The use of business models and the development of business models in construction has been a field of research with a very broad scope. From research, which shows that participants in the construction industry have little to no understanding or ability to use business models (Pekuri et al., 2013 and Abuzeinab et al., 2014), to the barriers of implementing green business models (Mokhlesian et al., 2012 and Abuzeinab et al., 2017). Thus, the focus areas are many and varied. Recent research shows a rising interest in business models related to construction (e.g. Wikström et al., 2010, Kujala et al., 2010 and Bos-de Vos et al, 2016). While Bos-de Vos has an explicit focus on business model of architectural companies, Wikström and Kujala review business models with a focus on project organizing and identify various types of project-based business models.

Kujala et al., (2010) propose five types of business models used by project-based firms; Basic installed base services, customer support services, operations and maintenance outsourcing, delivery of life-cycle solutions and development of life-cycle solutions. They further observe that:"…there is a solution-specific nature - or solution specificity - to business models. A solution includes a project component and an after-delivery service component, and the related offering is comprised of these two components as separate parts (project-led solution) or as an integrated whole (life-cycle-led solution)."

Wikström et al., (2010) developed a categorization of business models for the understanding of the specific and unique characteristics of project business, namely business models for single projects, project networks and business networks. They further identified two questions for future research and practice: 1. "Who takes care of the overall elaboration and development of business models in project business?" and 2. "Who is able to reap the benefits from value creation from increasingly intertwined and inter-organizational business models?"

Consequently, further research is needed on the combination of business models by integration and collaboration, on how business models evolve over time and on how value creation emerges from dynamics and evolution of business models in the value network.

**THEORETICAL FRAMING**

Business models are a potential source for companies to obtain a competitive advantage. New, effective business models can result in superior value creation and replace the old ways of doing things (Zott et al., 2011). Much research has been done on business models and business model components (e.g. Magretta, 2002; Johnson et al., 2008; Osterwalder and Pigneur, 2010; Zott et al., 2011) and numerous definitions exist. The two models, which formed the bases of the data collection in this paper is the business model canvas from Osterwalder and Pigneur (2010) and the model created by Johnson et al., (2008) and reworked by Christensen et al., (2016).
Christensen et al., (2016) adopted and refined Johnson et al.'s (2008) framework to contain the four elements: Value proposition, resources, profit formula and processes. They further identified the importance of interdependencies describing the integration required between individual elements of the business model. They suggest an internal logic of the business model, where components of the model are congruent with other components. Congruency in this context means that elements have to support each other. As an example; the value proposition has to be supported by the available resources. If this is not the case, either more or different resources should be acquired, or the value proposition should change. Figure 1 shows the four elements are grouped into priorities and capabilities.

In this paper, we adopt an understanding of business model in line with Christensen et al., (2016), who states that business models by their very nature are designed not to change, and they become less flexible and more resistant to change as they develop over time.

Figure 1: Analytical framework adapted from Christensen et al., (2016)

METHODOLOGY

The paper presents the findings from a series of workshops and interviews with companies representing the construction value chain. This research was conducted as part of an innovation partnership, REBUS, which consists of Danish research institutions, building clients and construction companies representing the entire value chain. The research work presented in part in this paper, has two major themes; Strategic collaboration and business models

We organised three workshops in 2018 to explore the participants' perspectives on business models in construction. In the first workshop representatives from all companies were asked to present their value proposition using the business model canvas methodology (Osterwalder and Pigneur 2010). The second workshop sought to inspire the participant by reflecting on how disruptive technologies could challenge existing business models of construction, and the third workshop focused on mapping typical business models based on the participants' experiences from working in the industry. Originally, we planned to use Osterwalder and Pigneur's business model canvas as the main framework throughout the research process. However, the first workshop showed that this framework was too comprehensive to explain and
understand to the participants. Subsequently, we decided to use Christensen et al.'s framework (Figure 1) for workshop 3.

Building on this framework, we explored archetypical characteristics of different business models found in the construction industry. This included identifying priorities (value proposition and profit formula) and capabilities (resources and processes) of construction companies representing different institutional roles.

The workshops included participants representing clients, architects, engineers, contractors and material suppliers. The third workshop represents the primary empirical material for this paper and had three high level representatives: a construction materials manufacturer, a large contractor and an experienced building client. The workshop had a duration of two hours and the findings were supplemented by follow-up interviews with a professional service provider, a large consultant company, and literature studies. In the third workshop, the participants were asked to brainstorm on the capabilities (resources and processes) and priorities (value proposition and profit formula) of each of the institutional roles of construction (i.e. architect, engineer, contractor and supplier). Subsequently, the participants presented the findings from this brainstorm to each other. To emphasise that the participants had divergent understandings of each role, we asked the participants to listen to other participants' view on their own role, before presenting their own view.

The last workshop was audio recorded and Post-it notes was transcribed to document the findings. After the workshop, the Post-it notes were subsequently organized and analysed to identify contours of the archetypical business models.

**FINDINGS**

Through the workshop, interviews and analysis, we identified four business model archetypes, which utilise three distinct profit formulas illustrated in Table 1. Each business model is sustained through unique capabilities in the form of resources and processes, which support a specific value proposition.

**The Architects and Engineers**

The preliminary findings show that professional service providers, like architects and engineering businesses, build on a profit formula concentrating on selling hours to cover high variable costs. It is important to note that the way to classify costs can depend on the boundary conditions that a company has in a given market. Since professional service providers are knowledge firms, the fixed cost (e.g. office space leases, insurance and office equipment) is negligible when compared to the variable cost of wages to highly skilled specialists.

Both architect and engineering businesses have a strong focus on advising the clients as a central part of their value proposition by using e.g. references to previous projects. However, their underlying capabilities differ, and while a typical architect's competences concentrate on integrating aesthetics and functionality, a typical engineer focus on quality assurance and in-depth technical studies. Architects and engineers share a strong emphasis on digital tools and the ability to win competitions. They primarily differ with regards to competencies and, to some extent, the scale of projects. Participation in competitions and bidding processes represent a significant upfront cost, which every competing company must recuperate through overhead on other projects. Consequently, many professional service providers prefer making framework agreements with building clients to avoid the extra cost and risk of competitions. This requires competences in managing long-term relationships with
Table 1: Overview of archetypical business models in construction

<table>
<thead>
<tr>
<th>Value proposition</th>
<th>Architect</th>
<th>Engineer</th>
<th>Contractor</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High architectural quality</td>
<td>Advise the client</td>
<td>Convert project material to buildings -&gt; buildability</td>
<td>Products with few flaws and complaints</td>
</tr>
<tr>
<td></td>
<td>Art</td>
<td>Prestige (reputation)</td>
<td>Give the client what is economical possible in the project</td>
<td>Sustainability &amp; Comfort</td>
</tr>
<tr>
<td></td>
<td>Development</td>
<td>Ensure the building’s durability</td>
<td></td>
<td>Materials are delivered on time</td>
</tr>
<tr>
<td></td>
<td>Advise the client</td>
<td>Innovative solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Listen to the users</td>
<td>Trustworthy solutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit formula</td>
<td>Selling hours to cover high variable costs</td>
<td>Selling hours to cover high variable costs</td>
<td>Ensure constant cash flow to cover variable costs and contractual risks</td>
<td>Sales of products and systems</td>
</tr>
<tr>
<td>Resources</td>
<td>Creative and competent employees</td>
<td>Strong professional skills especially on technology</td>
<td>Construction skills specially trained employees</td>
<td>Production facilities</td>
</tr>
<tr>
<td></td>
<td>Strong digital tools</td>
<td>Strong digital tools</td>
<td>Special equipment</td>
<td>Manufacturing expertise</td>
</tr>
<tr>
<td></td>
<td>Communication resources</td>
<td>Commercial relations and project alliances</td>
<td>Purchasing Competencies</td>
<td>Good relationship with customers / contractors</td>
</tr>
<tr>
<td></td>
<td>Commercial relations</td>
<td>Project management and control</td>
<td>Project and construction management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project management and control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processes</td>
<td>Integrate aesthetics and function</td>
<td>In-depth technical studies</td>
<td>Calculate expenses</td>
<td>Understand the market on the short and long term (10, 20, 30 years)</td>
</tr>
<tr>
<td></td>
<td>Set the right teams</td>
<td>Keep the balance between unique and standard</td>
<td>Read the market (expenses, capacity, etc.)</td>
<td>Develop new products / new markets</td>
</tr>
<tr>
<td></td>
<td>Convert ideas / needs into design</td>
<td>Make &quot;good enough&quot; solutions</td>
<td>Adhere to schedule and flexibility</td>
<td>Optimize production</td>
</tr>
<tr>
<td></td>
<td>Create a basis for construction, Win competitions</td>
<td>Quality assurance / review</td>
<td>Manage purchasing and logistics</td>
<td>Advertise products</td>
</tr>
<tr>
<td></td>
<td>Continuous development</td>
<td>Secure realizable solutions (buildability, architecture, price)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
cover the often-long span of time between an expense being paid by the contractor and the building client reimbursing the contractor. The high variable cost of contractors comes both from wages to employees (in-house production) but also from, building materials and sub-contractors. The sustained cash flow is achieved by carefully following the market and shaping projects in a way that fits the capabilities and capacity of the company. Depending on the contractor, some of the turnover is secured through tendering processes - but in all cases the ability to document the capabilities and capacities is important e.g. through references.

The key value proposition of the contractor is to convert project drawings and other specifications to physical buildings, delivering the project within the economical boundaries of the project. This require contractors to be capable of ensuring buildability of design, calculating for realistic estimates on costs and time, managing purchase and sub-contractors, assessing and handling risk through the project life cycle, monitoring and controlling project progress and handling the various stakeholders in and around the project. The capabilities of the contractor first and foremost consist of human resources and include technical construction skills and project management competences.

The Supplier

The profit formula of material suppliers is based on selling products and systems. Typically, they strive to optimise the capacity of their production facilities to cover high fixed costs. Compared to the institutional roles, the suppliers usually have large fixed costs based on investments in production facilities. This makes them less agile in terms of scaling the organisation to the market and thus they work with longer time horizons - up to 30 years. The value proposition of the supplier centres around providing products on time with a minimum of flaws. Consequently, material suppliers have capabilities within supply chain logistics and strive to avoid legal responsibilities for erroneous handling of their products during the construction process.

The suppliers focus intensively on developing good relationships to their customers, which typically include large contractors and wholesalers. Although architects are not direct customers, material suppliers tend to prioritise showcasing products to architects to influence purchasing decisions derived from the early design phases. Thus, architectural offices often include a substantial amount of demo products to increase visibility of suppliers' products. To stay competitive, suppliers focus on utilizing their production capacity. This includes sustaining and developing capabilities within automation, lean production and digitalization. In addition, suppliers emphasise the importance of new product development to respond to changing user requirements. However, given the high cost of production facilities, the innovation and variance of products tend to be constrained by the capabilities of the production system. Furthermore, many suppliers struggle to remove products from the market although new products are launched, resulting in a high degree of product variance and high complexity costs.

DISCUSSION

The identification of four archetypical business models raises several questions. One is on the modularity of business model in construction: To what extend does the business models fit one another or are they in conflict? And under what circumstances? Combining the architect's aspiration for unlimited flexibility with the
supplier's high degree of product complexity can result in a toxic environment for contractors in charge of realizing the project within budget.

This further raises a question on how business models can be combined across businesses. Both Zott and Amit (2008) and Wikström et al., (2010) support the observation that business models are not constrained to firm level, but they can also exist between companies. Here it is interesting to follow the development of strategic partnerships, where construction companies collaborate with a certain client or segment on a portfolio of projects over a longer period of time. When these long-term partnerships are established, conflicting business models can create friction. To execute construction projects successfully, strategic partnerships therefore need to identify their conflicting interests and address these.

This paper does not describe the archetypical business model of construction clients. This is a limitation, which will be addressed in our further research that focus on strategic partnerships. The construction client can by the way they formulate tendering conditions promote specific forms of strategic partnerships, which requires new integrated business models, where companies from different parts of the value chain have to engage in long-term collaboration on a project portfolio (Jensen et al., 2017).

Another topic concerns the gradual development of business models. Christensen et al., (2016) suggest that business models remain stable over time, but also that they can be developed through gradual experimentation. The similarity (and compatibility) between the business models of architects and engineering businesses may be one of the reasons, why we are currently witnessing blurring boundaries between engineering and architecture. In Denmark, architects are increasingly hiring engineers to support their design, while engineering companies are buying architectural businesses to improve their service to the clients. In addition, suppliers and contractors also experiment with new business models in Denmark. Contractors strive to become consulting contractors through early involvement in construction projects, and suppliers increase investment in complex system products that require design competencies.

Business models frame how construction companies collaborate, and how trends and digital technologies are implemented in construction practices. By challenging their current business models, construction companies may gain a competitive advantage in a dynamic market, where sustainability and digitalisation are important drivers of change. The identification of business model archetypes thus represents a platform for further research and discussions on how new technologies and changes in boundary conditions influence construction businesses.

**CONCLUSION**

The construction industry continues to struggle with productivity, profitability and quality. Business models will not directly solve these challenges caused by a multitude of factors, but business models can be a tool to understand and develop the construction industry.

To help in the development of new and innovative business models, this paper has supplied a fundamental ingredient; identified current archetypes of business models in construction. We have identified four business models with three distinct profit formulas. The business model for the architect and engineering firm share a profit formula, "selling hours", but they have distinct features, which sets them apart when it
Constructing Archetypes

comes to the other three dimensions in the business model; Value proposition, resources and processes. Suppliers and contractors have their own distinct profit formula; "sales" and "constant cash flow", respectively.

Further research can use these four archetypes as a starting point, e.g. in the alignment of business models in a business network context or a strategic partnership. Knowing the current starting point is paramount in our understanding and development of the construction industry.

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SUSTAINABLE RENOVATION
USING RENOVATION CONCEPTS FOR MASS HOUSING ENERGY RENOVATION

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New Dutch policies for a CO2-neutral building stock in 2050 and the phasing out of the use of natural gas for heating and hot tap water, force for a much higher housing renovation rate and lower cost per renovation. To realise the ambitious policy goals a new long-term research program in the built environment is being set up, combining research of Technical Universities, Universities of Applied Sciences and research institute TNO. The program should lead to innovations that make the transition to sustainable existing buildings and neighbourhoods efficient and affordable and has to provide the knowledge needed to realize this in practice. BTIC has high expectations of: 'customized mass production' through far-reaching industrialization, digitization and robotisation on the basis of a limited number of standards and new business models and forms of cooperation at the supply-side, that tempt people and the business community to accelerate. The objective of this paper, based on a literature review, is critically reflect on the intertwined expectations and underlying assumptions of the BTIC program being synchronizing and upscaling demand for deep renovation making use of prefabricated standarised renovation measures and ‘renovation concepts’, leading to innovations and by this to low cost housing renovation. To answer the stipulated research questions of the BTIC program, economic theories, innovation and innovation adoption theories and organisational theories have to be explored further. Knowledge has to be developed about upscaling demand, economies of scale, process and product innovations in the case of renovation.

Keywords: housing, innovation, prefabrication, renovation concept

INTRODUCTION

On December 12th, 2015 the adoption of the Paris Climate agreement was announced (United Nations, 2015). The goals of the Paris Climate agreement present a major challenge for national policy-makers, because it asks for a far-reaching decrease of global greenhouse gases emission (PBL, 2016). The Dutch Climate Agreement (In Dutch: Klimaatakkoord), the Dutch contribution to the Paris Climate agreement, has set a central goal on the horizon: the decrease of greenhouse gases with 49% in the year 2030 compared to the year 1990 (Klimaatakkoord, 2018a). This is an intermediate step on the way to the goals of the Paris Climate agreement in 2050.

The 2010 Energy Performance of Buildings Directive (European Union, 2010) introduced the requirement of implementing energy efficiency measures in connection to major or deep renovations to encourage more ambitious renovation. The EPBD also asked EU Member States to introduce cost-optimal energy performance requirements for new buildings as well as for renovation activities. The 2012 Energy

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Efficiency Directive (European Union, 2012) complemented the EPBD by encouraging ambitious renovations through the requirement for EU Member States to establish strategies for the renovation of their national building stocks as well as to annually renovate the 3% of the central governments building stock to a high energy performance level.

The existing housing sector plays an important role towards achieving the energy efficiency targets in the European Union (Filippidou et al., 2016; Ürge-Vorsatz et al., 2007). Since the implementation of the Energy Performance of Buildings Directive, energy efficiency is a matter of great concern in the Dutch non-profit rental housing sector. This shift was not only stimulated by European policy, but also by national political pressures on the sector to show a higher degree of social performance. Aedes, the national umbrella organisation for Dutch housing associations (which almost exclusively own the non-profit housing stock in the country) has embarked on activities targeted at an entirely “CO2-neutral” social housing stock in 2050, which prospect is in line with several national and international policies which aim an energy-neutral built environment in the same year (Aedes, 2017). To reach this goal high investments are needed. Filippidou et al., (2017) present in a study the renovation rates for the non-profit housing stock of the Netherlands, based on the changes in the energy performance of over 850,000 dwellings for the period of 2010-2014. The results show that although many energy improvements have been realized, they result in small changes of the energy efficiency of the dwellings. Deep energy renovation rates are very low.

Before the end of the government's term in 2021 the Dutch Cabinet wants to make 30,000 to 50,000 existing homes per year independent of natural gas or ready to disconnect them from natural gas supply. In addition to the agreements from the National Climate Agreement, sector organisations of housing associations, construction firms and energy network companies (Aedes, Bouwend NL, Uneto-VNI, Netbeheer Nederland, OnderhoudNL) and the energy companies have the ambition to make at least 100,000 homes free from natural gas or ready to disconnect them from natural gas supply free in the period 2019 through 2021.

Building and Technology Innovation Centre

A new public-private partnership, the Building and Technology Innovation Centre (BTIC), wants to act as a flywheel to achieve the policy aims for a climate neutral built environment in 2050 (BTIC, 2018). BTIC is the result of the Dutch Building Agenda launched in 2016 with the aim of achieving an ambitious innovation and innovation program. The Building Agenda has been designed around the major societal challenges: energy transition, the use of raw materials, climate change, mobility, digitization and health. In BTIC, the Dutch Universities of Technology, Universities of Applied Sciences, the national research institute TNO, three ministries, and sector organizations for construction firms and for engineers work together on the necessary innovations in construction and technology.

The BTIC focuses on 5 programs for the built environment and infrastructure, the first of which will start at the end of 2019 (BTIC, 2018). Those programs are: (1) Integrated energy transition existing buildings, (2) Digitization (3) Circularity, (4) Infrastructure, and (5) Spatial adaptation and climate change. The program ‘Integrated energy transition existing buildings’ is about innovations that make this transition to sustainable existing buildings and neighbourhoods efficient and affordable and the knowledge needed to realize this in practice. Within the BTIC
program ‘Integrated energy transition existing construction’ four program lines are being distinguished (BTIC, 2018): (1) Renovation concepts and processes, (2) Heat pumps and heat storage, (3) Transition process, and (4) Control of collective energy supply.

The BTIC focuses on ‘disruptive and open innovations’ to make the transition to a CO2-neutral built environment feasible and affordable in 2050 with the objectives of a healthy profitable sector and affordable, quality solutions for building owners. In addition to innovative techniques and products, innovations are also needed for new production methods, new forms of learning and knowledge transfer, and adapted ways of tendering.

BTIC has high expectations of: ‘customized mass production’ through far-reaching industrialization, digitization and robotisation on the basis of a limited number of standards and new business models and forms of cooperation at the supply-side, that tempt people and the business community to accelerate (BTIC, 2018). In other words the research program foresees and advocates a transition from the traditional contractor-subcontractor-supplier model to value-based consortia that deliver guaranteed solutions with performance guarantees.

OBJECTIVES AND METHODS

The objective of this paper is to critically reflect on the intertwined expectations and underlying assumptions of the BTIC program being synchronizing and upscaling demand for deep renovation making use of prefabricated standardised renovation measures and ‘renovation concepts’, leading to innovations and by this to low cost housing renovation. The second objective is to draft an agenda for further research.

We define renovation concepts as (integrated) prefabricated renovation measures for dwelling types, making use of standardisation, a standard process, prefabrication of building products, whole facades and roofs, combining innovative products and technologies, plug-and-play components, and on-site assembly. The applied research method is an explorative literature review of tendering approaches of the demand-side, especially Dutch housing associations as repeat construction clients, and the conditions for innovative behaviour of the construction industry. The study does not address the topics of innovation adoption and diffusion and end-user acceptance.

The BTIC program acknowledges that change in the construction industry urges an integrated approach. In the report ‘Scaling up deep energy renovation’ (i24C and BPIE, 2016) seven main components are described that are seen as critical to scaling up and increasing the rate and depth of energy renovation. “Only by interconnecting these components and key actors it will be possible to create a viable path forward” (i24C and Buildings Performance Institute Europe (BPIE), 2016: 6). The components are: Legislation, Business model, Value chain ecosystem and leadership, Marketing and awareness raising, Financing model, Technical solutions and products, and Aggregation of demand. “Aggregation of demand responds to fragmented building ownership in Europe by grouping demand to make deep energy renovation more feasible technically and economically” (i24C and BPIE, 2016: 7). Private-sector customers are themselves too fragmented to catalyse change. “The public sector accounts, as both a large customer and a setter of standards, has the clout and the means to encourage the industry to improve” (The Economist, 2017). Dutch housing associations are semi-public organisations, being repeat clients of renovation, with
favourable conditions for synchronizing and upscaling demand and continuity in production flows, owning large series of relatively homogeneous properties.

**Renovation by Dutch Housing Associations**

In 2018, 313 housing associations owned 30% of the Dutch housing stock, being approximately 2.4 Million dwellings. Evidence from the recent past has shown that housing association generally are motivated to make considerable progress in the energy performance of their homes, but that they also face considerable internal and external resistance, reason why the average progress is slower than originally intended (Filippidou et al., 2017; Nieboer, 2017). This suggests that the aim of a CO2-neutral housing portfolio is difficult to attain in current circumstances.

There is ample body of literature on process innovations such as partnering (e.g. Bygballe et al., 2010) and success factors of partnering (e.g. Kim et al., 2010), however literature on partnering in housing renovation and upscaling demand is very scarce. Over 10 years ago, housing associations begun to develop supply chain partnerships in new-build, maintenance and refurbishment, (Straub, 2009). In recent years a series of innovative procurement and tendering models and tools, and collaborative relationship models, like soft selection methods, best value procurement, design contests and market challenges (NéZeR, 2017), main contracting and partnering agreements have been introduced although traditional procurement processes are still used for the majority of projects. In this respect it is important to note that Dutch housing associations are seen in Europe as private organisations and don’t have to obey public procurement rules. Strategic partnering, that could be a favourable relationship model for upscaling and continuity in demand, is still in its infancy. Often ‘pilot projects’ with innovative procurement and tendering models focus on one limited renovation project and are not followed by other projects, or other projects are done by other consortia. The lack of a strategic partnering approach results in a lack of learning curves.

Roders et al., (2013) conclude in their evaluation of partnering projects between Dutch housing associations and renovation and maintenance contractors, that partnering does not automatically lead to innovative product solutions. In the first place, the cooperation is strongly focused on improvements in the process: better cooperative preparation by all parties involved and a coordinated implementation schedule. The new way of working together is seen as innovation in itself. Much less attention is paid to inventing and applying innovative products. Contractors dare to take little risk in the field of product innovation because they are uncertain about the payback opportunities, clients are reluctant to enter into the long-term partnerships that help to cover development risks (Roders et al., 2013). The partnering agreements involved in the research project are about single projects. If a partnership becomes strategic, then the conditions to develop innovative solutions by the supply-side are much better. Then the steps can be taken from existing processes to new aligned renovation processes, from new building processes to new renovation products and, for the supply-side consortia, from new products to new markets (Roders et al., 2013). New markets, e.g. private sector housing, could bring along a greater demand.

**Renovation Concepts**

Development of affordable energy renovation concepts, and a fast renovation process are seen as essential in realizing a climate neutral built environment in 2050. The Dutch Energiestroom programme, introduced in 2013, meant to stimulate the development of disruptive innovations in renovation processes, products and services,
and organisations (Stutvoet, 2018). Four Dutch construction consortia started to develop renovation concepts for six housing associations, called the Stroomversnelling, that could upgrade the energy status of mass-housing dating from the sixties and seventies to (nearly) zero-energy or zero-on-the-meter dwellings. Van Oorschot et al., (2016) characterize this as modular, platform-based retrofit concepts, that drastically improve the overall performance with respect to energy consumption and indoor climate while building aesthetics radically change. Rovers (2014) describes one of the precursors of renovation concepts: A serial retrofit process of 150 single-family dwellings in Kerkrade, the Netherlands with a renovation time of ten days per house with the houses inhabited during the renovation process.

Although the Energiesprong programme has challenged the Dutch building industry and clients to innovate drastically, and the cost of net zero energy renovations of terraced housing have been reduced considerably (Stutvoet, 2018), market diffusion of this kind of renovations is still very low. In the national debate the still very high cost for renovation are the most mentioned reason. Most housing associations prefer to spread out their limited financial resources to a greater part of their housing stock in need for energy measures. The construction industry argues that they need a much higher demand to innovate and reduce costs further.

To investigate the business case for energy renovation making use of prefabricated facades Aczarate-Aguerre et al., (2017) made an estimation of the effect of production processes on the cost of renovation per dwelling. Based upon a series of interviews with contractors and suppliers in the Dutch building sector they expect a cost reduction range at average of 5%, based on a volume of 1,000 renovated dwellings, In a positive scenario the cost reduction range could be 10%. This according to the authors, reflecting the industrial effect by which, when producing a large number of identical or highly similar products, a lower cost per unit is achieved by assumed more effective production processes or more widely distributed overhead costs (Aczarate-Aguerre et al., 2017).

Innovation in the Construction Industry

The Organization for Economic Cooperation and Development (OECD, 2015) defines innovation as: "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practises, workplace organization or external relations. Inter-organizational collaboration of supply networks is seen as a core mechanism for improving efficiency and innovation. This is hard to reach in a fragmented market of small and medium-sized firms in the construction industry. “Different suppliers and other stakeholders are brought together around temporary projects in different stages of the production process” (Kahkonen, 2015: 130). Kahkonen (2015) argues that this can be seen as a fundamental characteristic of building. The idea of deep retrofitting making use of prefabricated components could be seen as systemic innovation, a model where the solutions have wide and deep impacts amongst stakeholders of the sector (Slaughter, 1998). Within systemic innovations reaching the required critical mass is a key challenge for the business case. In this respect Harty (2005) makes a distinction between innovations that can be contained within a single sphere of influence and those that extend beyond this into the wider inter-organisational landscape of construction work, calling them bounded and unbounded innovations. The innovations systems perspective emphasises the significance of a large and differentiated group of innovation actors and an enabling framework for learning-
oriented interactions between them (Edler and Georghiou, 2007). Literature about product and process innovations in the construction industry is often about innovations implemented in projects (e.g. Ozorhon et al., 2016 and not about standardising project-related innovations in new marketable products.

Part of the systemic innovation are needed product and process innovations, e.g. innovations in the to be installed HVAC systems in deep renovated dwellings: smaller, with a higher performance and for much lower cost. Industrial innovation in the construction value chain faces a number of interlinked challenges (e.g. Arnoldussen et al., 2017):

- An uncertain economic and policy outlook that can make it difficult to justify investment in innovation;
- The need to manage risk inherent to innovation projects because they aim to develop and deeply new processes or products;
- The need to balance collaboration to protect knowledge;
- Conservative mind-set of those involved in the value chain.

Arnoldussen et al., (2017) emphasize in their analysis of innovation in the construction sector (in the Netherlands) also a lack of investments caused by finance difficulties caused by risk. The profit margins in the building industry are very low, compared to other industries, making them risk-aware and shaping bad conditions for innovations. “Companies that employ lots of workers without investing much can simply cut their workforces. (…) but the trade as a whole is reluctant to spend money on the sorts of technologies, from project-management software to mass production, that have revolutionised so many other industries” (The Economist, 2017). It can be argued that for a successful product development the involvement of global operating product manufacturers and suppliers is needed to reach the economies of scale and by that cost reduction.

Adamczyk et al., (2012) made an in-depth study of innovation contests. The conclude that, in comparison to many traditional new product (or service) development initiatives, innovations contests are a powerful alternative for generating new ideas. The contests focus on integrating various stakeholders into innovation activities at an early state of the innovation process. "By means of collaborative as well as competitive elements integrated in an innovation contest, participants are challenged to come up with new product or service solutions for the underlying problem" (Adamczyk et al., 2012: 347). For the aimed disruptive innovations of BTIC contests as tendering method could be an interesting option to explore.

DISCUSSION

New Dutch policies for a CO2-neutral building stock in 2050 and the phasing out of the use of natural gas for heating and hot tap water, force for a much higher housing renovation rate and lower cost per renovation. Proof that aggregation of demand will lead to lower renovation cost is meagre. By aggregating and streamlining replicable processes in the building industry you might expect that economies of scale result in lower cost. Moving from a unique project approach to an industrialised product-centred approach or even further to a service-oriented approach that uses innovative technologies and business models, could reduce the cost of energy renovations.

The BTIC (2018) aims for disruptive and open innovation to enhance the transition to a carbon neutral built environment in 2015, feasible for the building sector and
providing quality solutions affordable for building owners. A disruptive innovation is an innovation that creates a new market and value network, and can be seen as systemic and unbound. It seems that here the critical mass is seen as the most critical issue.

Well-known shortcomings of the construction sector as small companies and fragmentation are also present in the Netherlands. Their investment in R&D is very low. Even more important is a growing shortness of skilled labour in the construction industry, also resulting in higher prices. At the other side this shortness of skilled labour could be a driver to innovate.

Interesting is the case of the Energiesprong programme within the innovation system perspective. Clearly, this programme was a wake-up call for the construction sector to operate differently and e.g. extending supply-chains to product suppliers and maintenance companies. Interesting is the international success of the Energiesprong. After the Netherlands, Energiesprong selected France, the UK, Germany and Northern Italy as initial markets to create demand for volume retrofits and a supply chain to service them (Transition Zero, n.d.). Although, also internationally the numbers of renovated houses are very limited, it drives the construction sector to change their working processes and to shape conditions to deliver solutions with guaranteed performance.

A higher and also more continuous standardised demand for energy renovation measures guarantees the supply-side of turnover. Thereby building renovation processes will be standardised, new products will be developed and integrated and the construction works will be industrialised. The underlying concept or prerequisite is the use of another demand specification. Using functional requirements, by clients in tendering, provide space to offer the best solutions by market parties. For this the use of other project delivery models could be necessary or desirable to integrate design and construction (and maintenance). Scale can be organized on the supply-side by forming smart coalitions and by sharing risks. Other business models could be needed, e.g. for SME cluster collaboration for large scale retrofitting (NeZeR, 2016). Also product manufacturers may take the leading role in supply-chain networks to innovate in energy measures.

Scale can also be organized on the commissioning side, by strategic partnering and cooperative tendering for renovation by groups of clients. In the Netherlands housing associations can play an frontrunner role in aggregating demand. These semi-public clients own thousands of dwellings of a similar housing typology, are very powerful local players and are professional clients with a long term perspective. The potential for standardisation and mass customisation in renovation of the Dutch housing stock is huge. This is especially the case for row houses and apartment buildings built between 1945 and 1992 (before the date of commencement of the Dutch building code). However, not all dwellings in a row still have the same characteristics and were maintained differently, making the adoption of renovation concepts and mass customization more difficult and asking for series of one. Besides, often more than one housing association owns dwellings in the same neighbourhood, and the stock could be ‘pepper potted’ by transactions to the owner-occupied sector. And organisational problems can arise. The housing associations act very differently, being independent private organisations with their own strategic policy targets and asset management strategies, and inequalities in financial resources (Nieboer, 2017).
However, new ways are being explored for the inter-organisational tendering. Sector organisations of housing associations and construction firms will start the 'renovation accelerator' (Klimaatkoord, 2018b). One will develop tenders for similar homes based on housing typologies, sustainability approaches and functional performance requirements, aiming for one-off and stepwise improvements of dwellings till 2050. Starting with a first trial auction in the second half of 2019 and auctions with suitable contract volumes from 2020 onwards, aimed at further upscaling and cost reduction to enable a large-scale and continuous construction flow.

Housing associations are also stimulating innovations by innovation contests. A first challenge in 2019 is about wall insulation: higher insulation grade, lesser thickness, cheaper and easy to apply. The winner is promised that, after further development of the innovation, housing associations will buy the product for a high number of dwellings. This will significantly reduce the risks for competitors to innovate (Isolatieuitdaging, n.d.).

**CONCLUSIONS**

To answer the stipulated research questions of the BTIC program, economic theories, innovation and innovation adoption theories and organisational theories have to be explored further. Knowledge has to be developed about upscaling demand, economies of scale, process and product innovations in the case of renovation. Deep renovation of the residential building stock, and especially the need for highly improved energy efficiency, tend to push the limits of the demand and supply-side economics. The construction sector has to change from a traditional situation of awaiting tenders for renovation projects into a market that offers smart, performance-based renovation measures and concepts for dwelling types. Besides, adopting product and process innovations, supply-side actors have to develop new complementary services based upon principles of service-life planning, life-cycle costing, energy performance and comfort parameters.

Given the barriers of institutional barriers, innovation adoption and diffusion, and related end-user acceptance, the question remains how synchronizing demand specifications, securing production flows and upscaling demand will lead by innovations to cost reduction of renovations, stepwise and on-off. Research directions are, but not limited to:

- What economies of scale can be expected by standardised and aggregated demand?
- What kind of innovations in renovation measures and renovation concepts will lower life-cycle costs?
- What tendering methods and market conditions encourage and stimulate successful innovation networks at the supply-side?
- What conditions enable and encourage housing associations for (inter)organisational synchronising and upscaling of demand for deep renovation?

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THEORISING TOOLS
FROM TOOLS TO THEORIES: FOUR APPROACHES TO CONSTRUCTION IT RESEARCH

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Construction IT (CIT) has recently developed into a research field in its own right, with a unifying goal of enhancing the use of digital technologies to improve performance by enabling faster, cheaper, and better construction. However, we argue that CIT research has even greater potential. Therefore, the purpose of this paper is to analyse the current state of CIT research and illustrate how its scope can be extended to make relevant and interesting contributions to the wider information systems (IS) community. Based on a phenomenology-inspired analysis of contemporary CIT research, we identified four streams of research. Each stream is characterized by its taken-for-granted assumptions, core audience, and assumed purpose of theories. The identified streams are: Building better buildings with IT; Building buildings with IT theories; Building theories of construction IT; and Building better IT/IS theories. For each stream, we discussed the general view on IT/IS and provided examples of potential publication outlets. This article provides a schematic overview of CIT research, as well as new insights into challenges and opportunities in extending CIT contributions, and making them relevant to a wider IS community.

Keywords: digital, theory, methodology, phenomenology, Construction IT

INTRODUCTION

Since the mid-1980s, digital technologies have enabled performance improvements in almost all industries. Within the architecture, engineering, and construction (AEC) industry, the use of digital technologies has not only become an important tool to improve everyday practices, but an integral part of university curricula and training for new practitioners (Sun and Howard 2004). In preparation for their careers, AEC students must not only learn their craftsmanship, but also understand the application, benefit, and challenges of new digital technologies. Alongside this development, a new research field addressing the role of digital technologies within the AEC industry has emerged. This field is generally referred to as construction informatics, ICT in construction, or construction IT (CIT).

As with most other fields of research, both the community and its outputs are quite diverse. CIT has attracted scholars from such various fields as informatics, computer science, industrial and civil engineering, business administration, and construction management. CIT has produced outputs ranging from studies of robotics and automation of construction processes, to studies of specific technologies such as building information modelling (BIM). Despite this diversification, a predominant and unifying interest, or goal, of this emerging field is related to finding new ways to utilize digital technologies to improve performance by enabling faster, cheaper, and better construction. Given the far-reaching project logic within the industry, where

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the iron triangle constitutes the boundary between successes and failure, this appears to be a relevant, obvious goal for CIT research. In fact, this assumed goal of finding new ways to utilize digital technology to improve performance is rarely, if ever questioned.

Paradoxically, we argue that this seemingly obvious goal might be counterproductive for the research field at large, and that the potential of CIT research is greater than just enhancing processes, practices, and outcomes. Therefore, our purpose is to analyse the current state of CIT research and illustrate how its scope can be extended to make relevant and interesting contributions to a wider IS community. We argue that researchers must understand both the phenomenology and uniqueness of the research field. Based on a phenomenology-inspired analysis of contemporary CIT research, which asks the question what makes theories interesting (Davis 1971), we argue that the general goals and assumptions of CIT research must be broadened. CIT research must move from predominantly focusing on IT as a tool to improve construction practices and processes to focusing on how the phenomena of IT in the AEC context, can provide an interesting and useful case for more general IS inquiries. In essence, this will make theoretically founded contributions to a wider community, which researchers recently have been asking for (see e.g., Bresnen 2017; Koch, Paavola and Buhl 2019).

BACKGROUND

To illustrate how CIT researchers can extend their work and make relevant and interesting contributions to a wider IS community, we must first address CIT as a research field and an interrelated research community.

CIT as a Research Field and Community

For most actors involved in research, it is well known that researchers develop, act, and communicate within one or several research communities, and that a common area of interest (theory or practice) lies at the core of these communities. Furthermore, it is widely accepted that each community has overlapping interests and connections with other surrounding communities. CIT is no exception. However, there are numerous ways to understand the inner workings and function of such research communities, in which the notion of communities of practice (CoPs) provides a suitable starting point. A CoP is a group of people who share a craft or profession (Lave and Wenger 1991). In its simplest form, CoPs emerge as people engage in a process of collective learning in a shared domain of human endeavour (Wenger 2011). In the case of this article, the endeavour is to collectively develop knowledge about the role of digital technologies within the context of the AEC industry. A CoP has three distinct characteristics; Domain, community, and practice.

The domain constitutes a shared area of interest that motivates members and provides meaning to their actions (Wenger et al., 2002). The domain provides a shared identity, based on the common interest. Members develop their special competence within the domain, which distinguishes them from non-members. To pursue their shared interest, members engage in joint activities and discussions. The community is the social fabric for learning, represented by the relationships built through engaging in collective knowledge development. This is manifested in academia through the many conferences, special interest groups, and joint publication outlets in which practitioners regularly engage. Therefore, a strong community fosters this social fabric and facilitates a willingness to share ideas (Wenger 2011). While the domain
provides the basis of shared interest (in this case, the role of digital technologies in the AEC industry), and the community is the social fabric for learning (exemplified by journals, conferences, and special interest groups), practice represents a shared way of seeing and doing things. Wenger et al., (2002) explain practice as a shared repertoire of resources which include experiences, stories, tools, and common ways of addressing problems. In essence, it is the institutionalized understanding of how things are done, illustrated by a collective set of taken-for-granted assumptions and the alignment of ways of doing things within a community.

Alvesson et al., (2017) provide a more critical description of how CoPs function, which positions the idea in contemporary academia. In their essay on the development of “meaningless research in the social sciences,” they describe research communities transforming into microtribes. As with CoPs, each microtribe is subject to internal logic. In the case of microtribes, this logic focuses at safeguarding internal interests, often ignoring development and history in other fields. Therefore, microtribes risk producing narrow, introspective, and ultimately “meaningless research”. A potential difference between the notion of CoPs and microtribes is the assumed narrow-mindedness of involved actors. In the case of CIT, different assumptions are made regarding, for example, the rationale for research and the utilization and (assumed) purpose of theories. We will return to the similarities, differences, and potential consequences of the CIT research field being a CoP or developing into a microtribe.

That’s Interesting

Having discussed the conceptual fabric of research communities, we now turn to the question of understanding the phenomenology of a specific research field, which we argue is important for enabling interesting contributions to a wider IS community.

In its simplest form, phenomenology represents how we think about ourselves. This article examines how representatives of CIT research think about and understand the field within which they are active and how this is reflected through their practices. The phenomenology of CIT research manifests in the activities and outcomes of the community we will analyse and discuss in this article. In doing so, we build on the notion of CoP, but also on Davis’ (1971) seminal work on why people find scientific discoveries interesting.

Davis (1971) asked: “What makes interesting theories different from theories which are generally considered non-interesting?” His conclusion points at the underlying assumptions of individual researchers. He stated: “Interesting theories are those which deny certain assumptions of their audience, while non-interesting theories are those which arm certain assumptions (Davis 1971: 309).” In other words, prospering theories deny the audience’s assumptions and (partly) contradict old truths, by that they challenge what researchers take for granted. By applying Davis’ (1971) logic to CIT research, two important questions can be posed: Who constitutes the audience of various research efforts; and what are the taken-for-granted assumptions of the specific audience?

Interestingly, what is taken for granted depends on the audience’s perspective, which is conceptualized in this article as the practice of CoPs or microtribes. Different CoPs and/or microtribes are not only interested in different domains (or subdomains), but hold different assumptions regarding, for example, the rationale for why research efforts are undertaken, the role of theories, and why research should be done. In answering the questions posed above, we are able to sketch out four streams of CIT
research by which researchers can reposition (and reframe) their research and potentially evoke interest from another audience.

**Four Approaches to CIT Research**

Building on these previous studies, and drawing inspiration from CoPs literature, the notion of microtribes and Davis’ (1971) analysis of interesting theories, we identified four streams of research within the CIT domain. Each stream is characterized by the core audience, the taken-for-granted assumptions, and the utilization and (assumed) purpose of theories. For each stream, we also discuss the general view on IT/IS, and examples of common publication outlets. The streams, which will be described and discussed separately, but are along a spectrum, are: Building better buildings with IT; Building better buildings with IT; Building buildings with IT theories; Building theories of construction IT; and Building better IT/IS theories. The streams are summarized and juxtaposed in Table 1.

**Stream 1: Building Better Buildings with IT**

The first stream is building better buildings with IT, which is representative of the taken-for-granted assumption that IT is a tool that should be used to improve construction practices. The interest is in developing and/or improving technology, applications, and technological use to further everyday practices and support those in the AEC industry to build better buildings, faster and cheaper. Using the vocabulary of Orlikowski and Iacono (2001), this represents a tool view of technology, in which IT/ICT is “the engineered artefact, expected to do what its designers intend it to do (2001: 123),” or a computational view, in which the interest is primarily in the “capabilities of the technology to represent, manipulate, store, retrieve, and transmit information, thereby supporting, processing, modelling, or simulating aspects of the world (2001: 127).” The core audience of this stream is primarily pracademics, students of building and construction management, construction-management professionals, and practitioners interested in developing their competencies or formulas of how to improve practices. Research in this stream is often undertaken in close collaboration with practitioners, but with little to no theoretical base. Examples of common outlets span from handbooks (Sacks et al., 2018) and reports (McGraw-Hill 2012), to practically oriented academic journals within the CIT field. Due to its somewhat instrumental view on technology, and it's clear practical focus, contributions to this stream are practically applicable, but often run the risk of being academically irrelevant.

**Stream 2: Building Buildings with Theories of IT**

The second stream, building buildings with theories of IT, is representative of the taken-for-granted assumption that IT/ICT is primary a tool which can (and should) be used to improve construction practices. This stream is distinguished from Stream 1 by the utilization and (assumed) purpose of theories. While research endeavours in Stream 1 are often atheoretical, research in this second stream draws inspiration from IT/IS theories to develop better practices. In the vocabulary of Orlikowski and Iacono (2001), the general assumption of IT is still primarily representative of a tool or computational view, in which IT is an artefact used for performance improvements. The core audience is quite similar to that of Stream 1, even if the common publication outlets are somewhat different. In contrary to Stream 1, contributions in this stream are published in practitioner-oriented academic journals such as Journal of Construction Engineering and Management and Engineering, Construction and
Architectural Management. Reading the scope statements of these journals manifests our observation that there is a clear emphasis on (and openness to) the practical applicability of contributions in the AEC fields. Examples of contributions to this stream are Kamari et al., (2018: 354), who focused on BIM-based decision-support systems; Hartmann et al., (2012), who focused on the alignment of BIM tools and construction-management methods; and Cheng et al., (2017), who focused on BIM-integrated smart-monitoring techniques for building fire prevention and disaster relief. Despite the genuine practical importance of such contributions, potential challenges are arguably related to the risk of reinventing the wheel, due to the limited theoretical anchoring and transferability of results.

Stream 3: Building Theories of Construction IT

The third stream is based on the assumption that theorizing should be done on the basis of IS and IT management theories, but with the goal of developing context specific CIT theories. In contrast to the first two streams, the taken-for-granted assumption within this stream is that CIT theory (to the extent it exists) is an important component of contemporary construction practices. The general views on IT/IS represent more of a proxy or ensemble view, rather than a tool or computational view (Orlikowski and Iacono 2001). A proxy view of technology implies an interest in the importance of humans in technology use; the diffusion of technologies within firms, industries, and economies; or the value of technology (Orlikowski and Iacono 2001). An ensemble view represents an interest in various aspects of the “dynamic interactions between people and technology” (Orlikowski and Iacono 2001: 125). The core audience of this stream is theoretically driven researchers, with a joint empirical interest in CIT. Examples of studies are Davies and Harty (2013), and their study into individual beliefs about consequences of BIM use; Jacobsson et al., (2017) and their proposition of an analytical framework to understand ICT transformation within the AEC industry; and Dossick and Neff (2011), who studied the organizational practices around BIM and the role of messy talk. Common publication outlets include academic construction-management and/or IS journals such as Construction Management and Economics and Automation in Construction. With a shift in focus from trying to improve practices, to developing context-specific theories, the research risks losing its practical relevance and merely becoming a product for other academics with similar interests.

Stream 4: Building Better IT/is Theories

The fourth and final stream generally assumes that the phenomena of IT/ICT in the AEC context can provide an interesting and useful case for more general IS inquiries. In other words, CIT is a relevant and suitable example of more general problems, and research efforts should try to contribute to more general IS and management theories, based on the uniqueness of the CIT context. Today, the core audience of this stream is primarily theoretical experts within communities outside of the CIT domain. As with Stream 3, the general views on IT/IS corresponds to a proxy or ensemble view of technology, focusing for example on the interactions between people and technology. Examples of interesting contributions to this stream include Boland et al., (2007) who, by studying digital 3-D representations in design and construction projects, contributes to innovation theory. Another example is Gal et al., (2008), who analyses two case studies in the AEC industry in which 3-D modelling technologies were introduced. However, their contribution was targeted at boundary practices, boundary objects, and organizational change. Both of these examples used the case of CIT to
address more general problems and provide contributions to other domains. Publication outlets in this research stream have a broader scope, such as Organization Science, Organisation Studies, and MIS Quarterly. As with all other streams, this one faces potential challenges, including the risk of contributions being contextually disconnected and having limited (or no) practical relevance. The four streams are summarized and juxtaposed in Table 1.

Table 1: Four streams of CIT research

<table>
<thead>
<tr>
<th>Research streams</th>
<th>1) Building better buildings with IT</th>
<th>2) Building buildings with IT theories</th>
<th>3) Building theories of construction IT</th>
<th>4) Building better IT/IS theories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core audience</td>
<td>Students of building and construction management; construction management professionals; and practitioners interested in competence development</td>
<td>Students of building and construction management; construction management professionals; and consultants</td>
<td>Researchers with joint empirical and theoretical interests in building and construction IT</td>
<td>Theoretical experts of a specific community of practice outside CIT</td>
</tr>
<tr>
<td>Taken-for-granted assumptions</td>
<td>IT is a tool that can (and should) improve construction practices. Research should focus on improving technology and its use</td>
<td>Construction IT is an important component of contemporary construction practices</td>
<td>Construction IT is a relevant and suitable example of general management and IS problems</td>
<td></td>
</tr>
<tr>
<td>Utilization and (assumed)</td>
<td>Studying construction IT, often without theoretical homestead</td>
<td>Drawing inspiration from IS to improve the use of IT in construction</td>
<td>Using IS and management theories to theorize about construction IT</td>
<td>Contributing to general IS and management theories</td>
</tr>
<tr>
<td>purpose of theories</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>General views on IT/IS</td>
<td>Primarily tool or computational view of technology</td>
<td>Primarily proxy or ensemble view of technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Examples of common publication</td>
<td>Handbooks, reports, and practical-oriented academic journals within the CIT field</td>
<td>Practitioner-oriented journals such as Journal of Construction Engineering and Management and Construction, Engineering, Construction and Architectural Management</td>
<td>Targeted academic CM and IS journals such as Construction Management and Economics and Automation in Construction</td>
<td>Broad academic management and IS journals such as Organization Studies and MIS Quarterly</td>
</tr>
<tr>
<td>outlets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential challenges</td>
<td>Due to its practical focus, CIT research risks being academically irrelevant</td>
<td>Due to limited theoretical anchoring, CIT research risks &quot;re-inventing the wheel&quot;</td>
<td>CIT research risks losing practical relevance</td>
<td>CIT research risks contextual disconnection, with little practical relevance</td>
</tr>
</tbody>
</table>

**DISCUSSION: FROM TOOLS TO THEORIES**

We are well-aware that these research streams, like most categorizations of social phenomena, are a vast simplification of a much more complex and inter-related reality. In practice, researchers are often involved and/or interested in more than one stream, concurrently conducting research with different focuses and publishing in different outlets for different audiences. We are no exception from this reality. Still,
we believe that this schematic overview opens up a discussion of how researchers might think to re-position research, reach different audiences, and potentially extend contributions beyond their current stream and/or the CIT field. In a field such as CIT, which can be plotted on a spectrum from practical to theoretical, it is crucial to understand the audience. Harty and Leiringer (2017: 6) argue: “Swinging too far towards impact and relevance can come at the price of drifting away from the epistemic terrains of academic research. Too far the other way potentially removes scholars from both their empirical context and their market for graduates.” In terms of CIT, best-practice arguments might be seen as not only relevant, but very interesting for the audience within Stream 1, but irrelevant for those in Stream 4. On the other hand, theoretical manifestations might be too abstract and nonapplicable for the audience in Stream 1, but very interesting for the audience of the Streams 3 and 4. All in all, the overview communicates the idea that different streams have different audiences (with different interests and taken-for-granted assumptions), which affect both the style of communication and focus of ideas. Through this, the above analysis contributes to the much-needed relevance-rigor debate for which construction-management researchers have recently called (e.g., Bresnen 2017; Koch, Paavola and Buhl 2019).

We should note that arguments for understanding different audiences and varying views within research are, per se, not new. For example, Jacobsson and Söderholm (2011) explained the lack of progress in the project management domain, based on such an approach. Alvesson and Sandberg (2014) argued for the need of more “box-breaking research” in management studies, and Harty and Leiringer (2017: 3) discussed the construction-management research community, stating: “Actors have their own ideas about the function and contribution of the academic community spanning the spectrum from an interest in long term, theoretically informed research, to short term, problem-solving with direct impact.” In a recent editorial in Business Horizons, McMullen (2017) also asked potential authors to consider: “What are your readers’ experiences and expectations, and how does your article inform, contradict, or change their meaning to offer new insights for practice?” (McMullen 2017: 5).

However, that is not all. To utilize the AEC industry and its studies to contribute to the fourth research stream, researchers must also understand and play on the uniqueness of the industry context and the role that IT/ICT plays within it. This is where there is an untapped potential for CIT research. From the reviews we have done, contributions to Stream 4 seem to be quite rare (for exceptions, see Carlo et al., 2012 Boland et al., 2007, and Gal et al., 2008). Very few IT/IS publications that make broad theoretical contributions to the IT/IS field use the AEC industry as an empirical context. Which group of researchers are better equipped to tap this potential than those with an in-depth knowledge of the AEC industry and CIT research?

Salient Characteristics of the AEC industry

However, in taking stock of the uniqueness of the AEC industry, it would be presumptuous to argue that we have a complete roadmap. Nevertheless, there are some well-known, salient characteristics that differentiate the AEC industry from other industries, which might make an interesting starting point (Turk 2000, 2006). We chose to outline these characteristics as the 5Ps: Product, Process, Production, People, and Place.

The first salient characteristic is the product. The AEC industry is characterized by its one-of-a-kind products, in that buildings and other facilities are often unique, or at
least highly customized based to client demands. Therefore, deployment and use of IT/ICT under such conditions would differentiate theorizing from industries with less customized products. The second characteristic, which is similar to the first one, is the process, which is carried out by a unique team of clients, contractors, and subcontractors. For example, theorizing about inter-organizational IT/ICT would produce interesting and novel results, in comparison to industries characterized by more stable partnerships. Third, the AEC industry is different in terms of production. Construction products are designed, built, and maintained in a one-of-a-kind process, which distinguishes them from mass- and process-production (Woodward 1958). The fourth P is people. Throughout the production process, team members (people) move in and out of production, which potentially makes it an interesting case for IT/ICT continuity and learning. Finally, the AEC industry is characterized by place, conceptualized as the simultaneous immobility of product and mobility of production. In this regard, the AEC industry context is very different from traditional factory production where IT/ICT is often studied.

CONCLUSIONS

In acknowledging the untapped potential of CIT research, the purpose of this article was to analyse the current state of CIT research and illustrate how researchers within this community can extend their impact to make relevant and interesting contributions to a wider IS community. To do so, we argued for the need to understand both the phenomenology and uniqueness of the research field. Using a phenomenology-inspired analysis, four parallel streams of CIT research were outlined. Based on previous conceptualizations of salient characteristics of the AEC industry we discussed the 5Ps: Product, Process, Production, People, and Place. Taken together, this provide a case and initial roadmap for broadening the scope of CIT research beyond what is common today, in order to move “from tools to theories”. Even if we argue for the need to question the basic assumptions of CIT research to make relevant and interesting contributions to a wider IS community, each stream is still important in its own way, providing contributions to various audiences. Positioning this contribution in the longstanding debate of rigor versus relevance, our argument is not that it is a matter of either/or, but rather both/and. There is a concurrent need for theory-centric knowledge serving academics and practical applications targeted at AEC practitioners. However, from the individual researcher’s point of view, we want to convey that all four streams have specific challenges in terms of relevance.

In the background of this article we promised that we would return to the notions of CoPs and microtribes in relation to the CIT research field. Based the reading and the results of this article, we would argue that the research field constitutes a CoP, but runs the risk of developing into a microtribe, depending on which practices will prosper and if the community moves into a virtuous or a vicious cycle. The fact that CIT has attracted scholars with diverse backgrounds, which potentially supports an increased openness toward other research communities and theoretical fields, supports CIT moving into a virtuous cycle. On the other hand, if influential actors safeguard internal interests and ignore the development of other fields might start CIT onto the path of a vicious cycle. The fact that Stream 4 has attracted limited attentions could be a warning signal. We hope that this article contributes to a virtuous circle, in that it calls for a broadened scope and illustrates how CIT researchers might make relevant and interesting contributions beyond their own tribe.
REFERENCES


USING A RELATIONAL ONTOLOGY IN THE ANALYSIS OF PROJECT TOOLS

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Project management tools are under-researched in project studies and studies of construction management. While traditional writing on projects takes a largely uncritical approach to project tools and their efficacy, critical studies of projects, while bringing much needed light to an uncritical acceptance of project tools, tend to air-brush them out of their accounts in favour of a focus on social and political processes. Consequently, as a community, we have no tradition of studying the role that project tools do play in shaping the organizing of projects. We draw on the insights of Bruno Latour to re-conceptualise the role of project tools in project managing and to re-instate them into productive critical accounts of project organizing. We then draw on recent work by Paul Leonardi on studying socio-materiality, to develop a research methodology appropriate to researching the organizational role(s) of project tools.

Keywords: critical management theory, methodology, socio-materiality

INTRODUCTION

The role that project management tools play in the lived reality of project management endeavour is under-researched. Drawing inspiration from relational and socio-material modes of analysis, we outline both a theory of project tools and a related research methodology. To achieve this, we take the step of treating project tools in the same way as material objects have been dealt with in socio-material studies. In other words, we view project tools as entering into, and becoming part of, the organization and regulation of the complex social relations required to make the work of organizing in projects possible. We argue the material tools of project management - the spread sheets, software planning tools, Gantt charts and to-do lists - need to be understood and researched as actors and influencers within emergent socio-material relations.

The paper begins with an overview of the field of project management studies and how it has dealt with project management tools to-date. This is followed by a selective review of Bruno Latour’s work and an analysis of how this might be used to think about project tools as quasi-material objects in socio-material relations. We then draw on the socio-material work of Leonardi (2017), illustrating it with a short ‘worked example’, as a possible template for how we might approach researching project tools in project and construction management.

Traditional Approaches to Project Tools

Traditional approaches to project tools are to be found in the normative managerial literature that dominates project management writing. Here project tools are framed

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as a rational response to the demands of organizing in complex environments. Projects themselves are understood as hierarchical organizational forms, amenable to rational managerial intervention in the form of planning, execution and control (Koskela and Howell, 2002). Research here is concerned with the efficacy of project tools and promoting how best to use tools (e.g. Turner, 1999; Kerzner, 2013; Maylor, 2010; Morris and Pinto, 2004). Within this frame, project tools are assumed to be useful and projects and tools are typically seen as synonymous with one another. The concern is to keep students and project managers up-to-date with the latest developments in tools and management technique (e.g. PMBOK (PMI, 2013). Projects, and by default project tools themselves, remain under-theorized (Soderlund, 2004; Koskela and Howell, 2002; Koskela, 2017).

Critical Approaches to Project Tools

An important strand of research in project studies, referred to as ‘critical studies of projects’ (Hodgson and Cicmil, 2006; Drummond and Hodgson, 2003) reformulates how projects should be understood by seeking more sophisticated social and organizational theories through which to characterize and research projects. Underpinning this strand of research is a rejection the Cartesian rationalism that underpins normative, traditional project management approaches, in favour of more processual and relational theories of organizing. Whereas normative writing on projects views them as control hierarchies, critical studies of projects (CPS) sees them as complex, emergent, unbounded and unpredictable phenomena (e.g. Ivory and Alderman, 2005; Alderman et al., 2013; Williams, 2002; 2005; Smith, 2007); as ‘becoming, rather than being’ (Linehan and Kavanagh, 2004). Within CSP unpredictability (Cleland and Ireland, 2006) and disorder (Hodgson and Cicmil, 2006; Drummond and Hodgson, 2003; Winter et al., 2006; Winter and Smith, 2006) are the norm for project organization, not stability and control. Within a CPS frame, projects are, it follows, assumed to be largely outside of the control of project tools and techniques; project management tools, and the texts which promote them, are seen as constituting a “technical fool’s paradise” (Clegg et al., 2006: 22).

Project management tools have, consequently, been a focus for ongoing critique by CSP scholars. Project tools are closely associated with the rationalist control agenda underpinning traditional project studies in as much as the stem ‘from’ a management cadre and mind-set that is inevitably distant from the actual doing of project work (e.g. Clegg et al., 2006; Cicmil et al., 2006; Winter and Smith, 2006; Hodgson and Cicmil, 2007). It has also been suggested the project management tools are themselves a cause of project failure. Project tools, applied poorly, can lead to inter-personal conflict, distrust, wasted effort and project breakdown (Cicmil et al., 2009). From a CPS perspective, project control is assumed to reside in the micro-politics of projects, rather than in the control tools mobilized by project managers (Cicmil et al., 2006). In their report to the ESRC on the ‘lived reality’ of projects Winter and Smith (2006) insist that project research should focus not on techniques or tools but on social agendas, practices, stakeholder relations, politics and power" (5).

As an emerging field, critical studies of projects have drawn in those scholars most interested in dealing with projects as complex social phenomenon - an approach to which we also subscribe. At the same time, however, project tools, and our interest in them, sits uneasily with the mission of CSP. Tools, within a CPS frame are invariably the subject of critique, rather than analysis. The aim of this paper is to reflect on how
we can study and discuss project tools, while remaining within a critical and relational sensibility.

**Bringing Tools Back in to the Critical Study of Projects**

Although there have been some calls to bring ‘non-human’ actors back in to critical project management studies we contend that such studies have adopted either a pre-figuring ‘critical’ perspective or a largely descriptive one, albeit using detailed study methodologies. Bossen *et al.*, (2014) provide a description of how Science and Technology Studies may contribute to a study of projects, which includes some discussion of material objects and Actor-Network Theory, but does not get beyond the critical characterisation of tools, the idea that distance from practice means that formal management tools are bound to fail. Sage *et al.*, (2010) examine the ‘power’ effects of the ‘project file’ but focus their interest on non-use. The project file was deemed ‘ineffective’ as a coordinating device. Whyte and Lobo (2010) provide an account of the role of electronic ‘objects’ in sharing knowledge across different physical sites in projects. The account, while interesting and detailed, characterises Building Information Management as a boundary object that links disparate work activities - as such it is a largely descriptive account.

**How Can We Move Forward from this?**

We believe we are not alone in wishing to take project tools more seriously. However, to do so effectively, we believe we need to fast-forward to contemporary studies of the material in social studies of science and technology to do so. We begin here with the work of Latour and the problem of not taking what he terms ‘non-humans’ seriously enough in the work of organizing and then to recent work by Leonardi and precisely how we might approach the study of project tools within a relational (projects as complex and emergent) ontology.

**The Contribution of Bruno Latour**


Latour’s early work on science, in particular ‘Science in Action’ (Latour and Woolgar, 1979) has been heavily influential. Latour (1993) complains that formal 'scientific method' has been 'extracted from the networks of its own practice', i.e. reified into a form of unrealistic canonical practice which accounts only for the formal methods of science without regard to the messy social and political realities that are also a part of it. This early work, thus, bares great similarity with the assumptions of Critical Studies of Projects, particularly with respect to the impoverished view of the 'lived reality' of projects brought about by the formal project management body of knowledge.

Latour (1992) frames the problem as one of Modernism itself, using the term 'purification' to describe the distilling out of the (apparently) different features of reality into distinct poles. He notes: "...they [Modernists] have cut the Gordian knot...on the left, they have put knowledge of things; on the right, power and human politics” (Latour, 1993, 3). Modernist discourse, he argues, carves reality into distinct bodies of knowledge "By all means, they seem to say...let us not mix up heaven and earth, the global stage and the local scene, the human and the non-human” (3). For Latour, this mixing up is precisely what should be done. Latour’s thinking largely
underpins the idea of relationality in organization studies - the idea that it is relations between actors, not top-down control systems, that produces organizations.

For Latour, talking about the social world without also talking about the material of which it is also composed, is non-sensical. Sociology, in focusing its attention on purely ‘social interaction’ (as re-thinking-projects as a lived experience has tried to do) cannot explain how the social is constructed and maintained (Latour (1992; 2007). As he argues:

The society they [sociologists of the social] try to recompose with bodies and norms constantly crumbles. Something is missing…To balance our accounts of society, we simply have to turn our exclusive attention away from humans and look at non-humans (Latour, 1992: 227).

Critical Studies of Projects may also be framed, then, as an accidentally Modernist enterprise - a purification of projects that effaces project management tools from their accounts of the lived reality of projects to leave accounts concerned only with the social and the political. This simplified version of the lived reality of projects is, in our view, problematic for CSP if it wants to engage with practice or indeed a workable theory of projects - which must, if we are to follow Latour, include all of its elements, human and non-human.

Latour (1993) uses the term hybridity to describe more balanced and complete accounts of reality; accounts that mix human and non-human entities. Non-humans, argues Latour, bring essential force to social relations. This is precisely how we should understand project tools - as the material interventions in human relations that help humans order those relations into what we term projects. Latour (1992) illustrates the point with the example of the ‘moral injunction’ to close doors behind one’s self. The moral injunction to close doors, Latour notes, is weak because it is purely social, easy to ignore - it has no real force. It follows, argues Latour, that some form of intermediary, something that will enforce the association between injunction and action is necessary. A doorman might solve the problem, but the doorman may also prove unreliable. Consequently, the moral injunction to close doors in public buildings has typically been reinforced with a non-human - in this case a technology, a mechanical automatic door closer. The link between the moral injunction to act in a certain way (close the door after you) is thus given material force. The great advantage of non-human interventions of this sort is the efficiency and reliability with which they act: “they don't sleep” and they form associations that "don't break down" (Latour, 2007: 67). It is not difficult to see the role of project tools in this conception of bringing ‘steel’, as Latour (2007) puts it, to the social relations in projects.

We can frame the study of project management in much the same way. On the one hand, whereas traditional project management theorists have often sought to focus, uncritically, on tools to the exclusion of the human actors, critical theorists have sought to focus on social and political processes, with little or no recourse to the role and effects of project tools. Latour offers a way of thinking in which the relationality that draws the social and the material together is the focus of study. The question asked by Latour is simple - how are these relations drawn together?

**How Should Be Research Project Tools?**

Leonardi (2017) argues that in the study of technologies we need a way of breaking down research into that aspect which focuses on the material nature of the object, that which focuses on the way in which the material is interacted with (and why) and whether such interaction does or not matter to the work of organizing (and if it does,
Relational Ontology in the Analysis of Project Tools

in what ways and what effects does it have). Leonardi goes on to outline three steps that analysis using a relational ontology must take.

**Step 1. Accounting for materials**

We need to understand how the object we are dealing with has been created.
What are the materials out of which the object is made?
How are those materials arranged into particular features?
What do those features do or not do?

Leonardi (2017)

Tools create and restrict opportunities for action. This is their point in fact, taking a Latourian perspective - to interact with human action in such a way as to alter it in particular ways. The particular nature of the material has effects on human relations. The synchronous forwarding of ‘locked’ CAD files, for example, creates very different social relations to the a-synchronous open interaction made possible by BIM models. In other words, they create different social relations, different modes of organizing and different identities and subject positions for the user. Though, at the same time, this depends on how their material properties are exploited - particular organization does not stem automatically from particular materiality.

**Step 2 - Accounting for materiality**

This step takes account of how people perceive the tools with which they must deal. Tools have ‘affordances’ (Leonardi, 2011) which are activated only through actual use - how they are used. If particular features are ignored, those affordances are not materialized, they do not exist. When project members interact with tools relations become sociomaterial; both the user and the tool are defined relationally - by the relations that emerge between them. A ‘BIM user’ is constituted differently to a ‘CAD user’. Elsewhere in sociomaterial study, this is referred to as the ‘mutual constitution’ of the social and the material (e.g. Orlikowski, 2007).

In practice, tools will have stability of use across different contexts. But this ‘truth’ should come out of the research, it is a question to be answered, not a given as it too often is on the normative project management literature.

Culture, including local norms of practice, can also of course shape what a group of individuals ‘wants to do’ with the tool. The affordances of tools thus also interact with local norms through individuals whose preferences are conditioned by those norms. These norms then stabilize, perhaps not permanently, a particular way of using a tool.

What social or cultural institutions have shaped a person’s goals?

How do those goals mediate the interpretations people make about what a technological artefact's materials can or cannot do?

Why people did or did not perceive alternative affordances or constraints based on the actual possibilities offered by the materiality itself (uncovered through answering the questions in Step 1 above)?

Leonardi (2017)

By answering these questions, Leonardi (2017) argues, the researcher understands how a material object (like a tool) becomes a social object. The researcher will be
able, by attending to step 2, to provide a robust accounts properly researched accounts of how local norms prompt some features, and not others, to be called forward into use.

**Step 3 - not all materials matter**

The third step in the analysis is to account how certain tools and certain features come to matter in organizational terms - how they come to be part of the organizing process. Leonardi (2017) describes how computer support technicians, when compiling reports, found that the new systems they were using gave them access to previous reports by junior colleagues. They came to rely on these for guidance far more than they did on guidance from senior colleagues. By no longer relying on input from their senior colleagues, but input from more junior colleagues, they had in effect up-ended the processes by which the organization produced reports. Critically, these new affordances took time to emerge. It follows that a snap-shot of how tools are used in practice gives only a limited picture. This implies the need for more longitudinal studies of project tool use.

In what ways are existing patterns of organizing dependent upon the materiality of certain technological artefacts?

Why do certain forms of organizing produce a social context in which a technological artefact's materiality can materialize in ongoing streams of action and interaction?

How have the affordances produced by a new technology sustained, altered, or transformed the way that people act and interact with each other?

Leonardi (2017)

**Tools in Their Social Setting - an Example**

I end here with a ‘worked example’ drawing on Gawande’s (2010) book on check-lists and their use in a number of spheres of organizing including medicine, flight and construction. Gawande’s (2010) brief account of the use of ‘checklists’ in construction is instructive. On exploring the offices of a construction site, he is struck by the complexity of the task at hand and by the role that simple checklists can play in dealing with that. Talking of the project manager he recalls: “The volume of knowledge and degree of complexity he had to manage, it struck me, were as monstrous as anything I had encountered in medicine. He [the project manager] tried to explain how he and his colleagues made sure all that all those people were doing their work correctly, that the building would come together properly, despite the enormous number of considerations - and despite the fact that he could not possibly understand the particulars of most of the tasks involved. But I didn’t really get his explanation until he brought me to the main conference room. There on the walls…hung sheets of butcher-block-size print outs of what to my surprise were checklists…As I peered in close I saw a line by line, day by day listing of every building task that needed to be completed, in what order” (Locations 812-20)

So, if we were able to return to Gawande’s site office as researchers, what would need to ask to conduct a thorough socio-material account of this project tool?

**Step 1. Accounting for materials**

The physicality of the display is significant in that it is available visually to anyone visiting the conference room. The conference room itself, and who is invited into it, is therefore also significant. It means, for example, that interactions can occur around it. These interactions might also, perhaps, be ‘curated’ by the project manager. The
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project plan, in this form, is also promiscuous in its sharing of data, sharing the data of any one party with all of the others. This information is made available very casually - it is not necessary to log on to a system to access it or to request to see the data.

All of these material features, once accounted for, may or not transpire to be actual affordances. For example, are discussions actually held around it? Finding this out would require direct observation and interview with those who use and control the conference room and the data spread-sheets.

**Step 2. Accounting for materiality**

We may surmise that the display in the board has a purely informational purpose, but we also perhaps suspect it has a ‘disciplining’ purpose. This should be a theory about the tool which we go on to verify or reject. Within sociomaterial theory it follows that ‘disciplining’ is something which emerges out of an interaction of the social and material; by entangling with one another they ‘produce’ a discipling effect. Whether the tool is experienced or interpreted as being intended to discipline will depend on what project participants bring to the interaction with the tool. This may be previous experiences of other projects, their own organisation’s culture and indeed this particular project’s culture as they have experienced it thus far. As all firm’s performance is also visible to other firms, it may be surmised that the tool itself is part of a conscious attempt, on the part of the project manager, to create a particular project culture. The tool is, after all, fair warning that ‘your’ firm is ‘visible’ to the project manager and to others. It implies, in other words, the existence of a panopticon. Firms with different cultures may also respond differently, it may re-enforce their hard working ‘can-do’ culture, or it may encourage less helpful behaviour, such as meeting time targets at the cost of quality. These differing responses are as important as the tool itself, however they are not a commentary on the veracity of the tool alone - but of how the social and material constitute one another.

To know this for sure we need, as researchers, to carefully follow these lines of inquiry, develop theories about what the affordances of this tool might be and ‘follow the actors’ (human and non-human), as Latour (2007) suggests. We need to ask the participants: How does this tool change things for you? How does it change how you work?

**Step 3. Not all materials matter**

As Sage et al., (2010) note, not all materials matter - project files that are ignored, do not matter to our understanding of how tools shape organizing. In the example presented above, it is more likely that we would draw the conclusion that this tool ‘does matter’, that it is does have effects and that it is genuinely part of the organizing processes of the project. If firms are ‘disciplined’ then this is an affordance of the tool. Conversely, if it inspires irritation and resistance, it does not have this disciplining affordance. However, to test this, again, we would need to observe how the project display is used - do project participants study it, reflect on it and discuss it with others, for example? We would need then to link this to step 2.

**DISCUSSION AND CONCLUSION**

Traditional theorists take project management tools for granted. Their interest is in the effects of these tools in making life easier for project managers and for producing better project outcomes in terms of cost, time and quality. Explanations for project failure tend to focus on the failure to use the available project tools appropriately - the
failure to exert the requisite amount of project control. Critical theorists reject the reality and possibility of project ‘control’ and are keen to de-bunk the usefulness of such tools; suggesting, in Leonardi’s terms, that such materials ‘do not matter’ and that instead it is only humans and their interactions that matter. More than that, critical theorists view project tools as the embodiment of wrong-headed managerial rationalism. In seeking to attack this rationalism, critical theorists have sought to foreground the role of the social and the political in projects, but at the expense of any serious account of what project tools actually do. The fact that critical theorists habitually use instances of their failure to dismiss management tools, should not detract from the fact that they clearly do have effects - we should be more interested in studying what these effects are and how they are achieved.

To understand these effects, to understand, in particular, why and how tools matter, we need to go beyond the methods, ontologies and assumptions of both traditional and critical accounts to examine the mutually constituting relationship of the social and the material in project organizing. We need to be meticulous in our methods of inquiry if we are to avoid ‘rushing to explanation’, as Latour (2017) has put it. I have suggested Leonardi’s (2017) template for researching technologies as an appropriate template for also researching project tools. In following this approach, we are prompted to explore, in appropriate detail, the relationships between the social and the material - between project participants and project tools.

REFERENCES


RISK MANAGEMENT
RISK PERCEPTION DIFFERENTIALS OF CONSTRUCTION PROFESSIONALS

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Risk perception is an essential and integral part of most strategic and executive decision-making. This is because such decisions typically reflect the medium to long-term future success of the organisations to which they apply. Risk perception reflects the subjective awareness and judgement of risk by individual executives. The effectiveness of any risk decision exercised by these professionals is affected by how they perceive that risk. Within the construction sector, such decisions involve large capital expenditures that can result in adverse financial outcomes if the risk component is not perceived and judged right. Earlier work done in the field of psychology indicates that individual perception of any risk situation differs based on their circumstance. The circumstances of construction professionals could be accounted for by their discipline, career, educational attainment, as well as their personal attributes. Establishing how the circumstances of professionals create a difference in their perception can be valuable for enhancing risk management practice. The important question posed here relates to the degree of explanation in risk perception that can be associated with such differential factors. The paper presents a review of extant literature to establish the key concepts and essential theories on developments in risk perception. The review conducted culminated in a conceptual model for investigating the nature and degree of differentials in risk perception of construction professionals. The conceptual model shows the relationship between the risk perception and its determinants. A quantitative approach would be adopted, using a survey to capture information that can be used to measure the variables from three different groups of professionals in the road section working in public sector consultancy. The consideration of the influence of individual risk perception presents a radical departure from the conventional approach to risk management. It forms part of a broader study that explores the potential for applying the radical approach of perception differentials that embraces the practitioner as key to achieving improvement in risk management efforts.

Keywords: decision making, management, perception, risk

INTRODUCTION

Risk perception is considered an integral part of decision-making process, because the way people eventually react to issues is significant in solving a problem (Slovic et al. 2005). The ability to solve problems is therefore dependent upon how well risk is perceived and eventually determines the success of an organisation (Carriço et al. 2015). How risk is perceived should be of concern to employers as well as researchers to make the best out of employees.
The risk perception of construction professionals is consequently critical in project delivery considering the capital-intensive nature and contribution of the construction industry to national development. Over the years, concerns of performance level which is the outcome of risk perception in the construction industry, have been raised at various levels of stakeholder consultations, conferences and seminars at organisational and international levels (Kikwasi and Escalante 2018; Ofori 2007). These call for a concerted effort to provide a sustainable and a robust platform for risk management especially in construction.

Current practices are focused on provisions made and subjective judgements of practitioners (Baloi 2002; Zhi 1995; HM Treasury 2004). These are deemed inadequate as per the concerns being raised. Efforts being made to overcome the limitations in the current practices in risk decisions making include the use of planning tools, information systems, software development and building data base to support confidence and define the likelihood of risk (ACORN 2015; Airmic et al. 2010; Philipp et al. 2016).

But notwithstanding all that, the result is that of people’s decision and that is where their judgement becomes important, and their judgement is held in their perception of risk. It has possibly been argued by others such as psychologists outside construction, that perception is what needs to be developed to enhance the decision that people make in finance and in other sectors with the use of simulation software. What is aimed at is to enhance the perception, the cognition and the awareness of risk of people who think risk. This is to get them to respond appropriately in conditioning their perception, which becomes part of their development and construction does not have anything of this sort. This opportunity presents a new and innovative way of enhancing how risk can be addressed and this forms the foundation of this study. This study thus takes a different approach considering the practitioner’s perception as key in achieving improvement in risk management efforts.

To do this, there is the need to understand what the concept of perception is, what variables play out to support any investigative effort and development that could come out of this study. This paper essentially is for a concept development and outlines the variables that support any development resulting from the study. It starts with the literature followed by the analysis of the dominant theories that culminates in a conceptual model. This can be used to support the investigation and development of perception dimension of making risk decision to be applied by construction professionals.

**Construction Professionals and Risk Perception**

The significance of the rightful judgement of risk of the construction professional, cannot be over emphasised (Olanrewaju and Abdul-Aziz 2015). Wrong decisions within the construction industry can result in serious financial consequences in the delivery of projects due to the high capital-intensive nature of its activities. Consequently, a nation can be adversely affected in the long run due to the industry’s contribution to national development.

The output from the construction industry forms an integral part of national output and represents a sizable part of its Gross Domestic Product (GDP) (Ofori 2012). As it relies on the products of several industries as inputs and its products provide the necessary infrastructure and physical structures for all other industries. It in turn serves as a major employer to many people directly and indirectly. The industry on the other hand provides ready market to several industries.
Due to its importance, performance with regards to managing risk to ensure that project targets are met should be of concern to every nation. An effective risk management system in project delivery impacts positively in any nation’s development (Ofori 2015).

The knowledge of risk and the steps involved in managing it by the players in the construction industry is critical, in minimising the likelihood of problems occurring. Thus, lead to the improvement of the perception of risk among practitioners in the construction industry.

Risk perception is often related to deviations from the formal procedures where there is no clarity or out of context situations. When laid down rules fail to present desired information or do not relate to provisions made, professionals tend to make their own decisions. Decision making has to do with solving problems which involves risk management. In the construction industry, problems are solved with the use of rule of thumbs or some laid down rules. The basis of risk management in the construction is on figures.

However, the use of the rule of thumb does not mean professionals do not perceive. Most often than not, decisions are made based on individuals’ subjective judgements (Akintoye and MacLeod 1997; Baloi 2002; Lyons and Skitmore 2004; Zhi 1995; Rastrelli 2014). If perception is subjective, then decisions made from perception would be peculiar to an individual. Therefore, the attributes of an individual define that person’s perception of risk.

Like any other industry, the construction industry is not without challenges. Associated challenges are not peculiar to developing countries but developed countries alike. As the factors that impact the industry are the same, such as the nature of products, resources needed, the sequential nature of processes and the multidiscipline of professionals involve (Fernández-Solís 2008; Ehsan et al. 2010).

Due to its importance, performance in terms of it meeting its objectives, should be of concern to every government. Any hindrance to performance means objectives would not be met. Furthermore, as construction becomes complex coupled with increasing demand for its products, the industry is presented with increased risk situations. The need for an effective risk management in this industry can therefore not be overemphasised.

**Risk Concept, and Practices**

The construction industry like in any human institution is faced with risk (Robinson 2006). Risk is inevitable in any human endeavour and to improve an individual’s or a corporate institution’s situation and overcome a natural hazard, there is the need to take risk. However, decisions exercised in relation to such risks have often than not resulted in negative consequences. Therefore, managing risk is of importance in the successful delivery of construction projects.

Risk can affect an action positively or negatively. For example, a decrease in prices of construction inputs, where fluctuation is applicable, means a gain for the client, signifying a positive risk to the client. This gain can only be realised if a provision is made. Risk therefore is a problem and mitigating these negative consequences is of prime importance to the successful delivery of projects in construction.
Risk Management in Construction

Risk management in the construction industry is usually based on subjective judgement and rule of thumb where a provision is available (Akintoye and MacLeod 1997). This includes the use of contingency plans and contractual provisions in contracts such as the use of insurance securities and in the case of rule of thumb such as using tolerances in design, which is dependent on the individual’s judgement.

Identified risks in the industry are handled on a case by case basis with a choice of how risk is managed. Moreover, because construction projects are unique, it seems to make it difficult for solutions from other projects to be easily applied. However, knowledge could be built on to form a basis in preventing same issues as well as improving on risk management. The way risk is managed has raised much concern to optimise inputs and maximise outputs to give value for money to clients (Green 2016). Thus, managing risk in construction is heavily dependent on the individual’s judgement.

The increasing demand for the products of the industry, and the desire for complex structures, there is the need to take advantage to apply measures that have worked in other sectors in context, incorporate and keep up with technology. In addition, there is the need to keep up with the changing trends in other sectors that provide inputs for the industry and determine the rate of its outputs. Such as available construction materials and type of skills needed for the smooth running of the industry as well as changes in the demand of its products. This calls for an effective management skill to ensure value for money (Gerbert 2016).

There are different definitions of risk which can be classified as objective and subjective. Where the objective approach is definite and subjective approach as in sectors other than construction such as the health sector carries a notion of outrage. Technically, risk is considered as the product of probability of occurrence of an event and the severity of the occurrence. The relative magnitude of these product determines how it is managed and this forms basis of how risk is measured and managed in construction. Though, this approach of measuring risk in construction is objective compared to other sectors, to some extent is subjective. Because the decision made on the choice of risk management depends on the appreciation of estimates for risk measurement and judgement of the individual involved in managing the risk.

Much of the decisions made in managing risk is determined by perception, which reflects how issues faced with in construction are addressed. There are numerous uncertainties in the construction industry and risk management is technical, based on absolute figures for probabilities and severity of risks. This peculiarity makes risk management in the construction industry different from that in other sectors. In other sectors, much of the decisions is linked to their cognitive ability. This could account for the inability to reap similar effect in the use of models, tools and techniques that work for other sectors in construction (Rastrelli 2014).

What is Risk Perception?

Risk perception determines how people react to risk. Why and how people eventually react to issues is of importance to individuals, industries and government. The outcome of the works we do, and the benefits derived from technologies serves as a drive to policies. Irrespective of whatever individuals, industry or government do, it is the result of a problem solved. How well the problem is solved depends on the
individuals’ risk perception ability and the extent to which the problem is understood (Carriço et al. 2015). Risk perception therefore appears to hold a core position of the political agenda and a concern to policymakers and researchers.

Risk perception represents the subjective awareness and judgement of risk made by people. Therefore, the effectiveness of any risk decision made by professionals is determined by how the risk is perceived. This supports the fact that different people make different estimates of the degree of danger of a risk (Lerner et al. 2003). What makes people different, stance from what affects us as a person. This is confirmed by proposed theories and studies that risk perception is influenced by external and internal factors and the personality as shown in figure 1.

Figure 1: Factors determining perception

Moreover, Dobbie and Brown (2014) indicate that perception is affected by emotional and cognitive factors which involve consequential and ethnic evaluation of risk. Their argument underlines the significance of how risk is prioritised which leads to diverse risk perceptions. Risk perception, therefore, seems to cross every human endeavour, thus, to draw a concise consensus, there is the need to understand the underlining factors that inform the risk decisions of construction professionals.

Decision making is key in the role of managers, such as construction professionals, as this determines achievement of objectives. Managers, however, do not make decisions based only on knowledge about the domain under consideration, but the extent of knowledge about the outcome of our actions (Damghani et al. 2009). This forms the risk factors of whoever is engaged to carry out work.

These risk factors constitute the factors that determine a person’s risk perception demonstrated in the way work is done, this in effect reflects in the outcome of the decisions made. These factors include knowledge about available systems developed overtime coupled with the situation in which one finds oneself, one’s upbringing and personality.

However, actions are not just perceived, they are influenced. They are found to be influenced by some factors (Sjöberg et al. 2004) as illustrated in figure 2 below. People react differently under the same condition as well as do people with similar personality. The subjective factors that affect risk perception such as those indicated in figure 2 can be categorised into the three main factors in figure 1. The factors outlined in figure 2 form the summary of what cause subjectivity in risk outrage.
Risk Perception Differentials of Construction Professionals

Figure 2: Factors of risk outrage

Risk Perception Concept in Construction

Although it has been established that there are differences in the risk perception of different people as well as professionals, there are some similarities, and this ensures they achieve the same target. For example, different professionals with different interests as far as project delivery is concern, work together to achieve the same goal, which is the completion of the project. This suggests that risk perception is not discrete but overlaps.

Figure 3 shown below illustrates the relationship of risk perception of these professionals. It depicts the fact that there is a level of commonality and this shows the level of agreement of people. If risk perception is identified as influenced by some factors, then these factors account for the differences in the risk decisions make. How then can these factors be enhanced to improve the risk decisions that construction professionals make and eventually develop a nation as a whole?

Figure 3: Risk perception of construction professionals

METHODOLOGY

The works of seasoned researchers who have contributed immensely in the area of perception and its determinants forms the basis of this study (Sjöberg et al. 2003). If the risk perception is found to be affected by factors that can be categorised as internal, external and personality factors, then measurable factors underlining these main factors can be assessed for measurement.

Measurable factors identified within the three main factors are; education, experience, personality, profession, age group, gender, mood and value systems. The risk perception of people is demonstrated in these traits as being pessimistic, normative or optimistic in their approach to the roles they play. A conceptual model developed as illustrated in figure 4, shows the relationship between risk perception and its determinants as established from existing literature.
Figure 4: Conceptual framework - Perception determinants’ effect on risk perception

On the left-hand side of the model shows the risk perception of an individual with a set of determinants using an appropriate measuring instrument. The measurable factors like age group and gender fall under internal factors, which is part of an individual that cannot be changed naturally. While profession, experience, mood and value systems form external factors which describes people’s reaction to issues. The external factors are influenced by the environment in which a person finds himself, the circumstances around, upbringing and formal training, shape the way the individual feels as well as the value placed on issues. These are acquired and dependent on the person’s experience which comes with time and exposure within this time. Whereas with personality, though it is inborn, it is not acquired with time but can be managed or controlled with time depending on life experiences. Further the social setting in the context of this study refers to the long term feeling towards work where one needs to manage risk as a result of the effect of the environment in which the person is, and not the short-term emotion which can change frequently. Such as the effect of organisational culture, provisions in the project environment. The cultural value on the other hand, refers to the value systems of an individual in the context of the construction industry characteristics. The model is mathematically expressed as:

$$RP = \beta_0 + \beta_1 Ed + \beta_2 Ex + \beta_3 Ep + \beta_4 Pr + \beta_5 Ea + \beta_6 Eg + \beta_7 \delta \text{ Equation 1}$$

Where;
- RP is risk perception,
- Ed is level of education,
- Ex is experience,
- Pr is profession,
- Ea is age,
- Ep is personality,
- Eg is gender and
- $\delta$ is social setting and cultural values

And $\beta_1$ to $\beta_7$ represent the weightings of the various factors. $\beta_0$ is a constant which signifies that everyone has a level of risk perception in the absence of the
determinants. For example, an insane person would give way to a moving vehicle, a child would not put his hand in fire, especially after an experience usually.

Having established the relationship of risk perception and measurable elements of the determinants of risk perception, a quantitative approach would be adopted to find out if there are systematic differences in the way different professionals perceive risk. If there are, how do the determinants account for these differences. A survey methodology would capture the measurement of the measurable elements of risk perception and its determinants and a multiple regression method use to find out the sensitivity of each factor on risk perception in a further investigation.

Data would be collected from three groups of professionals such as engineers, quantity surveyors and planners working with the Ministry of Roads and Highways in Ghana. These would comprise of public sector workers. A confirmatory test would be done with data collected in the United Kingdom (UK) to find out if findings in Ghana can be generalised and is not peculiar to Ghana.

**DISCUSSION**

The awareness of risk perception as key in the decisions made in risk situations, presupposes that it is vital in the output of the role individuals play. Since the output of the decisions people make reflects how problems are solved and this informs management decisions. However, risk perception of people has been established to be influenced by some identified essential attributes. These attributes therefore are the determinants of risk perception and forms the foundation of how people perceive in risk situations.

Having reviewed the concept of risk perception and the factors that influence it, a foundation is set to understand how these affect risk perceptions. This would lead to exploring how these differences can be enhanced to improve the risk decisions of construction professionals. This would be done by modelling the risk perception against the various determinants in the conceptual model developed based on existing literature.

Since the determinants of risk perception are identified and can be measured, their individual sensitivity to risk perception if identified can lead to giving management direction. Such that the determinants if applied to a small extent can make a significant change in an individual's risk perception. Enhancing the perception of the construction professional is expected to eventually lead to development in a nation at large considering the contribution of the construction industry in national development.

**CONCLUSIONS**

This study is aimed at establishing the awareness of risk perception among different construction professional and the effect of factors that influence their risk decision in the role they play. It considers the practitioner as key to achieve improvement in risk management efforts. Whereas other studies consider provisions in the area of logistic, funding, policies in the same regard, employment of management tools and information systems in improving risk management in project delivery. Ultimately, the use of these provisions depends on the decisions of people.

Meanwhile construction makes significant contribution to national development, and any effort directed at improving the risk decision of construction professionals can result in national development. Risk decisions in construction are mainly dependent
on the subjective judgement of professionals. Therefore, an awareness of their perception and how determinant factors affect the risk decisions they make is important for the delivery of construction projects.

These factors have been identified and applied in psychology and used as basis in this study. Since our situations are different our perception is likely to be different, and this forms the foundation of this study. A conceptual model has been developed based on the findings in literature and expressed mathematically showing the relationship between risk perception and measurable items that can be used to depict these factors. These can be explored further to understand how people perceive risk. The findings can be used to inform management and policy makers on how the risk perception of practitioners are affected by the determinant factors.

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