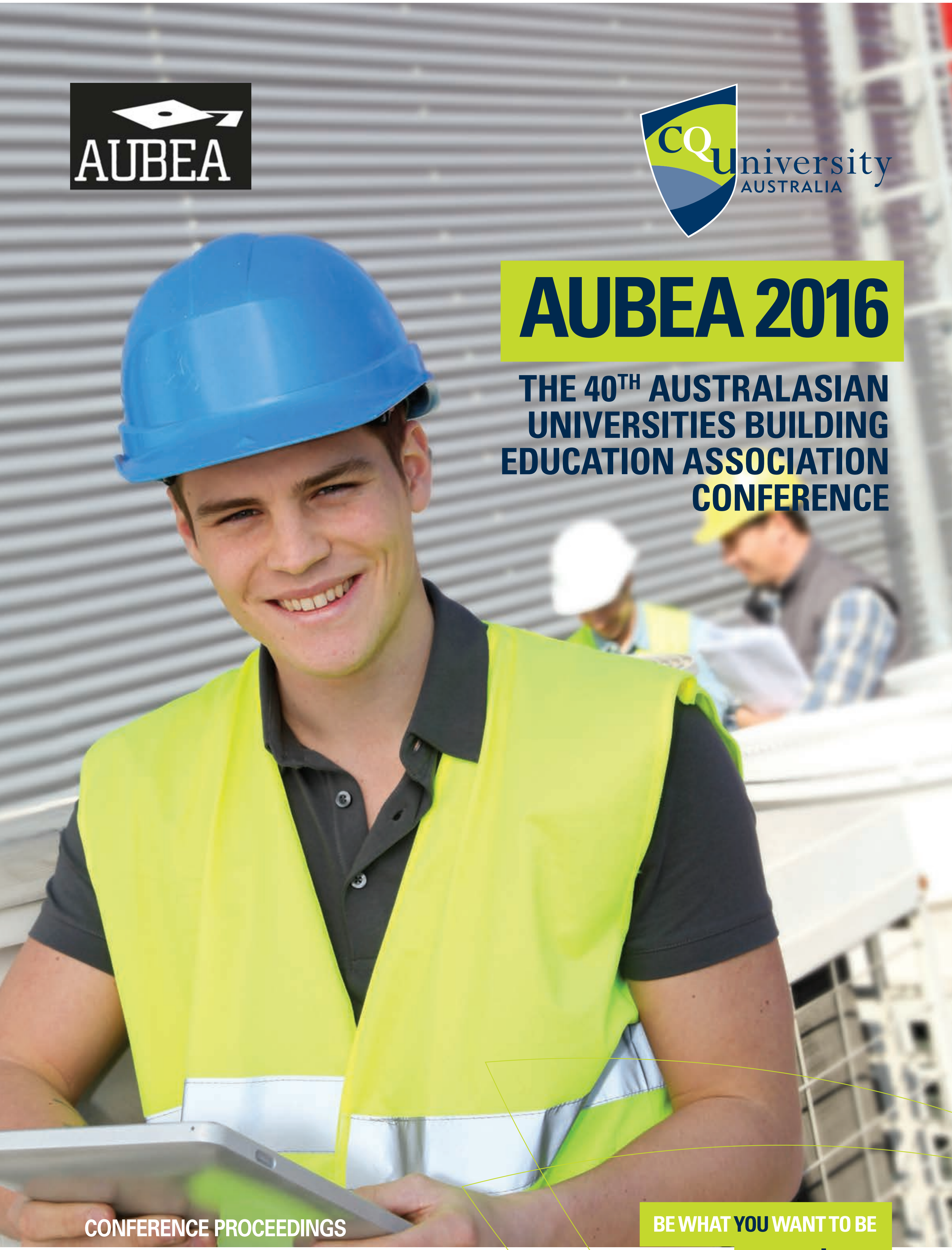

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Conference Proceedings

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THE 40TH AUSTRALASIAN UNIVERSITIES BUILDING EDUCATION ASSOCIATION (AUBEA) 2016 CONFERENCE

The 40th Australasian Universities Building Education Association (AUBEA) 2016 Conference was held in Cairns, Australia in association with AUBEA and Central Queensland University. A main theme of the conference was Radical Innovation in the Built Environment. The 21st century challenges us to change. Radical Innovation serves as a foundation towards achieving an expanding and sustainable Built Environment for educators and industry.

The Australasian Universities Building Education Association (AUBEA) was established in 1975 to promote and improve teaching and research in building through communication and collaboration. It comprises academics representing all universities providing education in building-related fields in Australasia and beyond. AUBEA maintains a strong connection to industry and professional associations and since its inception has organised annual conferences.

The annual AUBEA conference brings together building and construction researchers, educators and industry practitioners from Australasia and internationally, providing participants with a strong platform for knowledge sharing, collaboration, disciplinary reflections, institutional exchange and collective growth.

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To maintain and assure the quality of the conference proceedings, each abstract received was twice blind reviewed. Authors, whose abstracts were accepted, after the stage one review process was completed, were provided with anonymous reviewers' comments and requested to submit their initial anonymous papers.

The initial anonymous papers were twice blind reviewed again. Authors whose papers were accepted after this second review were provided with additional anonymous reviewers' comments and requested to submit their revised final full papers. These final papers were only included in the conference presentation programme and the conference proceedings after evidence was provided that all comments were appropriately responded to, having been double peer-reviewed for publication.

The reviewers were drawn from an expert panel, representing respected academics from the construction and building research community. The conference organisers wish to extend their appreciation to the following members of the panel for their work, which is invaluable to the success of the 40th AUBEA 2016 Conference.

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PROJECT SUSTAINABILITY IN DEVELOPING GREEN EVALUATION SYSTEM

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ABSTRACT

There is a growing concern on the environmental impacts resulted from construction activities. Green evaluation system has been advocated as an effective tool in reviewing, monitoring, and checking project sustainability in the construction industry. This paper focuses on developing a set of criteria for green evaluation system in measuring project sustainability in construction with a proposing innovative methodology, power spectrum, for analysing dominant criteria in the system from the questionnaire survey results. It is found that "Other measures for reducing waste pollution", "Top management support" and "Maintenance of equipment" are the top three criteria for the green evaluation system for improving the overall environmental performance. However, "Research and development", "Training" and "Monitor water usage" are found as the three lowest criteria for improving environmental performance. This paper identifies several major measures for improving project sustainability in the Australian construction industry. Although construction industry has a unique nature on projects, this can still help the practitioners choosing a direct and suitable method with effective improvement on its project sustainability. This paper can form a useful background for the development of project sustainability. This paper can provide an insight on effective implementation of green evaluation system in construction activities.

Keywords: Green evaluation system, environmental performance, power spectrum, bispectrum, project sustainability

INTRODUCTION

Environmental protection is an important issue around the world (Coelho & de Brito, 2012; Comoglio & Botta, 2012; Tse, 2001). Construction creates and provides facilities for human activities and social development; on the other hand, its impacts on the environment are very serious (Boiral & Henri, 2012; Bossink & Brouwers, 1996; Forsythe, 2011). Nevertheless, the construction industry has not been showing very much concern on the environmental issues (Lu & Yuan, 2012; Tse, 2001; Vandecasteele & Van der Sloot, 2011).

Environmental management system defines as management of an organization’s environmental programs in a comprehensive, systematic, planned and documented manner. This can use to establish environmental policies, objectives and targets, which can provide a framework for achieving and demonstrating a desired level of environmental performance (Comoglio & Botta, 2012; Katz & Baum, 2011; Li & Lin, 2011). However it is not easy for a company to establish a green evaluation system, which is an essential tool for effective accessing environmental performance (Hang, Qu, & Zhao, 2011; Sharma, Saxena, Sethi, Shree, & Varun, 2011; Zhang, Shen, & Zhang, 2013) and achieving continual environmental improvement (Sanvicens & Baldwin, 1996). The green evaluation system defines a system that help to assess environmental performance in any situations for construction activities and construction projects which provides valuable, ongoing input to various stages including planning, implementation, monitoring, measurement, and management review (Pullen et al., 2010; Tam & Le, 2014; Tibor, 1996) in a continuous improvement manner (Osmani, Glass, & Price, 2006; Tam, Wang, & Tam, 2007; Thoresen, 1999).

Unfortunately, due to the complexity of management and operational structure in the construction industry (Bella & Vaccari, 2014; International Organization for Standardization, 2006), and the lack of a well-defined series of indicators for evaluation in construction, there is no consistent environmental information available in today’s marketplace (McMahon et al., 2009; Shen & Tam, 2002). In the market, there are some major green evaluation system tools such as the Building Research Establishment Environmental Assessment Method (Building Research Establishment Environmental Assessment Method, 2008), Green Globes System (Canadian Standards Association, 2012), the Hong Kong Building Environmental Assessment Method (HK-BEAM Society, 2007), the Leadership in Energy and Environmental Design (Leadership in Energy and Environmental Design, 2008), Green Star Environmental Rating System (Green Building Council of Australia, 2012), Green Mark Assessment (Building and Construction Authority - Singapore Government, 2012) and GB Tool (Green Building Challenge, 2012).

A comprehensive green evaluation system can monitor environmental performance at all stages of a project that facilitates tracking and benchmarking of the performance, providing a tool for measuring continuous improvement. This paper focuses on developing a set of criteria for green evaluation system in measuring project sustainability in construction with a proposing innovative methodology, power spectrum, for analysing dominant criteria in the system from the questionnaire survey results.

RESEARCH METHODOLOGIES

To determine dominate criteria in the green evaluation system, a questionnaire survey was conducted. Respondents were required to provide the significance of each criterion by a 5-point Likest scale. As there was no official directory for Australian construction industry, to be best estimation from the authors and interviewed with professionals, it was believed that it has more than 2,000 construction companies in Australia. The survey was randomly sent to 450 construction organisation in Australia. Construction organisations with either in-house environmental management systems or certified as ISO 14000 in Australia were the target in this survey. Each target company had at least 10 years of environmental management system implementation, which showed that they have reasonable amount of environmental knowledge. This brings the insights of this survey focusing on the knowledgeable part of the construction industry in discussing the significance and design for the green evaluation system. 307 had been received with a response rate of about 67%. However, two of the questionnaires were not properly completed and only 305 questionnaires were valid.

After received the questionnaire responses, individual structured interviews were arranged with thirty-five respondents. These respondents agreed for the follow-up interviews as highlighted in the questionnaire. The interviews were intended for gathering further comments; elaboration and interpretation on the results obtained from the questionnaire.

GREEN EVALUATION SYSTEM

Green evaluation system serves as an assessment tool for project sustainability in construction in measuring environmental performance, analysing, foreseeing the performance trend as well as providing a consistent basis for comparisons, eco-labelling and environmental benchmarking among companies and construction sites. To support the application of the green evaluation system, a set of criteria needed to be developed. To facilitate the measurement of the green evaluation system, twenty-six criteria had been summarised which have been supported by previous literature.

Table 1 summarised the results of the power spectrum magnitudes and rankings for criteria in the green evaluation system from the questionnaire survey.

Table 1: Power spectrum magnitudes and rankings for the criteria in the developed green evaluation system

Criteria	Power spectrum magnitude	Ranking
Top management support	1.0524	2
Middle management support	0.8278	9
Frontline staff support	0.9632	4
Training	0.5300	25
Investment	0.6812	21
Environmental management programme	0.9538	5
Research and development	0.6181	24
Environmental planning	0.8382	8
Maintenance of equipment	0.9651	3
Water spray for reducing air pollution	0.8045	13
Screening for reducing air pollution	0.7393	17
Other measures for reducing air pollution	0.8963	6
Time management for reducing noise pollution	0.8020	14
Use of noise barriers	0.8708	7
Other measures for reducing noise pollution	0.7347	18
Monitor water usage	0.4780	26
Water reuse and recycle	0.8172	10
Wastewater collection and treatment	0.7296	19
Other measures for reducing water pollution	0.7724	15
Purchasing management	0.6649	23
Waste reuse and recycle	0.8063	12
Use of green construction technology	0.7670	16
Chemical waste treatment	0.7005	20
Other measures for reducing waste pollution	1.0646	1
Ecological impact	0.8085	11
Energy consumption	0.6750	22

The survey result showed that "Other measures for reducing waste pollution" was measured with the highest power spectrum magnitude of about 1.0646 among the 26 criteria. The interviewees suggested some special measures to reduce waste pollution based on their project experience. For example, cement can be independent stored in huts to reduce waste and prevent airborne dust. Further, all building service installations can be prefabricated off-site and ready for use upon delivery. Solid waste can also be sorted on site that facilitated recycling and reuse. It can use aluminium scaffolding, which can greatly reduce the consumption of bamboo sticks which would end up in landfills. A well established wastewater treatment facility, water sprinkler systems and near the exit to reduce airborne dust, waste segregation tanks for inert and non-inert waste, recyclable corrugated steel sheets to replace timber for subcontractor site sheds and other activities such as training policies, are also suggested by the interviewees. Other measures based on particular project constraints and environment, were found to be more significant in improving the environment, rather than set criteria.

Top management support" was obtained the second highest power spectrum magnitude of about 1.0524 from the survey results. Top management is responsible for policy setting. If they post a mandate of considering environmental impacts, the project team members will follow, noted by an interviewee.

"Maintenance of equipment" was obtained as the third highest power spectrum magnitude of about 0.9651 from the survey results. The interviewees argued that most of on-site equipment and plants are hired from plant hirers; as a result, the maintenance of equipment is out of their control. However, they supported that maintenance of equipment can help improve efficiency and effectively of construction activities, thus also improve productivity.

"Use of noise barriers' was measured with a power spectrum magnitude of about 0.8708 and ranked the seventh from the survey results. The interviewee suggested that rather than the traditional noise barriers surrounding the entire building site, movable noise barriers in curtain-form are suggested. This can suit for different equipment, extra noise barriers can be used in the curtain-form for reducing noise pollution.

"Environmental planning" was measured with a power spectrum magnitude of about 0.8382 and ranked the eighth from the survey results. The interviewees explained that a good plan agreed before the commencement of construction is effective in leading to a better environmental performance, rather than taking corrective action after the problems arise.

"Use of green building technology" was measured with a power spectrum magnitude of about 0.7670 and ranked the sixteenth from the survey results. The interviewees noted that projects can easily be adopt precast elements including staircases, slabs and structural beam that can reduce site material wastage due to site casting.

“Other measures for reducing noise pollution” was measured with a power spectrum magnitude of about 0.7347 and ranked the eighteenth from the survey results. Most site activities are carried out within building envelope to reduce pollution to the nearby buildings. Besides, an interviewee provided his/her project experience to reduce noise pollution to the nearby noise sensitive parties. For example, the use of internal jump lift replacing external material hoists can reduce air pollution resulted from the spread of dust. Concrete paved roads are also suggested within the site that can reduce dusty site traffic. Saw cutting can also be used instead of concrete breaker during demolition to reduce the generation of noise.

“R&D” was ranked with the third lowest power spectrum magnitude of about 0.6181 from the survey results. The interviewees agreed the importance of R&D for further development; however, it cannot expect a return from R&D in a short duration period. That could be attributed the fact that construction firms, in general, are financially constrained in their R&D activities by both internal and external resources.

“Training” was ranked with the second lowest power spectrum magnitude of about 0.53 from the survey results. There are a lot of literature supporting training and education can help improve environmental performance; however, the interviewees argued that training programmes provided by the top management are normally very general, which cannot be specifically help for their construction activities. If the training programmes can focus on specific site activities, it will be beneficial to the overall environmental situation.

Among the twenty-six criteria in the green evaluation system, “Monitor water usage” was ranked with the least and the lowest power spectrum magnitude of about 0.4780 from the survey results. The interviewees argued that reducing water pollution is not ranking as a high priority for construction projects. Reducing air pollution normally requires the use of water, which is a bit contradict with water consumption reduction. Furthermore, an interviewee highlighted that reducing water consumption can reduce their water bills; however, if they did not properly reducing air pollution, serious fines may be prosecuted.

This paper identified several major measures for improving project sustainability in the Australian construction industry. Although construction industry has a unique nature on projects, this can still help the practitioners choosing a direct and suitable method with effective improvement on its project sustainability.

CONCLUSIONS

Green evaluation system served as an assessment tool for construction activities in measuring environmental performance, analysing, foreseeing the performance trend as well as providing a consistent basis for comparisons, eco-labelling and environmental benchmarking among companies and construction sites. This paper developed a set of twenty-six criteria for the green evaluation system. Questionnaire survey and interview discussion were conducted in Australia to investigate the significance of the developed criteria. Power spectrum was used for the analysis instead of the normal approaches, including average value and relative importance index as the power spectrum is proved to be easily identified dominant factor(s). It was found that "Other measures for reducing waste pollution", "Top management support" and "Maintenance of equipment" were the top three criteria for the green evaluation system for improving the overall environmental performance. However, "Research and development", "Training" and "Monitor water usage" were found as the three lowest criteria for improving environmental performance. This paper identified several major measures for improving project sustainability in the Australian construction industry. The limitation of this paper was focused in Australian perspective. Other countries can adopt similar approaches to identify major measures for effective project sustainability in construction. However, this paper can form a useful background for the development.

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A REVIEW OF THE RISKS ASSOCIATED WITH BUILDING INFORMATION MODELLING ADOPTION

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ABSTRACT

Building information modelling (BIM) has been seen as one of the most promising recent developments in the architecture, engineering and construction (AEC) industry. Although BIM can bring about a number of benefits to users, it also inevitably involves diverse risks. This study attempts to provide a critical review of the risks associated with BIM adoption in the AEC industry. Content analysis was applied in the literature review, and a total of 16 risks were identified from 20 analyzed literatures. "Unclear ownership of the BIM data", "uncertainty over design liability", "technological interface among programs" and "professional licensing issues" were mentioned most frequently in these literatures. This study can set a foundation for future research that would assess these risks and develop a networking of risk paths associated with BIM adoption.

Keywords: Building information modelling, risk, review

INTRODUCTION

Building Information Modelling (BIM) is a process of representing building and infrastructure over its whole life cycle from planning, design, construction, operations, maintenance and recycling (buildingSMART Australasia 2012). BIM has been seen as one of the most promising recent developments in the architecture, engineering and construction (AEC) industry (Azhar 2011) and has the potential to revolutionize the AEC industry (Goedert and Meadati 2008, Gerrard et al. 2010). BIM means not only using three-dimensional intelligent models but also significant changes in the workflow and project delivery processes (Azhar 2011, Hardin 2011, Azhar et al. 2012). The increasing interest in BIM can be seen in conjunction with the Integrated Project Delivery (IPD) approach (Eastman et al. 2011). In addition, BIM replaces the traditional paper-based tools of construction management, puts them on a virtual environment, and allows a level of efficiency, communication and collaboration that exceeds those of traditional construction processes (Bryde et al. 2013).

Previous studies have identified a number of benefits that may be brought by BIM adoption. According to a recent study by McGraw Hill Construction (2014) in Australia and New Zealand, the most significant short-term benefits were reduced errors and omissions, enhancement of organization's image as an industry leader, reduced rework, and the most significant long-term benefits were maintained repeat business, reduced project duration and reduced construction cost. Another research conducted showed that the widespread adoption of BIM and related digital technologies and processes would potentially yield productivity savings to the Australian economy of up to $7 billion over the next decade (Mitchell 2013). In terms of time saving, Autodesk (2008) argued that Revit® Architecture software saved 91% of the time on checking and coordination and 50% on design development, compared with traditional Computer Aided Design (CAD) tools.

Because of its far-reaching benefits, there has been a current push for BIM by governments worldwide, including Australia (Panuwatwanich et al. 2013). To promote BIM adoption in Australia, two initiatives are underway (Mitchell 2013). The first one is the National BIM Initiative (NBI), which was developed by buildingSMART Australasia (2012) and presented to the Federal Government in July 2012. The NBI sets out six priority areas requiring Federal support: procurement; BIM guidelines; multi-disciplinary education; product data and BIM libraries; process and data exchange; and regulatory frameworks. It aims to facilitate the Federal Government's adoption of full collaborative BIM for all of its building procurements from 2016. The second one is the Virtual Australia and New Zealand Initiative (VANZI), which is a framework designed to allow the industry and government to work together in planning the future sustainability of Australian cities. The VANZI aims to provide better, quicker, less costly outcomes for all property purposes. The VANZI vision is an integrated 3D virtual world, where participants can securely collaborate to prototype, plan, design, engineer, build and manage new infrastructure and private developments (Mitchell 2013).

Although the benefits of BIM have been recognized within the AEC industry and the technology supporting BIM has grown matured, BIM adoption has been slower than anticipated in the Australian AEC sector. Based on a survey performed in three states (New South Wales, Victoria and South Australia), Gerrard et al. (2010) reported that the usage of BIM in the AEC industry was fairly low, and that BIM were more likely to be used in larger firms and projects. In addition, Alabdulqader et al. (2013) indicated that only 32% of the 25 surveyed firms in Queensland were aware of and actually adopted BIM as part of their work.

Risks associated with BIM adoption may pose threats to the achievement of the potential benefits, and thus attracted much attention from both academics and industry practitioners. Azhar (2011) divided BIM risks into two broad categories: legal (or contractual) and technical. Lesny and Reidy (2013) asserted that more use of BIM models would lead to greater risk, which could extend long after project completion, provided that the BIM models are used for lifecycle. Hanna et al. (2013) indicated that the risks associated with BIM adoption was one of the five main factors influencing the current state of BIM practice. Therefore, it is important to identify these risks. This paper attempts to provide a critical review of the potential risks associated with BIM adoption.

METHOD

In recent years, BIM has attracted great attention from researchers. In Scopus database, there have been 199 journal articles, including those in press, whose titles include either "building information modelling" or "building information modeling". To focus on the articles relating to both BIM and risk, the following search code is input into the search engine:

TITLE (building information modelling) OR TITLE (building information modeling) AND TITLE-ABS-KEY (risk) AND LANGUAGE (english) AND SUBJAREA (mult OR ceng OR CHEM OR comp OR eart OR ener OR engi OR envi OR mate OR math OR phys OR mult OR arts OR busi OR deci OR econ OR psyc OR soci)

A total of 30 articles were obtained, including 11 journal articles, 17 conference papers, 1 book and 1 review. The 11 journal articles are focused on in this study because journal articles tended to provide more detailed information than journal papers. After checking all the 11 journal articles, it is found that only four of them are really relevant to risks of BIM application. Thus, articles and professional reports, which are not included in the Scopus database, are also reviewed. Most of them are published by BIM professional bodies or software companies. Thus, a total of 20 literatures were reviewed. Content analysis can assist in classifying textual material, and reduce it to more relevant and manageable bits of data (Weber 1990). This method is often adopted to determine the major facets of a set of data, by simply counting how many times an activity occurs, or a topic is depicted (Fellows and Liu 2003). In this study, risks identified in each literature were first marked down, and then similar risks were assembled. Thus, a total of 16 risks were finally identified from the 20 analyzed literatures, as Table 1 shows.

Table 1 Risks associated with BIM-based project management

Risk	Literatures																				Sum
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Lack of BIM protocols	√		√		√												√			√	5
Unclear ownership of the BIM data		√	√	√	√					√		√	√	√					√	√	10
Professional licensing issues		√	√	√	√								√	√							6
Data security		√	√		√																3
Uncertainty over design liability		√	√	√	√	√		√				√	√	√				√			10
Reluctance to share information		√	√									√						√			4
Technological interface among programs		√					√						√					√	√	√	6
Lack of a check mechanism			√																		1
Cultural resistance											√	√								√	3
Cost overrun with BIM	√											√					√	√			4
Lack of competency or expertise in using BIM	√																	√			2
Poor communication among project participants						√		√													2
Lack of collaboration among project participants							√		√			√								√	4
Interoperability issues			√		√					√								√	√		5
Changes in the BIM model by unauthorized parties						√															1
Low quality of BIM data															√	√					2

Literatures: 1. Hanna et al. (2013); 2. Azhar (2011); 3. Azhar et al. (2012); 4. Simonian (2010); 5. Kuiper and Holzer (2013); 6. Rodriguez (2014); 7. Arayici et al. (2012); 8. Hutt (2013); 9. Ku and Taiebat (2011); 10. Fan (2013); 11. Jensen and Jóhannesson (2013); 12. Dossick and Neff (2010); 13. Thompson and Miner (2006); 14. Sieminski (2007); 15. Krygiel and Nies (2008); 16. Becerik-Gerber and Rice (2010); 17. Hanna et al. (2014); 18. Chien et al. (2014); 19. Hsu et al. (2015); 20. Stanley and Thurnell (2014).

RISKS ASSOCIATED WITH BIM ADOPTION

Lack of BIM protocols

Integration of multidisciplinary information in a BIM model requires establishment of BIM protocols in the project programming phase to ensure the consistency in information context and formatting styles (Azhar et al. 2012). According to the American Institute of Architects (AIA 2008), a BIM protocol is a contractual guide to the BIM process, which includes stakeholders' roles and responsibilities for items such as file sharing, model ownership, model file formats, specific leading trade models, scheduled model submissions for review, and responsibility for model changes on a specific project basis. Azhar et al. (2012) considered the lack of BIM standard protocol for model integration as a technology-related risk. Also, Hanna et al. (2013) reported that 61% of the respondents considered the lack of BIM protocols during construction as the highest risk factor, and Hanna et al. (2014) found that the highest risk encountered by electrical contractors was the lack of BIM protocol during the construction cycle. Furthermore, Stanley and Thurnell (2014) indicated that a lack of BIM protocols for coding objects by designers hindered the development of 5D BIM in New Zealand.

Unclear ownership of the BIM data

Azhar (2011) recognized the lack of clear ownership of the BIM data and the need to protect it through legal channels as a risk in the BIM adoption. In reality, intellectual property rights issues have been incurred under the application of BIM (Hsu et al. 2015). Specifically, if the owner pays for the design, the owner may feel entitled to own it. However, if team members provide proprietary information, their proprietary information should be protected by the copyright laws or other legal channels (Azhar 2011). Also, a specialty mechanical, electrical, or plumbing (MEP) contractor, who inputs detailed design into the BIM model shared by all team members, tends to maintain the right to that data when the project is over. This is because the proprietary information would be obtained by its competitors upon the completion of the project, if the data are part of a BIM model used by the owner (Simonian 2010). Therefore, every project should include a clear ownership right and responsibilities of the BIM data in the contract documents, with the consideration of the needs of project participants.

Professional licensing issues

Architecture and engineering are regulated professions (Allen et al. 2005). Generally, governments have a series of regulations that limit the use of the title of “architect” or “engineer” to those properly qualified and registered, and then require each project to be under the responsible charge of a licensed architect or engineer (Allen et al. 2005, Sieminski 2007). However, it is usually difficult to ensure that licensed design professionals are always in charge of the creation and modification of the data that forms a digital model (Simonian 2010). According to Azhar (2011), licensing issues would arise when the data from the project team members, who are neither the owner nor the architect/engineer, are integrated into the BIM model. For instance, equipment or material suppliers may offer designs related to their products for the convenience of the lead designer in hopes of inducing the designer to specify their equipment or materials. Although this seems good for business, licensing issues would arise if the designs were not produced by a designer licensed in the location of the project (Thompson and Miner 2006). The licensing issues may further delay the approval of the design and could negatively impact project schedule performance.

Data security

Eadie et al. (2013) indicated that all the project team members should attach importance to the security of the confidential data that are both external and internal to the BIM model, thus ensuring the successful BIM implementation. As the BIM model can be included in the extranet (Christensen et al. 2007), the data security would be threatened and lead to legal issues. Although D'Agostino et al. (2007) found that both BIM users and non-BIM users viewed security risks as limited hurdles of BIM application, it is still necessary to deal with the data security issues through the contract documents to reduce this risk (Christensen et al. 2007, Breetzke and Hawkins 2009).

Uncertainty over design liability

In most cases, contributors to a BIM model are from different parties involved in the design of a project. The uncertainty over which parties contributed to each aspect of the model tends to cause the confusion over who is liable, once a dispute in the project occurs because of a particular aspect of the BIM model (Hutt 2013). Assuming the responsibility for updating the BIM data and ensuring its accuracy involve a high level of risk. Requests for complicated indemnities by BIM users as well as the offer of limited warranties and disclaimers of liability by designers are important negotiation points that should be resolved before the full use of BIM in a project (Azhar 2011). In addition, the liability issues are likely to incur costs and reducing the savings produced by using BIM, thus negatively impacting the project performance. Specifically, new costs may result from the time for inputting and reviewing the BIM data (Thompson and Miner 2006, Azhar 2011), as well as the legal issues triggered by the claims presented by the general contractor due to misrepresentation or faulty designs (Rodriguez 2014). These types of errors could represent additional legal fees that were not contemplated on the original contract, reducing or minimizing the savings generated by the BIM process (Rodriguez 2014).

Reluctance to share information

BIM-based project management needs the information, models and data shared by project participants including architects, engineers, contractors, and owners. The willingness to share information has been seen as a critical success factor of the BIM adoption (Young et al. 2008, Won et al. 2013) while the reluctance to share information would hinder the use of BIM within a projects (Gilligan and Kunz 2007, Young et al. 2009, Eadie et al. 2013, Won et al. 2013). According to the interview findings of Dossick and Neff (2010), the reluctance to share information was likely to result from the issues of ownership, intellectual property and design liability. However, Autodesk (2008) argued that sharing models and information was not a requirement to BIM benefits. Although data or information sharing could make BIM more effective for those willing to collaborate closely, the choice could be left to project team members (Autodesk 2008).

Technological interface among programs

The issues relating to the technological interface among various programs arise because the dimensions of cost and schedule are layered onto the BIM model (Azhar 2011). In most cases, design team members use different software tools and work in parallel and need to incorporate their work (Arayici et al. 2012), and there may be inconsistencies among various software packages (Hsu et al. 2015). Also, sophisticated general contractors may require subcontractors to submit detailed critical path method schedules and cost breakdowns itemized by line items of work prior to the start of the project, thereby creating a master schedule and cost breakdown for the entire project. If the data are incomplete or submitted in different scheduling and costing programs, the general contractor has to re-enter and update a master scheduling and costing program, thus lowering the project productivity. Thus, Thompson and Miner (2006) suggested that the responsibility for the accuracy and coordination of cost and scheduling data should be contractually addressed.

Lack of a check mechanism

BIM involves the integration of the roles of all the project stakeholders, thus having the potential to generate higher-level efficiency and harmony among players. The harmony between project participants is distinct from the adversarial stance, which brings a more critical review of the project based on mutual guarding of each participant’s interests (Azhar 2011). However, the harmonious relationship among project participants tends to eliminate the check mechanism in the traditional paradigm (Azhar 2011). When all the project players view themselves as being in the same team, they may no longer look for mistakes in each other’s work, which is likely to increase design errors.

Cultural resistance

As the use of BIM has been seen as a revolutionary change in the approach to manage projects (Chen et al. 2013), companies are inevitably confronted with the challenges in getting their employees to accept new working procedures, which involves changing the mindset of employees. Cultural change has been as the most difficult part of BIM adoption because personal attitudes towards the new technology are shaped by the risks involved in using unproven means and methods, by the difficulty in implementing technology, and by the perception of other people’ attitudes toward new technologies (Tatum 1989, Dossick and Neff 2010). The cultural resistance would impede the BIM adoption in projects (Khosrowshahi and Arayici 2012, Eadie et al. 2013, Jensen and Jóhannesson 2013, Stanley and Thurnell 2014) because employees may still perceive that the current project management approach that they get used to is sufficient (Yan and Damian 2008), unless the BIM thinking is embedded into the corporate culture (Jensen and Jóhannesson 2013).

Cost overrun with BIM

Hanna et al. (2013) recognized the costs of using BIM in a project as a main factor that would influence the current state of BIM practice. Although BIM offers the potential for significant savings (Simonian 2010), cost overrun with the use of BIM was still ranked second in the study of Hanna et al. (2013), who reported that the BIM implementation usually represented 1-2% of MEP project costs. Similarly, Bradshaw (2006) believed that it was a long and costly process to become proficient in BIM considering the cost and time associated with buying and becoming familiar with new software programs. Additionally, the high cost of investment in BIM has been viewed as an important obstacle to the BIM adoption (Eastman et al. 2011, Bernstein et al. 2012, Khosrowshahi and Arayici 2012, Eadie et al. 2013, Won et al. 2013).

Lack of competency or expertise in using BIM

Lack of relevant expertise or competency significantly hinders the BIM implementation (Gilligan and Kunz 2007, Eadie et al. 2013, Won et al. 2013), and has been seen as a critical risk associated with the use of BIM (Hanna et al. 2013). Low-level competency or expertise in using BIM makes it difficult for project team members to obtain the benefits of BIM. Hanna et al. (2013) suggested that potential solutions would involve developing comprehensive standards and training programs for contractors, thus ensuring the adequate BIM implementation in projects. An enhanced level of the relevant competency or expertise enables the project team to obtain the full benefits of BIM throughout the project lifecycle (Eadie et al. 2013).

Poor communication among project participants

Theoretically, BIM allows project participants to easily communicate spatial and logistical issues, and improves access to relevant information. However, Dossick and Neff (2010) found that although BIM linked project participants together technologically, they were still organizationally divided, lacking timely access to crucial information and decisions. Also, Dossick and Neff (2010) reported that the industry was greatly depending on the individual leadership of particular people in the coordination process, rather than the closer communication connections among trades and among construction divisions. Furthermore, problems would occur when changes to the BIM model and specific requirements on construction and installation were not clearly communicated between project participants (Hutt 2013, Rodriguez 2014).

Lack of collaboration among project participants

Ku and Taiebat (2011) contended that close collaboration between the primary project participants, including the owner, architect, engineer, general contractor, subcontractors, and suppliers, is necessary to fulfill the benefits of BIM. Similarly, Sebastian (2011) believed that the fair and open collaboration between the owner and contractors enabled the optimal use of their competencies. In addition, Ku and Taiebat (2011) found that the professionals perceived lack of collaborative work process and capability to collaborate as barriers to BIM implementation. D'Agostino et al. (2007) and Won et al. (2013) also recognized poor collaboration among project participants as a critical obstacle to the sue of BIM in projects. The lack of collaboration among different project participants probably results from the fragmented nature of the construction industry (Stanley and Thurnell 2014). Furthermore, it merits attention that collaborative working poses difficulty in protecting intellectual property rights over shared data, information and models (Lesny and Reidy 2013). The intellectual property issues, together with data ownership and design liability issues, contribute to the lack of collaboration among project participants (Dossick and Neff 2010).

Interoperability issues

Interoperability refers to the ability to exchange data between applications to facilitate automation and avoidance of data re-entry (Azhar et al. 2012), requiring that drawings, master building specifications, standards, regulations, cost and procurement details, environmental conditions, and submittal processes work together (Smith 2014). The introduction of XML Schemas and the Industry Foundation Classes (IFC) has significantly helped to solve interoperability issues (Vanlande et al. 2008, Smith and Tardif 2012), but both approaches have their inherent limitations. Thus, interoperability issues have been viewed as a critical technological risk (Azhar et al. 2012). Also, poor interoperability among BIM software could serve as a barrier to the BIM adoption in project management (D'Agostino et al. 2007, Grilo and Jardim-Goncalves 2010, Eastman et al. 2011, Ku and Taiebat 2011, Demian and Walters 2013).

Changes in the BIM model by unauthorized parties

Rodriguez (2014) highlighted the risk of changing the BIM model on large-scale projects, in which some contractors and consultants may intend to make changes for their own interests, not sharing the ideas with other project team members. Thus, measures should be taken to reduce the opportunities for subsequent changes or alternation made by unauthorized parties, after the BIM model is established and accessible to project team members. Rodriguez (2014) suggested that a project team leader should be appointed to be the only authorized user who has the right to change the BIM model.

Low quality of BIM data

The value and benefits from the BIM adoption is dependent on the quality of the BIM data. Krygiel and Nies (2008) argued that if the data input into the BIM model was incorrect or not practical, the effectiveness of BIM in the design stage would not be guaranteed. In addition, Becerik-Gerber and Rice (2010) asserted that the accuracy of the as-built models should be up-to-date and informative to ensure a sustainable building after handover.

CONCLUSIONS AND RECOMMENDATIONS

This study attempts to provide a critical review of risks associated with BIM adoption. To achieve this objective, content analysis were conducted and 20 literatures were reviewed. Finally, a total of 16 potential risks were identified through the literature review.

Risk identification is usually recognized as the first step of a risk management process (Low et al. 2009, Zhao et al. 2014). Thus, future research would continue to analyze these risks and develop strategies to deal with them. In fact, risks are dynamic, fluid and highly interdependent (Chapman 2006, Cendrowski and Mair 2009), and cannot be segmented and managed independently. Therefore, the interactions among risks should be highlighted. Future research would investigate the interrelationships among the potential risks associated with BIM adoption and develop a networking of risk paths. In addition, different stakeholders usually hold different views on risks, so it is important to examine the differences in the perceptions of various stakeholders on these risks.

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CONCEPTUAL FRAMEWORK TO IMPROVE BIG DATA FLOW IN A CONSTRUCTION PROJECT

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ABSTRACT

Big data management has not been well implemented in the construction industry. One of the barriers preventing a construction project from accessing the full capability of big data management is poor data flow. The aim of this study is to improve such a flow. The study developed a big data flow management framework to support building professionals to identify pitfalls in the data flow of a construction project. Based on a literature review, this framework was modelled in accordance with communication theory and concepts of data life cycle management. The framework was embedded with comprehensive big data management guidelines to achieve more effective big data management. The framework governs the project data flow across different project development stages and multidisciplinary teams of a construction project. Findings of this study will help reveal how the data flow within a project and identify any hidden pitfalls. Based on the identified pitfalls, appropriate mitigations can, therefore, be developed to improve the data flow of a project. Thus, this would pave the way to achieve more effective big data management, as well as project management as a whole.

Keywords: Big data management, Communication theory, construction, data flow, project management

INTRODUCTION

Effective management of big data plays an essential role in the success of a project and the organisation. This management refers to, not only, appropriately and effectively collecting and analysing project data, but also to successfully sharing such data with project stakeholders (Schmarzo 2013). Effective big data management has been found useful in improving decision making and minimising the risks of a project (Manyika et al. 2011). Previous studies highlighted that organizations with more effective big data management could generate more productive results, such as, improved performance, in-depth understanding of consumer behaviour, and better planning and forecasting. These also include experiencing higher returns on equity, and enabling organizations to operate more efficiently and stay ahead of the competition (Russom 2011; Sagiroglu and Sinanc 2013).

Harnessing big data has enormous potential in every sector; however, most construction firms have not yet tapped into the full potential of big data management. The construction industry is heavily fragmented into small and medium-sized companies, and the planning and construction processes are strictly separated from each other. Each construction project is also unique, and involves complex data and documents in terms of drawings, contracts, reports, schedules, datasheets, technologies, and so on (Singhaputtangkul et al. 2013). In addition, notwithstanding that there are many decision-makers in a construction project, data associated with each project document need to move quickly and efficiently between the decision-makers (Singhaputtangkul et al. 2014). The diversity and complexity of the project data and documents coupled with the time and quality constraints of a project, collectively affect how well the data flow (Schmarzo 2013).

Undoubtedly, the flow of the project data, including documents, has a significant impact on effectiveness in big data management of a construction project. For instance, during the early design development phase of a project, various documents, including plans, calculation sheets, text documents, 3D models, and so on must be produced. There are many different sets of the data required to produce such documents. In many cases, these data sets were neither stored centrally and properly nor linked to each other. Hence, some sets of data may be lost, not easily found, not included in development of the documents, or not incorporated into relevant decisions. This pitfall limits the opportunity to correctly analyse and quickly transfer the data, and, as a result, increases the risk of delivering erroneous or inconsistent information to a project (Schorr et al. 2011). There are only a few studies that shed light on improving data flow in a construction project from an integrative project management and big data management standpoint.

To fill this gap, this study aims to establish a starting point of a big data management journey in the construction industry through improving project data flow. The objective of this study is to develop a conceptual big data flow management framework that will enable building professionals to identify pitfalls in the data flow of a construction project.

The study began by examining comprehensive guidelines to achieve effective big data management. This was followed by reviewing concepts of data management as well as data life cycle management. Subsequently, findings from the literature review were integrated with the guidelines to establish the big data flow management framework. The aim of which is to improve the flow of the project data, including documents, across all project development stages of a construction project.

CONCEPTS OF BIG DATA MANAGEMENT

Data management generally encompasses a very broad range of topics, often related to database operations such as query, update, deletion, insertion, backup, performance management, data security management, etc (Schmarzo 2013). Data management has to be applied throughout a data life cycle. There are three main phases of a data life cycle; namely, data collection, data analysis and data sharing (Pääkkönen and Pakkala 2015). Data collection is the process of gathering and storing information on targeted variables in an established systematic fashion that suits data analysis. Data analysis involves processing, inspecting, cleaning, transforming, and modelling data with the aim of discovering useful information, suggesting conclusions, and supporting decision-making. Results from data analysis are shared with relevant project stakeholders through appropriate communication means (Ball 2012). Data sharing refers to providing the necessary information to effectively manage the data in a long-term archival setting and to support reuse beyond the original purpose for which the data were created. Throughout this entire process, additional metadata and documentation are added (Lenhardt et al. 2014).

Data in organizations are getting bigger, so much so that management of such big data becomes more complex and requires greater attention. Effective big data management would hold the potential to transform how organizations drive business value (Schmarzo 2013). Big data management, alongside labour and capital, could play a significant role to promote the next frontier for innovation, competition, and productivity (McKinsey Global Institute 2014).

It is noted that big data refers to a scale of data and tools and a complex system made up of technology, process and people involved in data collection, analysis, and use. In theory, managing big data therefore consists of three pillars, which are technology, process, and people (Rankin et al. 2015). Guidelines governing each pillar can be found in Table 1. In brief, the technology pillar takes part in every data management life cycle step, and each step can be supported by various types of technology. Key considerations in applying the technology in managing big data are data integrity and accessibility, aggregation and alignment, and integration. The process pillar accounts for a significant portion of success in big data management (Rankin et al. 2015). However, it was found that, in many circumstances, the processes used to collect data could cause discrepancies, errors, etc., if these lack legitimate data governance (Ladley 2012).

The Data Governance Institute defines data governance as "a system of decision rights and accountabilities for information-related processes, executed according to agreed-upon models which describe who can take what actions with what information, and when, under what circumstances, using what methods" (The Data Governance Institute 2015). Data governance is an ongoing stage that involves ensuring data are accurate, clean (e.g., no duplicate records), comprehensive (e.g., no missing records), accessible to stakeholders, and secure (Rankin et al. 2012). Clear and effective processes are required for these qualities to be achieved. People are another important pillar for managing big data. It provides the cause and effect of poor data for development of solutions to correct a problem (The Data Governance Institute 2014). Data are an organizational asset just as the people who work for an organization are. Results from data analysis would be most effective when people analyse such data in a collaborative environment where all project stakeholders have sufficient data literacy, and speak a common language (Grossman and Siegel 2014).

Table 1 Guidelines for big data management

Pillar	Sub-pillar	Guideline
Technology	Integrity and accessibility	A project applies tools/techniques that can assure that data and documents are secured, and can only be viewed, accessed or modified by those authorized to do so when needed.
	Aggregation and alignment	Tools/techniques employed in a project can be comprehensively used with multiple present data formats throughout the data life cycle.
	Integration	Tools/techniques used in a project assimilate people and processes to quickly produce meaningful data sets.
Process	Rule	A project has a complete and clear flow for all documents. Rules, algorithms, and techniques required to make decisions are established.
	Decision right	Right decision makers are empowered to make decisions concerning data-related processes.
	Accountability	A project has, and actively follows, a responsibility and accountability matrix (or similar) for all staff who enter, manage and use data for all documents.
People	Common language and sharing culture	A project (or organization) has a common language where project team members can share opinions and make collaborative inquiry comfortably.
	Data literacy	Project team members possess the ability and skillset to read, create and communicate data in varying formal ways including building knowledge from data.

Figure 1 illustrates a simplified big data management structure integrating the big data management pillars with concepts of the data life cycle management. This structure is built upon the integration of the technology, process and people pillars combined with the data management life cycle steps.

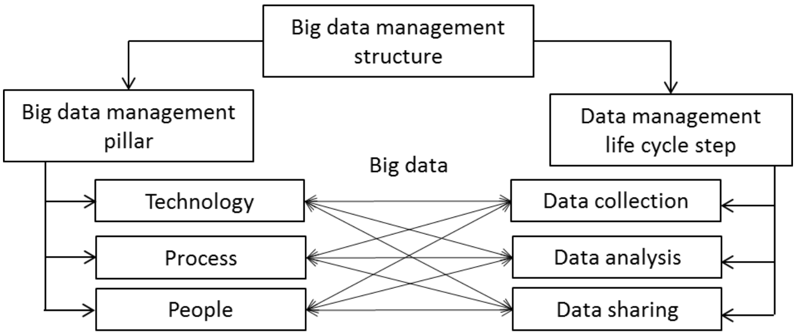

Figure 1 A simplified big data management structure

FLOW OF THE DATA IN A CONSTRUCTION PROJECT

As mentioned earlier, one construction project can produce various documents, and one document may require several sets of the data (Sydney 2012). Each set of data may involve different data collection methods/sources, analytics, and communication means, depending on quality requirements, resources availability, and so on. This makes it hard for a project team to manage such big data while maintaining productivity of a project (Senaratne and Mayuran 2015). For example, in the early design stage of a particular project, the project management team developed a master Project Schedule. Briefly, the team gathered planning documents from previous similar projects, extracted relevant data, listed activities of the project, sequenced the activities, and estimated durations of each project acitvity. The project management team then shared the document with other project disciplinary teams especially a design team and procurement team for review to ensure that design and procurement works of the project can be completed on time (Al Qady and Kandil 2013). To develop the Project Schedule document, the project management team would have a number of software options several sets of planning data, technologies for the sharing the document, and governing processes for the review.

It was found that the way project data are handled can either be the driving force behind a project's success or the bottleneck that often places a project in despair resulting in its failure to meet its time line, budget and scope (Stolovitsky 2010). Importantly, the methods chosen to collect project data, the data processing and analysis techniques/tools used to produce project documents, and the way project data, including documents, are organized and reported are what makes the project different in the way it is delivered. Misalignments between these methods and processes, such as poor data analysis techniques, lack of an effective document sharing system, and so on, can constitute pitfalls in the project data flow (Stolovitsky 2010).

Additionally, in any project development stage, the output, project data or documents, of one project disciplinary team could be a main source of input for another team. Furthermore, to produce a particular project document, a group consisting of one or more project disciplinary teams may require various sources of information from the other group (Singhaputtangkul et al. 2013). To ensure effective big data management, pitfalls in the data flow of the project documents produced by multidisciplinary project teams, including project management, procurement, design, and construction, must be examined across the project development stages. These stages are planning and tendering, design, construction, and closing out.

BIG DATA FLOW MANAGEMENT FRAMEWORK

As can be seen, the data flow in a construction project requires a more comprehensive big data management framework in order to identify the pitfalls. This study applied concepts of communication theory integrated with the big data management structure to establish such a framework. Efficient communication, cooperation and collaboration between project team members directly impacts on the success of a project (El-Saboni et al. 2009; Klimkeit 2013). Communication involves sending and receiving data, documents and information thereby enabling the whole team to understand each component of the project (Low and T'ng 1998). Communication theory defines three key elements of a communication cycle; namely "sender", "message", and "receiver" as shown in Figure 2.

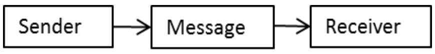

Figure 2 Communication theory

All three elements have to be present for each communication cycle to be completed. A sender develops or encodes a message, and conveys the message to a receiver through a medium. The receiver receives the message, decodes the message, interprets its meaning and provides feedback, if any (Newman and Newman 2009; Toseland and Rivas 2005). The medium used is important to communication, since it affects the process of decoding. Decoding the message correctly is essential, as it ensures the meaning is interpreted as is intended by the sender (Toseland and Rivas 2005). One entire data communication chain required to develop a particular project document may not only involve various sets of data from the teams, but also consist of multiple communication cycles. A receiver in the first communication cycle may also become a sender in the second cycle, and so on. Additionally, in each cycle, the data may be recycled many times between the sender and receiver (Miller 2014).

Figure 3 presents the big data flow management framework, modelled through the integration of the big data management structure with the concepts of communication theory. As can be seen, the framework suggests that a flow of the data to produce any project document is governed by the three big data management pillars throughout the data life cycle. Importantly, the framework divides the flow of the data into a number of communication cycles across the project development stages. Specifically, in each cycle, the project disciplinary teams can play a role as both the sender and receiver. If the sender and receiver are the same, this means the message are communicated among team members. The message is simply the project data involved in that cycle.

In addition, each communication cycle may consist of a forward path and backward path. The forward path is where the sender sends the message to the receiver, while the backward path refers to where the receiver returns feedback including recycling the message to the sender. It is also important to note that a sender or receiver in any cycle is not limited to only a single project disciplinary team. For example, in a forward path of one communication cycle, a project management team, as a sender, developed a Project Execution Plan document. This document was sent to different project disciplinary teams, as receivers, for review. In the backward path, all the receiver teams recycled the document embedded with their comments back to the sender.

Importantly, effectiveness of the data flow significantly correlates with how well the flow aligns with the three big data management pillars. This framework decomposes a data flow into smaller communication cycles and that each cycle can be thoroughly evaluated against the guidelines. This evaluation would help explain how the data are collected, analysed and shared in every communication cycle in relation to the guidelines across all the project development stages. At the same time, this would assist in identifying the misalignments or pitfalls hidden in the data flow, and developing the mitigation measures.

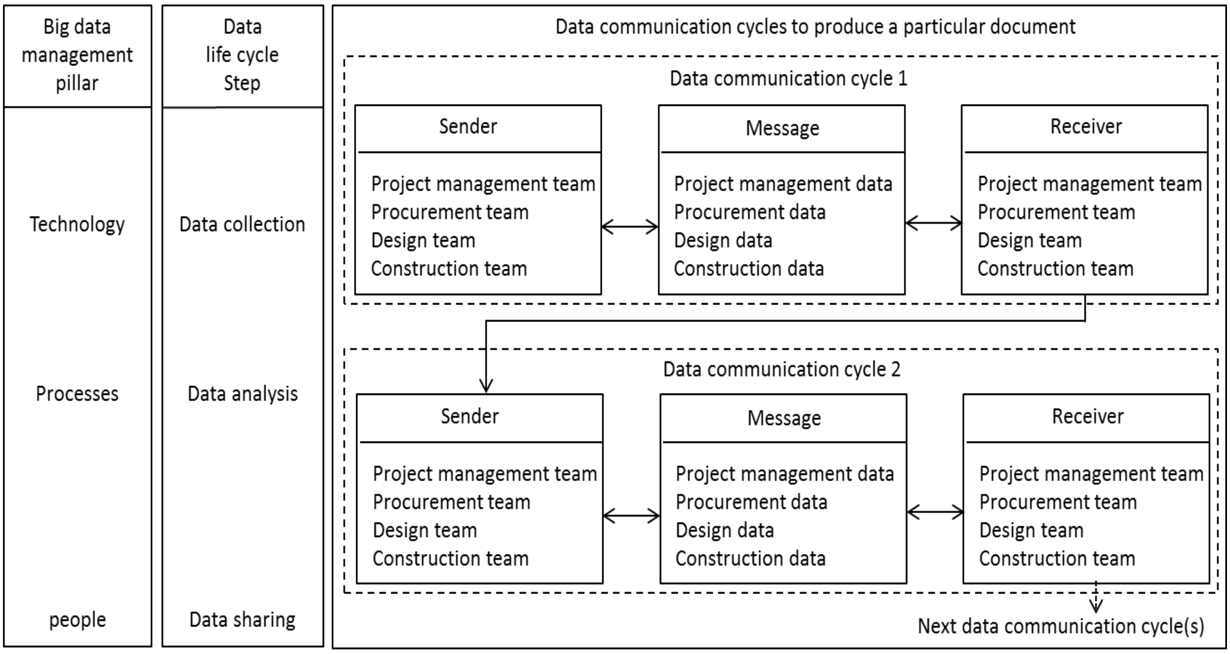

Figure 3 Big data flow management framework

CONCLUSION

Big data management has become more important in every sector including the construction industry. However, the lack of effective big data flow management seemed to limit a construction project to draw the full benefits from big data management. This study developed the conceptual big data flow management to facilitate building professionals to manage the project data flow of a construction project. The framework stipulates that, based on communication theory, a certain data flow may comprise several data communication cycles throughout its entire life cycle. One cycle is made up of a sender, receiver and message. A sender or receiver could be one or more project disciplinary teams. Every data communication cycle is governed by the three big data management pillars and their associating guidelines. The framework would assist the building professionals to examine the pitfalls in the data flow with respect to the guidelines. A main limitation of this study is that the conceptual big data flow management was developed based on the literature review. As such future studies are recommended to apply this framework with actual projects and determine its effectiveness in identifying the pitfalls.

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EMBEDDING LITERACY FOR CONSTRUCTION MANAGEMENT STUDENTS IN AUSTRALIAN UNIVERSITIES

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ABSTRACT

Learning and Teaching strategies in higher education should be carefully chosen based on the nature of students and their learning approaches. Construction Management students in Australian Universities are regarded 'non-traditional' (either with little family history in university or, first time mature aged or, having prior industry experience) and therefore, may have specific literacy needs that are unexplored. Hence, this paper was aimed at exploring the specific literacy needs for construction management students and to identify strategies that would help to improve. Case study research method was used for this research. A first year teaching unit, in which literacy is embedded into the construction management context, in a popular construction management programme in Sydney, Australia was selected as the case study. The data collection included observations and evaluations of student assessment tasks in the selected unit over two offerings. Based on the findings on its first offering, some common literacy areas were identified that most students struggle with. Certain strategies to overcome these were then employed in the second offering such as development of online literacy modules with videos and quizzes; and lectures on specific literacy topics. The paper discusses the findings on the identified common literacy development areas and the effectiveness of these strategies in improving construction management students' literacy. The findings will be useful to similar courses.

Keywords: Construction management, embedding literacy, higher education, literacy needs

INTRODUCTION

Due to the changing nature of higher education and the rapid expansion of self-funded universities, the annual student intakes in universities are continuously increasing giving more opportunities for different categories of students to enter into higher education. Australia, with no exception, has experienced a significant increase. According to OEDC (2012) report, young people from families with low levels of education get very high chances of completing a tertiary education in Australia and Ireland. Hardie (2009) affirmed this by stating that the increased participation in university education in recent years in Australia has meant that the broader group of 'non-traditional' students makes up an increasing proportion of all student enrolment. She defines non-traditional' students as students with little family history in university education, first time mature aged university students and students who have come to university with previous experience in trades and industry employment. A first year retention survey, conducted in 2006 in a university in Sydney, revealed that 52% of students are the first in their immediate family to attend university (Scott et al, 2008).

Hardie (2009) stated that this figure is higher in construction management (CM) discipline. On the other hand, the CM programmes in universities are experiencing large intakes during the last five years, which has almost trebled the intake during the last five years (Senaratne and Hardie, 2015). Approximately, half the CM students' intake each year comes from industry or trade backgrounds rather than directly from high school, which means that they already have some level of industry experience (Hardie and Love 2012). According to Hardie (2009), these circumstances with 'non- traditional' CM students should be seen as an opportunity rather than a challenge, which would require different ways of engagement.

Hence, learning and teaching strategies for CM undergraduate students should be carefully chosen considering their 'non-traditional' nature. In specific, literacy development is identified as a basic need for these students to raise their professional and academic standards. Hence, this paper was aimed at exploring the specific literacy needs for CM students and to identify strategies that would help to improve. The research question formulated was "how can we improve literacy skills of construction management undergraduate students based on their needs?."

LITERATURE REVIEW

Biggs and Tang (2007) identified the difference in teaching and learning declarative knowledge to functioning knowledge. They state that while fields like humanities and basic science would focus on building a base of declarative knowledge for the students, in programmes such as Engineering and Construction, it is the functional knowledge that needs more attention, as the ultimate learning outcome would be to work in a practical context. Declarative knowledge would be still learned to construct a platform for making ultimate informed decision-makers and performers. However, students should be given more opportunities to apply knowledge through problem-based learning. Williams and Pender (2002) showed the importance of linking CM teaching to real-life situations. For this reason, they argue that the teaching in CM should be a combination of traditional and problem-based methods of teaching.

This gives a higher importance of embedding literacy in the CM context, rather than teaching literacy as an isolated subject. Recent studies have emphasised the necessity and high effectiveness of using the embedding model to scaffold students' learning and development of academic writing (Arkoudis et al., 2014; Briguglio, 2014; Tran, 2013).

According to Briguglio (2014), embedding academic language literacy (ALL) fall into one of the four models, ranging from the least to the most supported/embedded. While in the least embedded model, student self-access ALL resources, in the more embedded versions, there are ALL programs, workshops or common units run by ALL staff, and ALL support integrated into the discipline, and jointly run by ALL and discipline staff. The most embedded/supported model is featured with ALL being integrated into courses/units and run by the discipline staff. Arkoudis's study (2014) also proved that students benefited most from the most supported/embedded model as this method allows the involvement of all students including at-risk ones in ALL activities and contribute to the building of ALL-related graduate employability attributes such as written communication skills.

On the other hand, Poon (2013) showed the popularity of blended learning approaches in CM programs in the UK. Blended learning offers institutions an opportunity to engage in using technology in conjunction with the more traditional delivery and was seen by Poon (2012) as suitable for courses, which are vocational in nature. Hence, using blended learning strategies in addition to traditional literacy embedding approaches are appropriate for CM undergraduate students. The next section sets forth the research method adopted for this research.

RESEARCH METHOD

Case study research method was adopted for this research. According to Yin (2013), a case study is an empirical inquiry that investigates a contemporary phenomenon within a real-life context, where the boundaries between phenomenon and context are not evident. It offers description, exploration and/or explanation based on the facts, experience and perspectives of case study actors. In selecting particular cases, Eisenhardt (1989) states that it makes sense to choose cases in which the purpose is 'transparently observable.' According to Dyer and Wilkins (1991), the essence of case study research is the careful study of a single case that leads researchers to see novel theoretical versions. Hence, this study opted for a single case study.

A first year teaching unit, in which literacy is embedded into the CM context, in a popular CM programme in Sydney, Australia was selected as the case study. The data collection included observations and evaluations of student assessment tasks in the selected unit over two offerings. The observation data was analysed qualitatively using code-based analysis. It involved identifying similar concepts, themes and patterns in the observed data. The next section presents and discusses the findings.

RESEARCH FINDINGS

Case Study Background

The unit that was under the study is designed for first year first semester students, who learn literacy skills in the context of CM. This unit encourages students to explore professional responsibilities and challenges faced by construction professionals.

Students are enabled to learn through a combination of learning approaches in this unit. In addition to weekly face-to-face lecturers in large classes, they are divided into small tutorial groups that run for 1 hour every week. The tutorials especially focus on active learning by engaging students to work on their assignment tasks progressively. In addition to these face-to-face approaches, several blended learning approaches are utilised in this unit as described later.

The unit includes three main assessment tasks. In the first assessment, students are required to do a case study into their preferred CM role and write a reflective piece on why they prefer this role. This assessment enables students to understand their future profession and its responsibilities, while improving their information literacy and reflective writing skills. In the second assessment, students are required to undertake a research in terms of finding alterative solutions for a chosen construction industry problem and write a structured report. This requires the students to deploy academic and business literacy skills including report writing, argument construction and referencing. The final assessment is an oral presentation that enables to improve students' verbal communication skills.

The unit has a special focus on embedding literacy while introducing the students to construction management practice. The research findings are reported in three stages. Stage 1 involves evaluating students' assessments to identify common literacy issues, in the previous offering. Stage 2 involves strengthening embedding literacy through several strategies. Stage 3 involves observations on the effectiveness of these strategies.

Stage 1: Identification of literacy needs through assessment analysis

Students' assessment papers were analysed using the framework for assessing and scaffolding academic writing (Tran, 2015). Based on this framework, each paper was examined in terms of four aspects, namely structure and organisation, language convention, language use and referencing. The 'structure and organisation' aspect refers to whether or not the writing is organised in a prescribed structure, and the paragraphs are well-constructed and clearly communicate their points. The 'language use' aspect is concerned with the use of appropriate vocabulary and expressions while the 'language convention' aspect focusses on grammar correctness, spelling and punctuation. The final criterion, referencing, refers to how evidence is used to support the arguments as well as the mechanics of referencing.

The result of the analysis indicates the students' performance in each aspect and reveals the types of errors students tend to make in academic writing, particularly in the specific genres. The main types of errors identified include topic deviation (structure and organisation), wordiness/ lengthy sentence structure (language convention), informal tone (language use) and referencing mechanics (referencing).

Stage 2: Strategies implemented

The particular assistance offered in terms of embedding literacy was through following strategies:

1. <u>Development of clear assignment outlines with details instructions and marking rubrics</u>: It was noted that students in their very first unit expects detailed instructions on their assessment tasks. Therefore, the unit delivery team closely worked with the curriculum and literacy advisers to come up with very clear assignment outlines and marking rubrics. The purpose was also to help students write to the topic and avoid topic deviations. Some samples of the assignment outlines used and a rubric used are given in Figure 1 and 2.

This assignment is structured in three sections.

1. Overview of roles possible for CM graduates – 100 words
2. Case study of ONE specific CM role – 300 words
3. Personal reflection on why you wish to pursue a career as the role you identified in section 2 – 400 words

Section 1: Overview of roles possible for CM graduates – 100 words.

Construction Management (CM) is a diverse field with many possibilities. Research and write about the common jobs that may be undertaken by a CM Graduate. You are expected to provide tittles for the jobs, together with brief descriptions of their roles. You may use bullet points for this section, after you have introduced the general topic with a topic sentence.

Section 2: Case study of ONE specific CM role – 300 words.

In this section you will be required to develop a 'case study' of one particular CM job. The case study should include at least the following information:

- Job title
- Duties / Responsibilities (activities) and reporting relationships

Figure 1: A sample of instructions given for an assessment task

Criteria / Allocated marks	Unsatisfactory	Satisfactory	Credit	Distinction	High distinction
Overview of roles possible for CM graduates	Unable to identify jobs with their roles in the CM area	Lists some common jobs with description of basic roles, though the roles can be remotely relevant to the jobs.	Lists some common jobs and describes their roles sufficiently.	Lists most common jobs and correctly describes their roles.	Lists most common jobs that are highly relevant to CM and correctly and clearly describes their roles.
2 marks	0-0.5 mark	1 mark	1.25 mark	1.5 mark	2 marks
Case study of a specific role	Fails to state the option to develop the study or to provide relevant interview data (for option 1) or relevant sources (for option 2); Fails to use Harvard referencing style;	States the option to develop the study and provides interview data (for option 1) or sources (for option 2), though the data or the sources can be remotely relevant; Attempts to use Harvard style for references, though with	States the option to develop the study and provides some relevant interview data (for option 1) or some relevant sources (for option 2); Referencing follows Harvard style, but with some errors and/or inconsistencies;	States the option to develop the study and provides adequate interview data (for option 1) or a large number of sources (for option 2), most of which are relevant; Referencing mostly follows Harvard style both in-text and	States the option to develop the study and provides comprehensive interview data (for option 1) or a variety of sources (for option 2) that are highly relevant and informative; Referencing consistently

Figure 2: A sample of marking rubric given for an assessment task

2. Online Literacy modules: This is an academic literacy resource, which was offered in three modules and especially designed to help students to develop the required standards of academic literacy for their assessments. Each module comprised of weekly reading and learning activities. The topics targeted covered all literacy areas and a special emphasis was placed on sentence structure and language use, which were two common errors identified in stage 1. A sample of weekly topics is given in Figure 3.

Module 1: Academic Writing (Week 1-7)

Week 1: Academic Style

Week 2: Tips for Academic Writing

Week 3: Improving the flow

Figure 3: A sample of weekly activities in online literacy modules

3. <u>Annotated Exemplars</u>: Students were provided with two annotated exemplars for their research report: a good example and a 'not so good' example with identified areas for improvement (see Figure 4 for a sample). These were designed to further help the CM students to avoid common errors and learn to write academically.

Structure / content	Text	Language features
Identification of the problem / issue to be addressed The significance of the project.	Sustainability in suburban Sydney is **paramount** in promoting intergenerational equity. With **increasing** population and decreasing space/land, alternatives to current systems and methods used in homes in regards to insulation, lighting and ventilation must be found. Sustainable products keep working **indefinitely**. Natural systems have been doing this for **millions of years** and therefore [company name] has investigated how we can incorporate **more** natural ideas onto our predominantly man made lives. Currently, we rely on air conditioners, heaters, inefficient lights and fans to provide us with ventilation, heat and light in our homes. However there are natural alternatives which are becoming **more** popular in the construction industry. Energy use in Australia accounts for over 77% of greenhouse gas emissions and in New South Wales 85% of homes have electricity as their primary energy source,	Language is used to either 'turn the volume up' or 'turn the volume down'. This type of language is called **graduation**, as it grades meanings up or down (ie not just important but 'paramount', not just years but millions of years, not just a city, a major city). Statistics are used to emphasise the significance of the issue (i.e. it will effect a large amount of

Figure 4: A sample of an annotated exemplar

4. <u>Videos, quizzes and specific lectures on literacy</u>: There were several pre-recorded lecturers/ videos along with quizzes developed jointly by the library and literacy development team to cover key literacy areas related to the assessments such as 'reflective writing', 'oral presentations', 'searching information' and 'Harvard referencing'. Further, face-to-face lectures by academic literacy team were organised for explaining how to avoid common mistakes.

5. <u>Blended learning initiatives</u>: Students were encouraged to engage in online discussions through the discussion board and also engage in online collaborations between the groups who were assigned online. Other blended learning initiatives included online making and feedback report.

Stage 3: Observations on the Strategies used

1. <u>Effectiveness of clear instructions and rubrics:</u> It was identified the clear instructions and marking rubrics helped the students in understanding the assessment tasks. These were evident in the written comments of the student feedback of the unit. Almost all students followed the given structure and expected outcomes. In particular, these assisted students to avoid the literacy issue of topic deviation, which was identified as one of the common weakness among CM students.

2. <u>Effectiveness of online literacy modules:</u> Some students engaged in these weekly self-learning tasks, while some did not utilise it effectively. It was noted that the online mode was helpful compared to giving a full document for the students to read. The distribution of reading sections and exercises into different weekly topics helped the students to engage with it more actively.

3. Effectiveness of annotated exemplars: The annotated exemplars helped students understand the task in a more in-depth manner as they clarified the key standards and criteria. The annotated exemplars are also believed to lessen student anxiety about writing in the case of an unfamiliar format or genre. Providing students with an annotated exemplar of a 'not so good' paper also alerted them of the mistakes or errors other students often make to avoid for themselves.

4. Effectiveness of additional videos and lectures on literacy: The academic language literacy lecture was designed based on the analysis of common errors in stage 1 so that it focussed on addressing the problems that majority of students had in their assignment writing. Therefore, apart from generic topics like essay/paragraph structure and referencing, the lecture emphasised the presentation of common errors and how to avoid them. Students benefited from learning how to fix errors like topic deviation, wordiness, and informal tone by using practical strategies such as thematic development (to avoid topic deviation), reducing redundancies (to get rid of wordiness) and utilisation of nominalisation and passive voice as well as formal vocabulary (to improve formal academic tone). All the examples in the lecture were carefully chosen to reflect the context of construction management, which made it easier for students to understand linguistic contents.

5. Effectiveness of blended learning initiatives: Online marking using GRADEMARK tool was found effective for individual report marking and feedback. Since there were literacy related grademark sets developed by the literacy advisors that could be shared between the markers, it enabled providing detailed feedback to students on developing literacy aspects. The majority of students had read the feedback report according to the records shown on the feedback tool. The markers found specific challenges in providing feedback through online marking for group reports. It was noted that the common discussion board was not effectively utilised by the students in their learning process. However, the online participation within the assigned group was more effective and students used tools such as wiki page to share documents and comment on each other's write-ups.

CONCLUSIONS

The aim of this paper was to present and discuss a case study on embedding literacy in a popular construction management undergraduate programme in the Sydney region. The findings were discussed in three stages. In stage 1, the common literacy needs of the CM students were identified through an assessment analysis. In stage 2, a combination of several strategies was implemented to assist students in different literacy areas. In stage 3, the observations of the effectiveness of these strategies were discussed.

Overall, it was identified that clear instructions, detailed marking rubrics and the annotated exemplars were widely used by the students to avoid topic deviations and some common literacy weaknesses. However, use of other strategies such online modules, videos and quizzes were not effectively used by certain students. The reason could be due to the flexibility offered to the students in terms of engaging with them. The students were encouraged and directed with frequent reminders at the lecturers and the tutorial classes, but were given the option and responsibility to engage with them on their own time. These self-learning activities were not assessed and included in the final unit grade. Hence, the students who generally do not engage with the units only focused on the immediate assessment targets and often failed to see the long-term benefits of additional learning activities for their future academic and professional roles. Therefore, to obtain better results, it is recommended that the student participation be assessed on using these strategies. Further, more awareness and training are needed for students to confidently use them.

A limitation of this case study is it evaluates effectiveness of the strategies qualitatively based on participant observations and fails to offer quantitative data to derive firm conclusions. However, further studies over a long period are required to fully understand the effects of the strategies discussed.

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MODEL USES: FOUNDATIONS FOR A MODULAR REQUIREMENTS CLARIFICATION LANGUAGE

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ABSTRACT

Building Information Modelling (BIM) tools and workflows can increase design productivity, reduce construction waste, and improve connectivity of facility operations. To achieve such benefits, model-based deliverables (e.g. model-based cost estimation, construction planning, or asset tracking) first need to be clearly specified by owners/clients and, second, be delivered by supply chain players according to these specifications. While there are many guides, protocols, and standards for defining information content within models, there is little guidance for specifying the uses to be derived from this modelled information. To bridge the gap between what is expected from BIM, and what will actually be delivered, there is a need for a clear and modular 'requirements clarification' language. Based on published research – including a framework, conceptual ontology, and competency model – as well as on-going practical applications, this paper introduces the Model Uses concept, comprising a Model Uses Taxonomy and a Model Uses List. Model Uses are the intended, planned, or expected project deliverables resulting from generating, collaborating, or linking models to external databases. This paper explores the conceptual foundations of Model Uses and then provides practical examples – an implementation task list and an assessment module - of how this modular language assists in identifying BIM project requirements and facilitating project delivery.

Keywords: Building Information Modelling, Model Uses, Knowledge Blocks, Modular Language

INTRODUCTION

There is a growing disparity between the different types of BIM guides, protocols and standards covering information exchanges throughout a project's lifecycle. On one hand, there is a variety of competing schemas for defining information content at object/element scale – e.g. Levels of Development, Levels of Detail, and Levels of Information (USACE, 2007) (BIMforum, 2016) (DBW, 2016) – and information management specifications for design, construction and post-construction activities - e.g. PAS1192-2:2013 (BSI, 2013) and COBie (East, 2013). On the other, there are only a few guides covering the pre-definition and post-measurement of project outcomes. To help address this imbalance, this paper builds upon available literature and earlier research to introduce the Model Uses *concept*, *taxonomy* and *list*. Model Uses are the "intended or expected project deliverables from generating, collaborating-on and linking models to external databases" (BIM Dictionary, 2016). Acting as a *knowledge block*, each Model Use represents a set of predefined requirements, specialised activities and specific project outcomes, grouped together under a single heading so they can be easily specified, measured and learned. In combination with other knowledge blocks (e.g. Competency Items and Defined Roles), Model Uses provide a foundation for the development of a Modular Requirements Clarification Language, a performance-centric approach to services' procurement and project delivery.

Definition

As a concept, Model Uses is a major reinvestigation and a practical expansion of the 'BIM Uses' taxonomy, a "method of applying Building Information Modeling during a facility's lifecycle to achieve one or more specific objectives" (Kreider & Messner, 2013, p.6) (NBIMS, 2013), and of 'BIM Outcomes', "the possible desired results to be obtained from the application of BIM" (ISO/TS 12911:2012, p.11). While the two terms Model Use and BIM Use are applied interchangeably across industry, Model Uses – as defined in this study – represent a *conceptual departure* from BIM Uses and an *umbrella term* covering multiple industries and their varied model-based use cases. This adoption of the Model Use term arises because:

- The acronym 'BIM' in the United States often refers to the Building Information *Model* while – in Australia, the United Kingdom and many other countries - it consistently refers to Building Information *Modelling*. Since the term is intended to describe the relationship between the *user* and the *product* (the model), *Model Use* is less ambiguous;
- Unlike BIM Use, the term *Model Use* is not exclusive to the construction industry and can be applied to Geographic Information Systems (GIS - e.g. Urban Modelling), Product Lifecycle Management (PLM - e.g. Sheet Metal Cutting) and similar information systems;
- The term *Model Use* is semantically connected to *Model View* and *Model View Definition* (ISO 29481-1:2010, p.32); and

- The term *Model Use* has recently been adopted by the same research colleagues who popularised the term BIM Use (Kreider and Messner, 2015).

It is also important to differentiate between *Model Uses* (what is planned or requested) and *Model-based Deliverables* (what is actually delivered). That is, "deliverables and BIM uses [Model Uses] are two sides of one coin – BIM uses represent the tool or process – deliverables represent the output" (NATSPEC, 2014, p.6). In essence, Model Uses translate quantifiable project requirements (input) into measureable project outputs.

To avoid confusing Model Uses (e.g. Clash Detection, Thermal Analysis, and Relocation Management) with Model-based deliverables, the latter will be suffixed with a *Delivery Format* (e.g. Clash Detection *Report*, Thermal Analysis *Chart*, and Relocation Management *Animation*).

Benefits sought from defining Model Uses

This study is intended to set the scene for the introduction of a *Modular Requirements Clarification Language*. Such a language would facilitate communication between industry stakeholders and contribute to the reduction of project complexity by:

- Identifying project requirements and deliverables to be included in Requests for Proposals (RFP), Employer's Information Requirements (EIR) and similar;
- Assessing individual competency and organisational capability against predefined performance targets;
- Defining Learning Outcomes by identifying the competency sets embedded within each Model Use, Document Use, and Data Use; and
- Bridging the semantic gap between interdependent industries and information systems - Construction (BIM), Geospatial (GIS) and Manufacturing (PLM).

Available Model Use lists

There are a number of Model Use lists currently available. Below is a partial list of *Noteworthy BIM Publications* (Kassem, Succar and Dawood, 2015) reviewed as part of this study – in chronological order:

(1) **PENN State BIM Project Execution Planning Guide** (2010): 25 well-defined BIM Uses mapped to four phases. This classification was adopted by the **US National BIM Standards v3** (2015). Also in 2015, Kreider and Messner published the **Model Use Ontology** with *Model Use* replacing the *BIM Use* term without providing a conceptual justification;
(2) **VA BIM Guide** (2010): 19 Requirements for using BIM, only 10 defined;
(3) **PD ISO/TS 12911-2012** Framework for building information modelling (BIM): a list of generic Outputs (e.g. drawings, reports, animation);
(4) **New York City BIM Guide** (2012): 15 well-defined BIM Uses;
(5) **Finland COBIM Standards** (2012): 12 loosely defined 'common BIM requirements' across phases;

(6) **Massport Authority BIM Guide** (2014): 51 well defined BIM Uses; and
(7) **The Port Authority of NY & NJ** (2015): 38 BIM Uses – none defined.

These publications are significant contributions to this topic, and collectively provide a solid basis for this study. However, to enable the development of a flexible Model Uses Taxonomy and a comprehensive Model Uses List, a number of identified limitations must be first addressed - including:

- The *small number* of identified BIM Uses / Outputs in these collective efforts cannot represent all model-based deliverables across design, construction, and operation. For Model Uses to support a Modular Requirements Clarification Language, they need to address all possible activities and outcomes;
- The *similar names* of BIM Uses which may cause confusion. For example, 'Phase Planning (4D Modeling)', '3D Control and Planning', and 'Programming' – as in NBIMS (2015) – will need to be further differentiated;
- The *inflexible association* of BIM Uses with specific asset lifecycle phases. Model Uses can apply across multiple phases – especially within high BIM capability organisations and project teams (Succar, 2010);
- The *lost opportunity* to link BIM Uses / Project Outputs to roles, learning outcomes, performance metrics, and individual competencies; and
- The *conceptual ambiguity* and *isolation* of these efforts. Few of these noteworthy publications have clear conceptual origins or from part of a larger conceptual structure. The conceptual ambiguity inhibits the expansion of available lists and the conceptual isolation prevents the generation of relations between Model Uses and other concepts (e.g. with Competency Items).

The above limitations are significant and have thus been addressed during the development of a new Model Use concept.

DEVELOPING A NEW MODEL USE CONCEPT

The process of developing a new Model Use concept was completed in three steps: first, the Model Use term was *conceptually grounded*; second, information represented by Model Uses was *differentiated* from other types of information; and, third, Model Uses were organised into a taxonomy.

Conceptual Grounding of the Model Use concept

Model Uses are a *product of* and an *extension to* the expansive BIM Framework (Succar, 2009). As illustrated in Fig. 1, Model Uses are derived by overlaying three existing conceptual structures:

- The **Tri-Axial Framework** which identifies Model Uses as the *intended* or *expected* model-based *deliverables* [Tri-axial Framework>Fields>Field Components>Deliverables (Model-based Deliverables)];
- The **Competency Framework** which defines Model Use classes according to the nine topics within the Operation Competency Set [Competency

Framework>Competency Hierarchy>Competency Tiers (Domain Tier)>Competency Set (Operation Set)>Competency Topics]; and

- The **BIM Ontology** which identifies the Model Use *concept* as a *knowledge block* [BIM Ontology>Knowledge Objects>Knowledge Set (Knowledge Blocks> Information Uses>Model Uses].

The introduction of Model Uses as a *new conceptual construct* is based on the BIM Framework Conceptual Reactor, a cumulative theory-building approach discussed in Succar and Kassem (2015). The Reactor explains how – by passing through an iterative, three-stage theory-building process (Meredith, 1993) (Meredith, Raturi, Amoako-Gyampah, & Kaplan, 1989) – the BIM Framework can be continuously extended according to evolved research objectives.

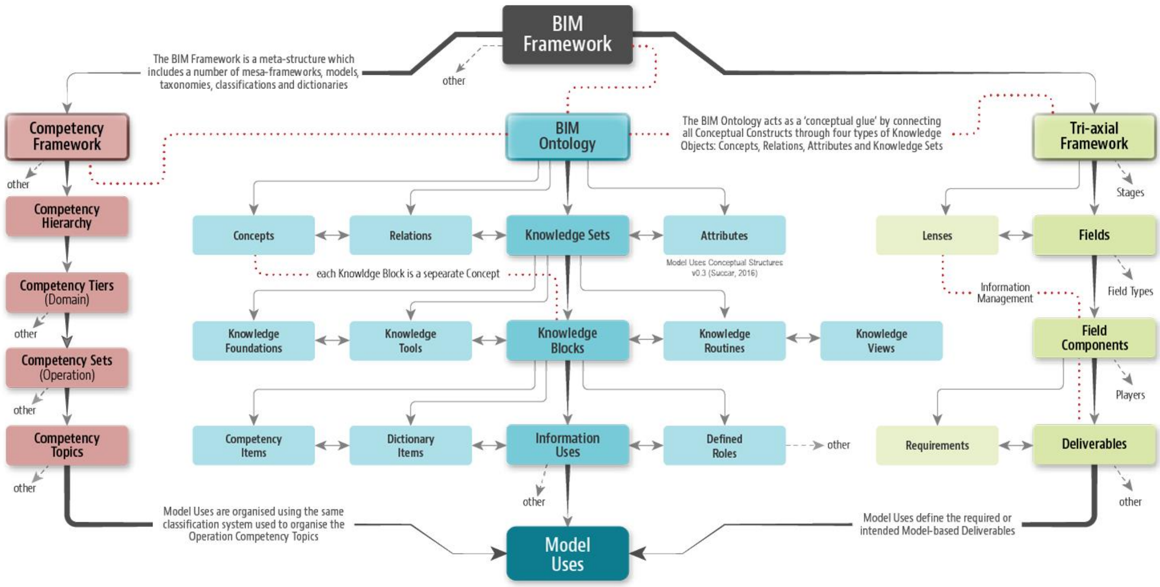

Fig. 1. Conceptual structures underlying the Model Uses concept, taxonomy and list (larger image)

Identifying the Information Represented by Model Uses

For Model Uses to enable the development of a Modular Requirements Clarification Language, it is important to establish what differentiates Model Uses from other types of information generated or captured throughout a project's lifecycle. Using an *Information Management Lens* (Succar, 2009), three main *Project information Types* were identified:

- **Documented Project Information**: project information collated within documents for functional purposes. Documented Project Information are captured and exchanged either manually or through digital means, and are intended for use by the human actor (e.g. drawings, maps and reports);
- **Modelled Project Information**: project information collated within models for functional purposes. Modelled Project Information are generated by the human actor or driven by machine-captured data (e.g. structural analysis and asset tracking); and
- **Structured Project Data**: granular project information *collated within* or *driving the generation of* documents and models. Structured Project Data are inputted by the human actor (e.g. Fabrication Scripting); captured through

sensors and scanners; derived from connected data sources; or generated through machine learning.

These Project Information Types clarify what information is *embedded in* or *exchanged as* **models** (and thus can be represented by *Model Uses*); *embedded in* **documents** (represented by *Document Uses*); or *stored/exchanged as* **data** (represented by *Data Uses*). The remainder of this paper focuses exclusively on Modelled Project Information and introduces a Model Uses Taxonomy for organising this information type.

Organising Model Uses into a taxonomy

To properly represent Modelled Project Information, Model Uses are organised into a conceptual structure that follows six guiding principles:

Principle 1: accuracy of representation, the taxonomy carefully delimits the definitions and thus overall number of Model Uses: if the number is too small, definitions would be wide and imprecise; and, if the number is too large, definitions would overlap and cause confusion.

Principle 2: flexibility of use, Model Uses are defined for applicability across varied contexts so they can be:

- Equally applied across markets;
- Equally applied at any/all project lifecycle phases;
- Equally used for service' procurement, capability development, organizational implementation, project assessment and personal learning;
- Flexibly prioritised to suit the varied requirements of each project; and
- Easily assigned to any/all project participants based – not only their traditional roles but - on their proven experience and assessed capability.

Principles 3-6: **clarity**, **coherence**, **extensibility** and **minimal encoding bias**, Noy & McGuinness' criteria (2001) for developing ontologies.

THE MODEL USES TAXONOMY AND MODEL USES LIST

Based on the aforementioned six principles, the Model Uses Taxonomy was developed. It include *three Categories* and *nine Series* (Fig. 2):

Category I: General Model Uses represent Modelled Project Information applicable across varied knowledge domains, industries, and information systems. General Model Uses are collated within a single Series, General Modelling (1000-1990) and are affixed with the term 'modelling' as a differentiator from other categories - examples [synonyms]:

- 1020 Audio-visual Systems Modelling [Sound Systems Modelling; Video-network Modelling]
- 1420 Temporary Structures Modelling [Scaffolding Systems Modelling; Fence Modelling]
- 1490 Urban Modelling [City Modelling; Precinct Modelling]

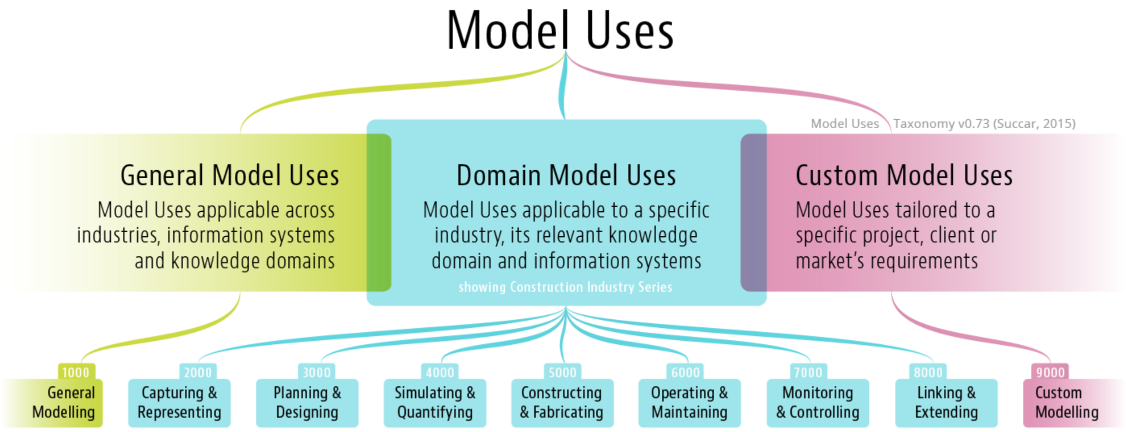

Fig. 2. Model Uses Taxonomy (larger image)

Category II: Domain Model Uses represent industry-specific Modelled Project Information. Table 1 below collates all *Construction Domain* Model Uses into seven Series:

Table 1. Partial Model Uses List (Domain Model Uses - v0.73, Sep 8, 2015)

CODE	MODEL USES	CODE	MODEL USES
Series 2: Capturing and Representing (2000-2990), *synonyms not listed*			
2010	2D Documentation	**2060**	Photogrammetry
2020	3D Detailing	**2070**	Record Keeping
2030	As-constructed Representation	**2080**	Surveying
2040	Generative Design	**2090**	Visual Communication
2050	Laser Scanning		
Series 3: Planning and Designing (3000-3990), *synonyms not listed*			
3010	Conceptualization	**3070**	Lift Planning
3020	Construction Planning	**3080**	Operations Planning
3030	Demolition Planning	**3090**	Selection and Specification
3040	Design Authoring	**3100**	Space Programming
3050	Disaster Planning	**3120**	Urban Planning
3060	Lean Process Analysis	**3130**	Value Analysis
Series 4: Simulating and Quantifying (4000-4990), *synonyms not listed*			
4010	Accessibility Analysis	**4140**	Reflectivity Analysis
4020	Acoustic Analysis	**4150**	Risk and Hazard Assessment
4030	Augmented Reality Simulation	**4160**	Safety Analysis
4040	Clash Detection	**4170**	Security Analysis
4050	Code Checking & Validation	**4180**	Site Analysis
4060	Constructability Analysis	**4190**	Solar Analysis
4070	Cost Estimation	**4200**	Spatial Analysis
4080	Egress and Ingress Analysis	**4210**	Structural Analysis
4090	Energy Use	**4220**	Sustainability Analysis
4100	Finite Element Analysis	**4230**	Thermal Analysis
4110	Fire and Smoke Simulation	**4240**	Virtual Reality Simulation
4120	Lighting Analysis	**4250**	Whole modular Analysis
4130	Quantity Take-off	**4260**	Wind Studies
Series 5: Constructing and Fabricating (5000-5990), *synonyms not listed*			
5010	3D Printing	**5050**	Construction Logistics
5020	Architectural Modules Prefabrication	**5060**	Mechanical Assemblies Prefabrication
5030	Casework Prefabrication	**5070**	Sheet Metal Forming
5040	Concrete Precasting	**5080**	Site Set-outs

CODE	MODEL USES	CODE	MODEL USES
Series 6: Operating and Maintaining (6000-6990), *synonyms not listed*			
6010	Asset Maintenance	**6050**	Handover and Commissioning
6020	Asset Procurement	**6060**	Relocation Management
6030	Asset Tracking	**6070**	Space Management
6040	Building Inspection		
Series 7: Monitoring and Controlling (7000-7990), *synonyms not listed*			
7010	Building Automation	**7030**	Performance Monitoring
7020	Field BIM	**7040**	Real-time Utilization
Series 8: Linking and Extending (8000-8990), *synonyms not listed*			
8010	BIM/Spec Linking	**8050**	BIM/IOT Interfacing
8020	BIM/ERP Linking	**8060**	BIM/PLM Overlapping
8030	BIM/FM Integration	**8070**	BIM/Web-services Extension
8040	BIM/GIS Overlappping		

CATEGORY III: Custom Model Uses represents a mixture of *General* and *Domain* Model Uses to reflect any custom project requirements. Custom Model Uses are collated within a single Series, Custom Modelling (9000-9990) - examples:

- 9XXX Modelling of floating sculpture with wave-powered signal beacon
- 9YYY Modelling security systems for a correctional facility
- 9ZZZ Modelling ventilation systems for an astronaut staging station

The current Model Uses List includes 125 items (download full list from BIMexcellence.org/model-uses) reflecting current abilities of software solutions. Future iterations may incorporate additional items and/or updated descriptions following the relevant advances in technology and the evolving expectations of industry stakeholders.

A Note on Model Use Validation

The Model Uses List was developed by collating BIM Use definitions from publicly available sources and then organising them through the Taxonomy. Nine international subject matter experts were invited to review the model; eight offered their written commentary. The List was refined based on this commentary which was then anonymised and redistributed to the experts. To test usability, Model Uses were collated into online assessment modules (BIM Excellence, 2016) and embedded within an Employer's Information Requirement (EIR) document. Additional comments were sought and addressed before the Model Uses Taxonomy and List were published as a peer-reviewed blog-post (BIM ThinkSpace, 2015). While this validation process is both lengthy and laborious, the feedback received proved instrumental in improving Model Use definitions and the Model Uses List. Continuous testing and calibrations are being conducted with Model Use definitions subjected to public scrutiny through the BIM Dictionary (2016) which provides an opportunity to place commentary on each term.

PRACTICAL APPLICATIONS OF MODEL USES

After introducing the Model Uses concept, Taxonomy and List, the following sections demonstrate the practical applicability of Model Uses through a sample *Implementation Task List* and a *Performance Assessment Module*.

Model Use as an Implementation Task List

Each Model Use represents an *intended* set of project outputs from generating or exchanging Modelled Project Information. To deliver each output set, multiple activities need to be conducted. These activities are either unique to each Model Use or common across multiple Model Uses. Table 2 is a sample Model Use Implementation Task List collating a subset of common tasks. These tasks can be allocated to individuals, mapped against project milestones, or – as shown below – grouped according to organisational *Performance Improvement Phases* (Succar, 2016):

Table 2. Model Use as an Implementation Task List – Clash Detection used as an example

I		**SCOPING PHASE** - activities include:
	a	Establish if [**Clash Detection**] is applicable for this {Project Type}
	d	Establish if [**Clash Detection**] is required for this project
	c	Establish the relative priority of [**Clash Detection**] for this project
	d	Establish who is the {Responsible Party} to conduct [**Clash Detection**]
II		**ASSESSMENT PHASE** - activities include:
	a	Assess if the {Responsible Party} has the ability to conduct [**Clash Detection**]
	b	Assess the quality of the [**Clash Detection**] delivered by {Responsible Party}
III		**ANALYSIS PHASE** - activities include:
	a	Analyse whether [**Clash Detection**] abilities match Clash Detection {Requirement}s
	b	Generate a *Proceed*, *Pause/Clarify*, *Stop/Modify* or *Abort* [**Clash Detection**] {Request}
IV		**PLANNING PHASE** – activities include (not in order):
	a	Select the software application suited for conducting [**Clash Detection**]
	b	Gain access to model(s) in the format necessary for conducting [**Clash Detection**]
	c	Prepare model(s) or part model(s) for [**Clash Detection**] – sample tasks:
	c1	Delete/purge/turn-off non-mission critical parts; and
	c2	Open/import/collate model(s) into [**Clash Detection**]{Software Application}
	d	Define target components/systems for [**Clash Detection**] (select set, load filter…)
	e	Identify target results for [**Clash Detection**] – examples:
	e1	Spatial, geometrical or semantic; or
	e2	Drawings, Details, Quantities, Specifications or Analytical Data
V		**ACTING PHASE** - activities include (in chronological order):
	a	Execute the [**Clash Detection**] {Program} {Script} {Extension}
	a1	Check for redundancy and errors; and
	a2	Remove/isolate redundancy and errors
	b	Generate [**Clash Detection**]{Report}
	c	Communicate [**Clash Detection**] results
VI		**MEASURING PHASE** - activities include (not in order):
	a	Confirm workflow for next round of [**Clash Detection**]; or
	b	Refine process for next round of [**Clash Detection**]
Note: [Clash Detection] can be replaced with other Domain Model Uses		

Model Use as a Performance Assessment Module

A comprehensive Model Uses List provides an expanded opportunity to assess the performance of organisations against specific Model Uses

(Alaghbandrad, April, Forgues, and Leonard, 2015). An assessor can use this List to: **First**, identify one or more *target* Model Uses, each representing a set of expected project deliverables. **Second**, an assessor can evaluate the ability or performance of project participants – organisations, individuals or teams - against each Model Use. For example, below are six sample assessment questions (BIM Excellence, 2016) using Cost Estimation as a sample Model Use:

- Are you experienced in conducting [**Cost Estimation**] on {Project Type}?
- How many Cost Estimates have you completed over the past {Period}?
- What BIM Software Tool(s) were used to conduct [**Cost Estimation**]?
- Do you have documented processes for performing [**Cost Estimation**]?
- What are the Standards, Protocols and Classification Systems followed when performing [**Cost Estimation**]s?
- What [**Cost Estimation**] {Document Types} do you deliver at {Phase X}?

Third, the assessor generates a report identifying/comparing the abilities or performance of projects participants; as exemplified in Fig. 3:

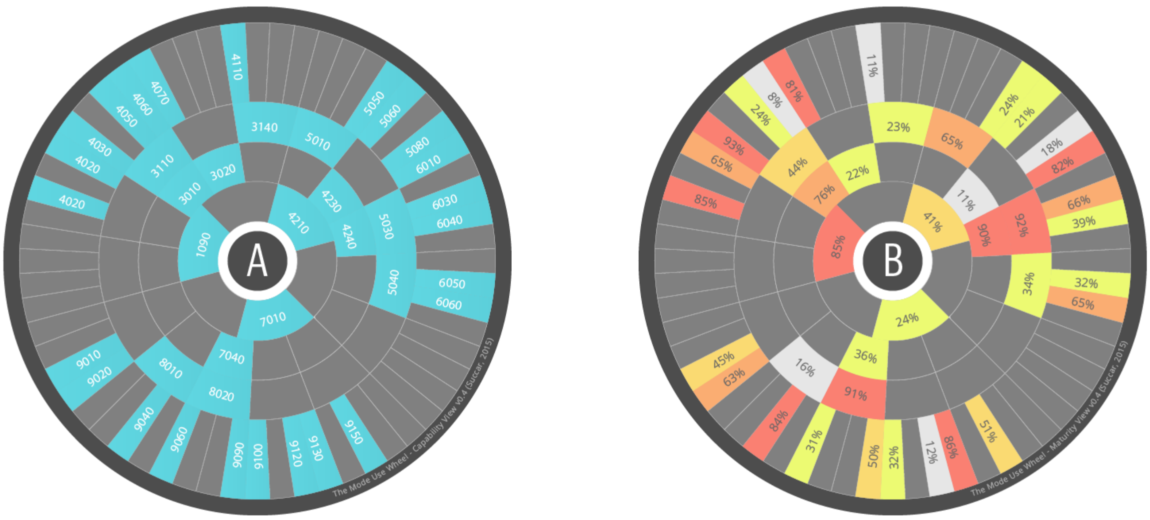

Fig. 3. Model Uses Wheel – target requirements (A) verses assessment results (B) – larger image

The Model Uses Wheel (Fig. 3) is a visual summary of assessment results:

- The cells in **Wheel A** identify *target* Model Uses selected by the assessor
- The cells in **Wheel B** provide a visual summary of *assessment results*
- Assessment results vary from *Low* (0-20%); *Medium-Low* (21-40%); *Medium* (41-60%); *Medium-High* (61-80%); to *High* (81-100%)
- Depending on the assessment type, the results may reflect either the *Maturity Level* of an organisations or project teams (Succar, 2010); the richness of Modelled Project Information; or the *Competency Level* of an individual or group (Succar et. al, 2013).

The partial questions list and sample chart exemplify how the Model Uses List - when combined with target-specific metrics – enable a wide range of assessments and - by extension - the development of learning programmes and certification regimes.

CONCLUSION

This paper introduced the Model Use concept and Model Uses Taxonomy as a *product of* and an *extension to* the expansive BIM Framework. A Model Uses List was provided and two sample practical applications were demonstrated: Model Use as an Implementation Task List and Model Use as a Performance Assessment Module. Model Uses – in conjunction with other *knowledge blocks* (e.g. Competency Items and Defined Roles) - lay the foundations for a Modular Requirements Clarification Language that enables the translation of project goals into granular requirements; comparison of project requirements with actual deliverables; and conducting multiple types of interconnected performance assessments. Current research and future publications will expand this Language by formulating *knowledge routines* (e.g. project workflows) that connects varied knowledge blocks into a performance-centric - as opposed to compliance-centric - approach to BIM services' procurement, information management and project delivery.

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CONSTRUCTION EDUCATION IN AN ARCHITECTURE SCHOOL IN CHINA BASED ON REAL-LIFE PROJECT: FROM VIRTUALITY TO REALITY

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ABSTRACT

The skills shortage in the construction industry in China is exacerbated by a very high demand for students in architecture schools, for construction tradespeople and for architects with a working understanding of how buildings are constructed. This has become a growing problem and an invisible barrier among practitioners, universities and the construction industry in recent years. Students majoring in architecture are familiar with construction drawings, but lack construction-related knowledge to translate these drawings into buildings. In contrast, some construction practitioners are not familiar with the factors that influence design and design processes. This highlights the need for practical construction education in architecture schools. This paper explores the construction teaching practices in an architecture school in China. The Industry-Education-Research Cooperation (IERC) approach involves the construction of buildings rather their representation as drawings. This paper analyses and compares students' efforts in five-year graduate design degrees. It then analyses the benefits of IERC and the differences between it and traditional construction education. This is followed by a discussion of the significance and implications of these approaches to training, teaching and learning about construction. The findings reveal that traditional construction courses have drawbacks including not only formalism, low uptake of knowledge, but also disconnection and gaps between theory and practice, virtuality and reality, drawings and buildings, as well as universities and construction enterprises. The IERC construction education mode is based on real-life projects and is recommended as an approach that benefits universities and the construction industry as a whole.

Keywords: Construction education, real-life project, teaching practice, virtuality to reality

INTRODUCTION

Background

The past decades have witnessed rapid urban development in China. Cities there are facing a high demand for construction activities, especially for housing. This phenomenon highlights a significant demand for skilled construction tradespeople. Given this, Chinese universities have produced many architects who are familiar with design and construction drawings. However, after graduation these individuals sometimes find that they cannot translate design ideas from drawings into real-life buildings. Inexperienced and unskilled architects may make poor decisions and give instructions that result in increased costs and inefficient processes.

Problem description

Architectural education is inextricably linked to construction education. The construction industry is complex and fragmented, involving numerous players, skills, and technologies. Like all other engineering disciplines, construction is an applied field, meaning that its education must centre not only on theory, but on how things get done (Osama et al., 2000). A US survey indicated that engineering education has to reform and it needs a paradigm shift (Leonhard, 2005). However, the dominant pedagogy for engineering education still remains "chalk and talk", despite the large body of education research that demonstrates its ineffectiveness (Mills and Treagust, 2003). Today's engineering graduates are graduating with knowledge of fundamental engineering science and computer literacy, but with little knowledge of how to apply it in practice. The complexity of modern buildings also leads to invisible barriers between architects, builders and project managers. This highlights the need for and exploration of practical construction education in Universities.

Meanwhile, China is facing similar dilemma and what's worse, architectural education in China overlooks construction education. This is because architects generally believe that builders should be in charge of site activities. This has resulted in that the current architectural education system in China attaches great value to design, but little value is placed on construction. As a Chinese architect said "Chinese architectural education largely ignore(s) this. Architects do not concern themselves with how to build the building. It leads to architects' lack of construction experience and ignorance of material characteristics when they conduct design and build activities (Peng, 2010, p.222)".

RESEARCH AIM

Chinese architecture schools have attempted to reform their architectural education gradually. Several design-build courses have been developed to focus students' attention on building rather than on design. However, the outcomes of these courses are unpredictable. There is potential to improve the ways students are taught about construction processes. This exploratory research aims to contribute to a new paradigm shift in construction education and to identify how universities can facilitate construction education for the industry.

RESEARCH CONTEXT

The first author is a PhD student undertaking studies in the Department of Building Science and Technology at Southeast University, China, commencing in 2010. The student was a teaching assistant in traditional design/build courses and the group leader of the five-year real-life design project "Emergency Construction" using the IERC construction mode at Southeast University. The student is conducting the research under the supervision of the second author who is an academic in Department of Building Science.

METHODOLOGY

It is well documented that an insider position or experience is crucial to understanding a community (Thoresen and Öhlén, 2015). This research adopts a phenomenological approach to understand people's perceptions, perspectives and understandings of a particular situation (or phenomenon). A phenomenological research study thus attempts to answer the question "What is it like to experience such and such?" During the data collection phase, the first author reflected on his lived experiences as a participant in construction education activities. Then the first author collected and analysed the comments from stakeholders based on interview surveys and audio/video records. This paper presents findings based on these data.

IERC CONSTRUCTION EDUCATION

Definition

Industry-Education-Research Cooperation (IERC) is not only a new kind of construction course but also a new construction education mode. The IERC mode represents a collegial and cooperative relationship between industry, education and research. Funding is at the core of this mode. The biggest difference between IERC construction courses and traditional build courses is that the learning outcomes are based on real-life buildings. If construction courses require industry funding, the learning outcomes must have commercial value and provide other benefits to industry. For example, industry may benefit by having their profile raised in students' eyes, and thus have opportunities to attract talented students. Furthermore, some academics' research programs dovetail with these courses and allow organisations to share in research outcomes.

Real-life Project

"Emergency Construction" was the first attempt to use the IERC education mode for a graduate design project in architecture school at Southeast University (Figure 1). The purpose of the small building students were required to design and construct was to provide an effective and timely solution to provide housing after a disaster. The objective was to design a shelter that could be delivered to site three weeks after a disaster and could be used for at least one year. Therefore, the house needed to be able to be more readily transported and constructed than permanent houses. It needed to perform better physically than tents as well. Ease of prefabrication, transportation, assembly, use, demolition and reuse were thus of paramount importance. The final learning outcome was a real-life building that was exhibited on campus.

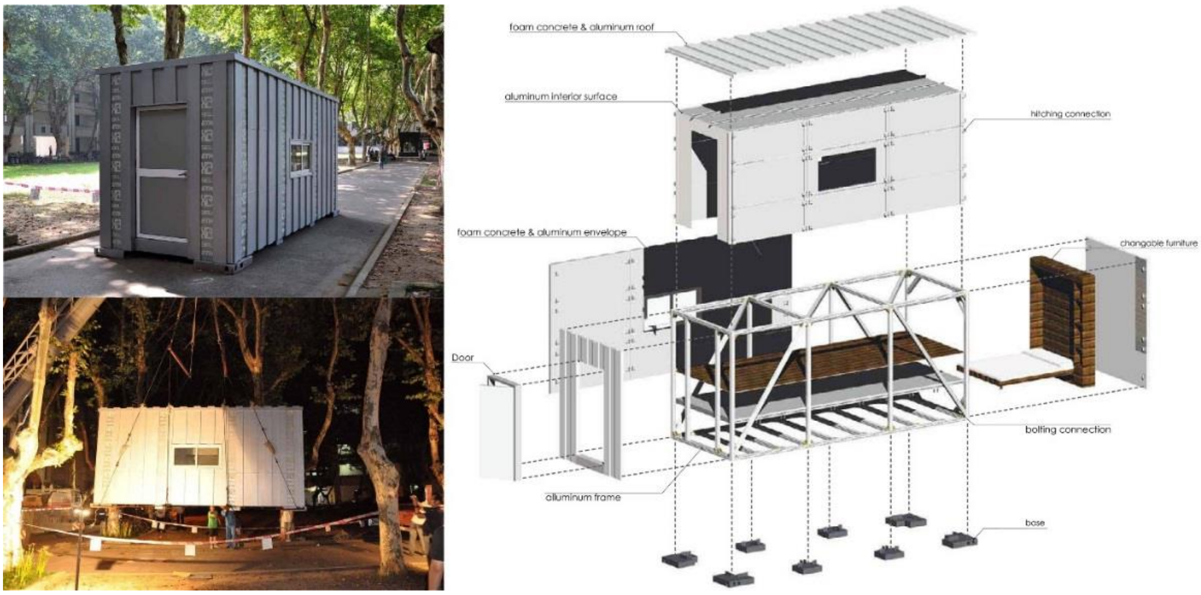

Figure 1 2011 Graduate design project "Emergency Construction"

(Source: Author, 2011)

Based on the aforementioned requirements, aluminium was chosen by students as a structural material. All the prefabricated components of the building were connected with bolts that were tightened with a simple wrench, making it possible for students to assemble the structure by themselves. The envelope system was composed of aluminium panels whose outer skin was aluminium and inner was foam concrete and glass-fibre net. This envelope assembly was the first practical application of a patent resulting from research in the architecture school. The experiences of students in the design/build exercise contributed to this research program as well.

Funding

It was challenging to raise funds for the course the first time. The XinBa Building Decoration and Construction Company had a good cooperative relationship with the architecture school and were approached for assistance. In return for funding the course, the company were offered a partnership with an excellent architecture school that would benefit the company's reputation. In China, public praise means commercial value. In addition, by understanding the expected learning outcomes of the course, the organisation became aware of potential future applications. Finally, the XinBa Building Decoration and Construction Company decided to fund the course. Not only did it provide financial support, the company's own manufacturing factory and skilled construction workers were able to assist. This was a participant of this course as well.

Teaching procedure and building process

There were two phrases of this course. Phase one was taught formally in school via seminars and workshops, whilst phase two was in the XinBa factory. There the teaching mode was practical and experiential.

In **phase one**, students were divided to several groups. Every group (4-5 undergraduates) had a postgraduate as group leader. The groups then developed their own designs based on the aforementioned requirements and with the guidance of teachers in building science and technology. The teachers chose one design that best met the requirements of the exercise. The design included architectural design, materials selection and a technical proposal. This procedure took seven days. The chosen design was submitted to a civil engineer to make sure the structure was safe. The building was then divided into four parts: structure, envelope, interior, and equipment and furniture. Each part was allocated to a group of students ("Structure Group", "Envelope Group", "Interior Group" and "Equipment and furniture Group"). Each group was responsible for detailing, organising and constructing their own work. To facilitate the construction process, groups used parametric software (Revit and Naviswork) to develop their designs from "design drawings" to "building process drawings". This took 14 days. In general, phase one took about 20 days.

Drawings were submitted to XinBa and work progressed to **phase two**. The teaching venue moved from campus to the factory. Here the skilled workers at XinBa first produced prefabricated components with CNC machines based on students' drawings. Students could only watch and reflect on production for obvious reasons. This process lasted four days. After production, every group assembled their part of the building with the assistance and guidance of skilled construction workers. This process took seven days. Finally, the building was delivered by a container-truck from the factory to the campus. A mobile crane was used to position the building for exhibition. After exhibition, the building was delivered back to the XinBa factory for future application and promotion.

Workplace health and safety considerations were a major consideration on this course. Before phase two, the school insured all students. In the workplace, every group was equipped with one skilled safety guard from XinBa to ensure students' safety.

RESULTS

Comments from stakeholders

The teachers perceived that this graduate design project, based on real-life building, had profound significance for construction education in China. An academic in School of Architecture at Southeast University commented:

> *"I think there were two significances of it. The first one was the significance for green construction technique. This building was a positive attempt to adopt off-site manufacture technique developed by students and teachers in university. The second one was the significance for construction education in universities. It was my first time to see the students attending construction courses as real builders across the whole process from drawings to real-life buildings. This building experience would benefit a lot to students and this kind of education activity worth popularizing in other universities in China."*

An undergraduate student attending this construction course said:

> *"Through this course, I felt the gaps between drawings and real-life buildings. As an architect, the drawings should be treated with strict and caution. I should learn knowledge more than design skills in the future."*

From the perspective of enterprise, a manager of a large building materials organisation that supported this project said:

> *"I was glad to see the learning outcomes was the real-life buildings and it was not easy for a university. We can seek for more cooperation opportunities in the future."*

Benefits and learning outcomes

IERC construction education mode (based on real-life projects) presents a model of a "triple-win" construction education approach to architectural education. If the relationship between industry, education and research can be built, the funds provided by industry makes it possible to transfer teaching exercises and activities from simple structures into real-life buildings. Students have opportunities to transform their ideas from drawings into actual buildings. Teachers may also be able to identify additional opportunities for cooperation with industry. Furthermore, the teaching activities provide opportunities for and contribute to academics' research programs and allow industry to share research results. A further spin-off is that PhD students are able to guide postgraduates and undergraduates as teaching assistants (under the supervision of teachers) to improve their professional skills and abilities as organizers and coordinators.

The learning and building process required every group to produce "building process drawings" and to simulate the building/construction process using Navisworks. Drawings needed to be more detailed than the construction drawings normally prepared for academic purposes; they needed to support production, prefabrication, assembly and transportation. Through this process students and teachers became aware of gaps between theory and practice. In many cases students' drawings could not be fabricated or assembled. They became aware that some issues cannot be represented on drawings and were easy to overlook. For example, they were not aware of the need to control manufacturing tolerances to ensure that components could be accurately assembled. Little attention was paid to these issues but when it comes to off-site construction and accurate assembly, architects need to be aware of and cater for these issues.

Of profound importance to this course was that the project leader and workers in XinBa were seasoned construction professionals. They played critical roles that could not be replaced by university academics. They took on the roles of the "masters or teachers" of the groups while the students effectively became "apprentices". This teaching mode is very different from a simple internship on a construction site. The students were real builders instead of passive participants. They updated their "building process drawings" in a timely manner to make sure they corresponded to the building and construction processes actually used. This provided the students with powerful learning experiences of applying their construction knowledge. It helped them to bridge the gaps between digital representations and reality. The exercise was thus practical and experiential.

DISCUSSION

Current construction education in China

Modern architectural education in China is less than 100 years old. The Architecture School at Southeast University was established in 1927, marking the beginning of Chinese modern architectural education history (Gu, 2007). At the beginning of the 20th century, several overseas scholars including Liang Sicheng and Yang Tinbao who studied in the University of Pennsylvania introduced advanced architecture pedagogy to China. They became the earliest founders of Chinese modern architectural education. This pedagogy has played a leading role for decades in China and has profoundly influenced current Chinese architectural education. Although many architecture schools in China now have their own design-build pedagogy, most of them were based on the pedagogy introduced by Liang Sicheng and Yang Tinbao (Ding, 2009).

The Chinese University of Hong Kong was the first to open building courses in 1997 in China (Jiang, 2009). Great emphasis was placed on cultivating students' practical abilities. The courses started as small hands-on exercises to build “full-size construction”. Students were taught to design as a way of rational thinking. This encouraged students to consider more factors when they were building.

Influenced by the course “Building Walls” in ETH Zurich, Southeast University included a “Landmark Design” hands-on course in their teaching plan in 1997. This can be seen as one of predecessors of other design-build courses in China. “Landmark Design” has been the classic course in Southeast University for 18 years and continues to this day. It requires students to maintain a balance between design and build issues. It aims to help students understand the relationship between modelling and structure, as well as modelling and materials.

Although the main teaching goals of these courses were to test and verify the rationales underpinning designs and to make students realize their design ideas by building them themselves, rather than teaching students how to build them, they represent a milestone in the history of construction education.

Limitations and shortcomings

Construction education is being challenged to keep pace with the latest techniques. Most learning outcomes seem to prioritise improving students’ reasoning at the expense of their rational design abilities. From the perspective of construction education in China, architects are still consciously or unconsciously separate from builders. In short, modern architectural education in China can be described as “regarding form but disregarding content, regarding art but disregarding technique, regarding expression but disregarding design (Wang, 2007).” Furthermore, Professor Zhang Hong (personal communication, May 15, 2014) believed that Chinese architecture schools subconsciously hope that their students will develop into master architects rather than outstanding builders. Master architects are well respected in Chinese society and famous architects attract considerable tangible and intangible benefits for individuals and their schools. Master architects attract students who aspire to be future master architects. Naturally, schools of architecture wish the same for their students. Correspondingly, students in architecture school have little interest in construction knowledge (Ding, 2009). As a result, the class distinctions between the artist and the craftsman still exist. Despite architecture schools put great value on building courses, these courses are still weakly positioned compared to design courses. In this context, construction courses have limited appeal.

In addition, current architectural education in China has its shortcomings. (Lu, 2012) Firstly, excessive emphasis is placed on the form structures take. Students focus more on modelling design than learning about construction processes. For example, in the “2014 Hua Chen Construction Competition”, students were required to create models from cardboard. However, ironically, because of the excellent workability of this material, this exercise became one that entertained rather than taught. The main aim was to model unique solutions. All submissions attempted to show their originality. Correspondingly, the assessment criteria for these exercises were largely based on modelling instead of the proper usage of this material and building/construction processes of the structures. They thus simply became additional design exercises that were packaged as construction education. How much real and useful construction knowledge can students actually learn from them? This question deserves serious consideration.

Secondly, traditional architectural education lacks authenticity. For example, most of the learning outcomes delivered by construction courses are usually construction drawings or 1:50, 1:10 and 1:1 construction models. Where physical models are built, they are usually of paper, cardboard, timber and / or bamboo. Even when full-size models are constructed, materials and joint connections do not accurately represent real-life buildings. The models are simply representations which may deepen students' understandings of materials' characteristics, connection details and building/construction processes. Models are simple compared to real-life complex and diverse buildings, and the learning opportunities they provide are obviously limited.

Finally, it is challenging for teachers to guide students in real-life projects and hard for architecture schools to raise funds to support real-life projects. Construction involves complicated systems and engineered solutions. In China, many teachers in architecture schools concentrate on design because the traditional architectural education focus is more on design-thinking than construction knowledge. Teachers are therefore ill-equipped to build projects themselves, let alone to guide their students to build (Li, 2011). Existing faculty lack practical experience, hence are not able to adequately relate theory to practice or provide design experiences (Mills and Treagust, 2003). Moreover, it is extremely difficult to secure funding for real-life projects that serve as leaning outcomes. Consequently the build component of many courses is limited to one or two design issues whose final outputs are not usually physical buildings in any real sense. This restricts learning outcomes to how to solve design issues rather than how to build buildings.

CONCLUSION

Architectural education is inextricably linked to construction education. The two complement each other and rely on each other. It is impossible to see them in an isolated way. The current construction education mode in China has its limitations and shortcomings which is being challenged to keep up with the rapid development of cities and the high demand for skilled tradespeople. To overcome these challenges, the IERC construction mode aims to break the barriers from virtuality to reality. In this model, industry, education and research are interdependent and the three benefit from and with each other. It presents a model of a "triple-win" construction education approach to architectural education. The findings of this exploratory study are limited to a single case study. The positive nature of these findings warrants further investigation. It is recommended that further research into the IERC construction education mode be conducted to verify the aforementioned outcomes and explore their applicability to other universities and countries.

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THE SAFETY PSYCHOLOGICAL CONTRACT

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ABSTRACT

The psychological contract (PC) exists in many guises in many sectors, it has been the subject of extensive research across fields of human resources management, health care and public sector, to name a few. Significantly, there has been little PC research concerning construction safety that is of particular interest to stakeholders and organisations that implement workplace practice notes, guidelines and rules to ensure safety is a priority objective. Growing awareness has provided significant improvements in construction safety, despite this the rate of incidents in construction is higher than in most other industries, often with devastating consequences. Benefit that accrues from existing actions is difficult to assess. Several approaches have attempted to reduce the propensity of accidents, near misses or the like on construction sites with varying success. To establish the existence of a safety psychological contract (SafPC) we examine the extant literature and present a model for future research. At a practicing managerial level this research introduces the SafPC and its relationship with construction safety, it serves to identify several beneficial aspects that in conjunction with a knowledge of factors associated with the SafPC provide enhanced teamwork and potentially refocuses intrinsic motivational factors desirable in a project environment.

Keywords: Construction Safety, Psychological Contract, Safety Climate, Worker Safety Behaviour

INTRODUCTION

Significantly the construction industry in Australia employs over 1 million people representing 9% of the Australian workforce (Safe Work Australia 2014). Safe Work Australia (2014) highlights that over the five years from 2007-08 to 2011-12 a total of 211 construction workers died from work-related injuries. This represents 4.34 fatalities per hundred thousand workers, which is nearly twice the national rate of 2.29. Falling from height accounted for 51 fatalities (18 were falls from buildings, 15 involved ladders and 8 involved scaffolding). Vehicle incidents resulted in 34 fatalities and being hit by moving or falling objects accounted for 29 deaths respectively. In other data serious injury claims in the construction industry are shown to have fallen 38% from 31 claims per thousand employees in 2000-01 to 19.1 in 2010-11. Although falling, this rate remains higher than the rate for all industries that is 12.7. In this period construction body stressing accounted for 34% of claims (muscular stress while handling materials tools and equipment), falls, trips and slips accounted for 26% of claims and being hit by moving objects (falling or moving materials and equipment) accounted for a further 16% of claims.

WORKPLACE SAFETY

Workplace safety is of particular concern to construction stakeholders and all organisations have implemented workplace practice notes, guidelines and rules to ensure that safety is a primary objective. However, the benefit that accrues from existing measures is difficult to assess. Several approaches have attempted to reduce the propensity of accidents, near misses or the like on construction sites with varying success. Table 1 identifies these tactics and provides a commentary on a likely outcome.

Table 1 Some approaches to reduce the propensity of accidents

Tactic	**Commentary**
Negative Tactics	
Safety poster campaigns (Saarela, Saari, and Aaltonen, 1989; McAfee, Winn, 1989).	Posting of feedback indicating how well employees are doing; in relation to areas of safety that are targeted for improvement. Did not make a lasting impact on accident and injury rates
Incentive and reward systems (McAfee and Winn, 1989)	Usually did not reward safe working procedures. Might discourage operatives from reporting accidents, incidents and near misses.
Positive Tactics	
Systematically monitoring safety-related behaviors and providing feedback in conjunction with goal setting and training (McAfee and Winn, 1989)	Demonstrated that safety behavior could be improved.
Safety training (Cooper and Cotton, 2000).	Safety training has been one of the fundamental methods for improving safety. This is based on the assumption that safety training in itself is a good thing, those who know what to do will conduct themselves in a safe manner.

However, importantly to this investigation there is a significant gap concerning the affect that a safety psychological contract (SafPC) has on worker safety behaviour (Walker and Hutton 2006).

With this gap in mind the aim of the investigation is to present significant extant theory on the psychological contract from disciplines other than construction to contextualise a SafPC. Following this the development of a contextual model moves the reader to consider the importance of a SafPC highlighting several constituent parts.

PSYCHOLOGICAL CONTRACT

The term 'psychological contract' (PC) first gained popularity in human resource studies during the 1990s (Guest & Conway, 1997; Rousseau, 1990, 1995; Sparrow, 1998). There has been little attention from construction researchers apart from (Dainty, Raiden, & Neale, 2004), (Raiden, 2009 p.78). (Dainty, 2012 p.258). Beyond this studies centered on the application of the PC in construction have been largely unexplored, with the exception of recent general research on PCs and workplace safety in the construction industry from (Walker, 2010, 2013; Walker & Hutton, 2006), which provides direction to the study.

The basis of the PC relationship within a firm is reciprocity between the organization and employees on the perceived obligations and expectations from one another (Guest, 2002), providing a good fit for the production line facility we have used as the case study. The main theoretical underpinnings of the concept are generally attributed to Rousseau (Rousseau, 1990, 1995) who distinguishes between two types of PC:

1. Transactional contracts: involve specific, monetizable exchanges between parties over a finite and often brief period of time. For example, competitive wage rates and the absence of long-term commitments. (Robinson, Kraatz, & Rousseau, 1994 p.139), and
2. Relational contracts: which in contrast, involve open-ended, less specific agreements that establishes and maintains a relationship. These contracts involve both monetizable and non-monetizable exchanges. For example, inducements in relational contracts characteristically include training and development opportunities and a long-term career path within a firm. (Robinson et al., 1994 p.139)

Both contracts identified above provide a good match for the focus of this research.

What is clear is that as the PC evolves around individual beliefs and perceptions, it is highly subjective and can be particular to each employee (Rousseau, 1995). In essence, the psychological contract constitutes an unwritten agreement between the organization and employees based on mutually accepted promises and obligations among the organization and the employees (Sparrow, 1998).

Slightly adapting the definition provided by Herriot (1997), we define the psychological contract as:

"the perceptions of both parties (organisation and individual) to the employment relationship of reciprocal promises and ***obligations*** *implied in that relationship"*

Another view of the PC as an analytical HR tool to examine complex changes that occur throughout an organization when new employment practices are adopted (safety for example); Sparrow (1998), Rousseau (1998) together with Guest and Conway (1998) suggest the PC is a means to understanding the overall state of the employment relationship within an organization. They argue that the PC should be regarded as a tool through which management can establish and maintain a 'healthy' PC, and that change could subsequently be instituted more easily, with increased levels of commitment and satisfaction (Guest and Conway 1998; Guest and Conway 2004). Guest and Conway (1998) used employee perceptions of trust in management and whether employees felt they were fairly treated to measure the extent to which employees believed that promises made on behalf of the organization had been fulfilled.

In the context of the study, they concentrated not on pinpointing the 'who, what and when' of original promises made; but on confirming that the important outcome was that employees *believed* promises had been made.

THE SAFETY PSYCHOLOGICAL CONTRACT (SafPC)

The construction industry's chronic level of fatalities, serious injury and ill-health appears difficult to change. This has led researchers and practitioners to focus on organizational and social factors, including safety climate, to induce positive change to the industry's poor safety performance (Lingard, Cooke, and Blismas 2010). Safety climate is considered a sub set of organizational climate and is believed to shape workers' behaviour through the expectations they form about an organizations value and reward (Zohar and Luria 2005). In addition, a relationship between safety climate and safety behaviour has been well established in safety research and its consequence are recognized as safety outcomes, which are crucial indicators for improved safety on construction sites. However, surprisingly little is known about the mechanisms by which safety climate influences safety behaviours of individuals in organizations. In this context, "leaders create climate" (Lewin, Lippitt, and White 1939), while Huang et al. (2004) argue supervisors' create a climate for their work groups in a similar way as leaders create climate. If what supervisors 'say and do' are in alignment, it is very likely that supervisor and employee would have a similar interpretation of safety climate (Huang et al. 2014). Although the importance of supervisors to worker safety behaviour has been well-established, the specific behaviours most likely to support subordinate safety outcomes are less clear, especially in the construction industry. Previous studies on supervisors' influence on worker safety behaviour in construction is limited, in the studies undertaken the interpretation of implications of supervisory leadership's affect on worker safety behaviour tends to be simplified (Fang, Wu, and Wu 2015).

Sully (2001) argued that to better understand the relationship between safety behaviour and an individual employee, it is important to understand the dynamics underlying the relationship between employees and their organization. Considering the construction setting, the supervisor is the most influential entity to represent the organization. In addition, they have been shown to develop high levels of physical and psychological closeness with their direct subordinates through bonds that begin to develop during their supervision of employees' day-to-day tasks. These bonds noticeably affect employees' perceptions of their psychological contracts (Bass (1991); Krackhardt et al. (1981); Lee and Taylor (2014)). The psychological contract literature has tended to treat immediate managers exclusively as key agents representing the interests of organizations with respect to the psychological contract between employees and organizations (e.g., Conway and Briner (2002), Robinson and Morrison (2000), Tekleab and Taylor (2003), Lee and Taylor (2014)). Noteworthy to this context, Sully (2001) proposed the psychological contract as means of exploring this relationship, arguing that safety was already based on reciprocity involving a duty of care on the part of the employer and a reciprocal obligation to uphold safety standards on the part of the employee.

Since safety climate is based on the perception of workers (Zohar 1980) and psychological contract is also developed from perceived obligations through the relationship with the supervisor (Rousseau 1990), it can be expected that psychological contract of safety is developed from safety climate and it influences worker’s safety behaviour in the same way that PC influences behaviour of the employees in an organization setting (Walker 2013). Blau (1964) while explaining social exchange theory, argued that if employees perceive that the organization is concerned for their well-being they will develop an implicit obligation to reciprocate by carrying out behaviours that benefit the organization. Evidence suggests that employees may reciprocate the positive experiences they have in an employment relationship by carrying out their core tasks at a high standard and by carrying out citizenship activities (Tsui et al. 1997). In addition, Hofmann and Morgeson (1999) argued that when employees work in an environment in which safety is a concern, they reciprocate by complying with established safety procedures. Considering the distinctive nature of construction and recognising the influence of supervisors and their reciprocal relationship with workers, this research proposes to use psychological contract of safety (PCSaf) as a conceptualisation to examine the relationship between supervisors and workers. This hypothetical relationship summarising the above is shown in Figure 1.

Figure 1 Mediated relationship of psychological contract of safety

One of the major arguments in the PC theory is whether it can be regarded as a 'contract' in comparison to formal contracts that have a stipulated content with clear-cut parameters (Arnold 1996). There are differences between the two contractual concepts, but the similarities are enough to justify the use of the term *psychological contract* (PC), as a signal of the authority it carries in employee relations (CIPD 2003) Sparrow (1998) (Deery, Iverson, and Walsh 2006).

As indicated in Figure 1 a SafPC is a mediator between Safety Climate and Worker Safety Behaviour. Several factors are suggested to build a SafPC with consequential beneficial outcomes related to resilient perceptions of trust; commitment and satisfaction in the workforce (cause); leading to enhanced safety behaviour (affect).

Briefly, trust is a belief that the word or promise of another is reliable with commitment being the proof of trust (Walker & Hampson, 2003). Trusting teams perform in an effective way and they are interested in their colleagues' welfare (Hennig-Thurau & Klee, 1997). Trust between employers and an employee is a prerequisite for empowerment – being one of the aims of the program. Commitment is said to be a long-term conviction to a relationship that will manifest in a positive way (Hennig-Thurau & Klee, 1997). One of the keys to satisfaction is favorable experience and predictability (Doney & Cannon, 1997). The cost of developing trust, commitment and satisfaction can be offset against the often tangible cost of wellbeing associated with safety non-conformance, misunderstanding and dysfunctional behaviours that place strain on safety performance. In addition, there is considerable evidence that suggests relationships remain intact if the parties are continually satisfied (Patterson, Johnson, & Spreng, 1997).

CONCLUSION

After more than 30 years of safety research, it is still unclear how safety climate influences safety behaviour. To address this gap, this research argues that the psychological contract of safety is the key to explain the dynamics between safety climate and safety behaviour, especially in construction. In addition, this research identifies the theoretical formation of the psychological contract of safety arising from safety climate. It proposes a framework to examine the mediated relationship of safety climate and safety behaviour by psychological contract of safety in a construction setting. The implications of this research are useful for managers, supervisors, safety advisors and workers on construction sites, helping to understand how safety activities should be managed and identify the factors that shape worker safety behaviour and safety outcomes. The next stage of the research is to test the proposed mediated relationship of the psychological contract of safety between safety climate and safety behaviour on a mega-construction project in New South Wales, Australia. While exploring the safety climate and safety behaviour studies, this research proposes a model of psychological contract of safety for the construction industry and emphasizes that an examination of this model can lead researchers and practitioners to attain a better understanding of the relationship between safety climate and safety behaviour which is still unclear in a construction context.

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THROWN IN THE DEEP END: WORK READINESS IN THE BUILT ENVIRONMENT

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ABSTRACT

Graduate attributes represent a broad set of skills which students develop during their program of study, and demonstrate upon graduation. Work readiness is a key attribute related to the acquisition of skills and knowledge which enable meaningful contribution to industry, and assist in the transition from student to practitioner. Previous research has considered work readiness from an educator and industry perspective, however there has been less of an emphasis on the student perspective. It is common for students undertaking studies in the built environment to enter industry midway through their program of study, therefore work readiness is required prior to graduation. A reflective approach is applied to the research. A third year student currently undertaking studies and working in the built environment considers work readiness from her lived experience. Findings highlight the fear and uncertainty students experience as they prepare for their transition from university into the work place. A model is presented which considers (i) work-ready characteristics required by students, and (ii) university-based initiatives which underpin development of work-ready characteristics. Work ready characteristics identified in the model are self-confidence, sufficient preparation, smooth transition, and a solid foundation. University-based initiatives are sufficient work integrated learning, staff with industry experience, strong links to industry, and support systems. Inclusion of the student perspective is recommended in future research to identify how universities can assist students undertaking studies in the built environment to be authentically work ready. It is considered this will have benefits for both the student and employers.

Keywords: built environment, graduates attributes, student perspective, work readiness

INTRODUCTION

Work ready students

Graduate attributes represent a broad range of generic skills that students acquire during their program of study. They link to employability skills and program learning outcomes. Work readiness is a graduate attribute, and usually refers to graduates who have completed their studies, and have commenced their professional career. Work ready graduates will have 'participated in learning opportunities to develop the confidence to approach employment with enthusiasm, appropriate knowledge and commitment and will possess the skills and knowledge to develop the ability to contribute to their community and the development of the industry in which they work' (RMIT University, 2015). Current conceptualisations of graduate work readiness lack consensus and different labels are used in the literature to describe the concept. These include: work preparedness, graduate employability, transferable skills, key competencies, and generic attributes (Nettleton, Litchfield and Taylor, 2008; Caballero and Walker, 2010).

Nettleton et al. (2008) identified application of knowledge, communication skills, critical thinking and creative problem-solving, global perspective, and teamwork as the key work ready skills. In contrast, in a review of the literature, Caballero and Walker (2010) identified communication, motivation, initiative, creativity and interpersonal skills as the most frequent skills related to work readiness. Hager (2006) argues that generic graduate attributes go beyond technical skills to also include attitudes, values and dispositions. The various combinations of attributes and skills that a graduate applies in different contexts can be referred to as capabilities.

Kramer (1974) first introduced the term 'reality shock' in relation to the experience of new workers transitioning into a work environment. Reality shock is described as "…the specific shock like reactions of new workers when they find themselves in a work situation which they have spent several years preparing for and for which they thought they were going to be prepared, and then suddenly find they are not" (Kramer, 1974, p.p.viii). Transition from university to work is often characterised as being highly stressful for students (Davis, 2010). The challenges experienced by students include time demands and constraints, feelings of isolation and bewilderment, and general stress (Maute, 2007). It has been argued that universities should prepare students for the general pressures felt by those new to the workplace (McNamara et al., 2011).

Combining work and study in the built environment

Curtis and Williams (2002) write of the 'routinisation' of students combining paid work and study, suggesting that this is now the norm. It is common for students in the built environment to commence their professional career while undertaking their studies. For example, Lingard (2005) found that hours spent in paid employment were at least as long and, in many cases, were in excess of hours spent at university for undergraduate property and construction students. Similarly, Forsythe and Zou (2006) found that 62% of undergraduate construction management students were undertaking paid work, and 41% worked in their chosen discipline. The work commitment increased in the latter years of study whereby 3rd year students were averaging 26 hours of work per week whilst concurrently undertaking full-time study, and 4th year students were averaging 38 hours per week.

Preparing for success in the work place

Research conducted by Savage, Davis and Miller (2010) on Built Environment and Design education found that final year students considered the critical qualities for success in the workplace to be inter-personal, social and communication skills. Students also identified humility, leadership, and teamwork as important skills. It is not clear however, whether these students were undertaking concurrent work and study activities. The research also identified that 'University plays a crucial role in ensuring graduates develop lifelong learning skills and attributes that can carry them onto a long and fruitful career, however, professionals and students did not feel universities were doing enough to ensure this development occurred' (Savage et al., 2010, p.103). While the research goes some way in understanding the perceptions of students and what they consider to be important skills for success in the workplace, more research is required to better understand how students undertaking studies in the built environment can be authentically work ready.

RESEARCH AIM

It is common for students in the built environment to commence their professional career while undertaking their studies. It is not well understood, however, if these students feel work ready and adequately prepared to contribute to their employer. This exploratory research aims to contribute to our understanding of the work readiness of this specific student cohort, and to identify how universities can facilitate work readiness for these students.

RESEARCH CONTEXT

The first author is a student undertaking undergraduate studies in the built environment. The student has completed the penultimate year of her four year program. Since her second year at university, the student has been employed in the built environment. Alongside her studies, the student works for two organisations. In the first organisation the student is employed as a contracts administrator for a property company. In the second organisation the student is employed as a project manager assistant at a project management consultancy. On an average week during the university semester, the student works approximately 20 – 30 hours. The student is undertaking research into the work readiness of students in the built environment, and this paper presents findings from the first stage of the research. The second author is an academic in the built environment, who is supervising the student's research.

METHODOLOGY

It is acknowledged that an insider position or experience is crucial to understanding a community (Thoresen and Öhlén, 2015). Consistent with this premise, the research adopts a phenomenological approach. Phenomenological research seeks to understand people's perceptions, perspectives and understandings of a particular situation (or phenomenon). In this research approach, a first-person point of view is applied through the use of reflection (van Manen, 1997). Furthermore, Fook (2011,p.61) advocates critical reflection as a research method, expressing a belief that 'by linking personal learning, research and change possibilities, people are better able to see how research and learning can translate directly into actions, and can also envision how this process might transfer to different settings.'

In the data collection phase of the research, the student prepared a reflection and was guided by the following questions: (1) How did you feel when you commenced your role in the built environment; (2) Did you feel adequately prepared to meet your work responsibilities; and (3) How did university prepare you to meet your work responsibilities. Thematic analysis was applied to the reflection which allowed themes to emerge a priori. Qualitative data from the reflection was independently analysed by two researchers who agreed on the emergent themes, thereby ensuring inter-rater reliability (Ballinger, Yardley and Payne, 2004).

RESULTS

Upon initially entering the workplace, self-doubt and lack of self-confidence emerged as a prominent experience for the student. Support from the workplace and the university were considered important in assisting the student to overcome the initial discomfort of entering the workplace, as well as assisting in building enduring self-confidence. Having industry knowledge as well as the capacity to translate learning into practice were also considered important in the successful transition from university into the workplace.

Self-doubt and lack of self-confidence:

Prior to and in the early stages of working in industry, there was a fear of being thrown in the deep end. The student explains: "*What I feared most was being thrown in the deep end. I know I wasn't alone, that I was surrounded by a team of people who would be able to offer their assistance, and yet I still felt like I was a little out of my depth*". Together with this fear, there were feelings of self-doubt and lack of self-confidence. These feelings arose from being unsure of expectations: "*I wasn't sure what was expected of me; what was I supposed to do? Am I asking too many questions? Should I get someone to look over this?*". The student reflected on her academic success and how this translated into the workplace: "*There was little relationship between my confidence in academic success and my anticipation of success in the workplace. While I am a HD student, I still found that I lacked the confidence I needed to believe that I could excel in the workplace*". This finding is consistent with previous research which acknowledges that students transitioning into the workforce will experience negative feelings such as pressure, stress, and bewilderment (Maute, 2007; Davis, 2010; McNamara et al., 2011).

Support from the workplace and university

In order to overcome initial feelings of self-doubt and lack of confidence in the workplace, support from both the workplace and university were considered important. In relation to support from the workplace, the student explained: "*I would have loved for someone to pull me aside and tell me that I was doing okay; it was almost as if I needed reaffirmation that I was doing the right thing, that I was fitting in*". The student acknowledged that a supportive supervisor had played a key role in this transitional stage: "*My supervisor was extremely supportive of me and eager to help or address any uncertainties. I think having this person really helped make it easy for me to settle into my position*". Given that the student was combining work and study, there was also a perception that the university played an important role in assisting the student to succeed in the workplace. In particular, lecturers with industry experience were valued by the student: "*I could go to a lecturer that has had industry experience with a query I had regarding an issue at work and be confident in their advice, as essentially they have been in my shoes before*". The findings suggest that support from the workplace and university can assist students to build self-confidence. This is important as self-confidence has been identified as a personal quality linked to work readiness (Knight and Yorke, 2003).

Industry knowledge

The student perceived that knowledge of the built environment was critical in assisting her to successfully transition into the workplace. The key sources of knowledge originated from curriculum which incorporated industry based problems, as well as lecturers who had industry experience and integrated this into the curriculum. In relation to industry-based problems, the student commented: "*I found that classes which encouraged me as a student, to apply my learning to industry based scenarios and problems helped me to better see the connection between study and industry and truly helped in preparing me for working in the industry. This increased my confidence in my personal abilities to tackle the problems that I would face in industry*". Together with this, the student explained how lecturers assisted in acquiring industry knowledge: "*I felt that the lecturers who drew upon their experience in the industry boosted my confidence in our ability to contribute in our industry communities, by giving us an insight into what industry is like*". Furthermore, the student explained: "*Lecturers with industry experience helped to prepare us for work, in that they taught us what to expect in industry*".

Capacity to apply learning in to practice

When considering how knowledge learned at university could be translated into practice, the student commented: "*I realised that applying your learning within the four walls of university is different than trying to apply the same knowledge in your career*". The student acknowledged that the knowledge she had acquired from university had been applied at work. For example, the student explained*: "I was able to directly see how I had applied what I had learnt in Leadership in Project Management to the real life industry scenario"*. The scenario related to ethical practice and informed the student's decision making process. Casner-Lotto and Barrington (2006) and Hart (2008) identify ethical judgement and responsibility as a skill which contributes to work readiness. The student gave another example related to the process of completing assignments: "*At university, you have to study set content and complete your assignment to a specific criteria. At work, I thought that there would be no set way to do things, that I'd have to figure it out on my own, and while there was flexibility, there was also structure in place*".

Upon entering the workforce, the student had felt pressure to apply learning to practice and to prove herself 'worthy'. The student explained: "*All of a sudden it feels like you have to grow up and start contributing to your workplace, to add value to your employer. I guess I didn't feel like an asset, I felt like there was so just so much to learn, that I had a while to go before I could make a real difference*". On reflecting on her early experience in the workforce, the student acknowledged that her expectation of "being productive" may have been misaligned with her employer's expectation: "*Now, I look back and I see how I was making a difference from the very beginning. It was just not exactly what I expected. And I know you can't go in and be given charge of a project straight away*".

DISCUSSION

Results indicate that work readiness is not a capability that students can develop alone. Instead, university plays a key role in preparing students for success in the workplace (Litchfield, Frawley and Nettleton, 2010; Savage et al., 2010). In the built environment, it is common for students to combine work and study. However, this presents a challenge for universities who predicate work readiness based on the completion of a program of study. Universities must consider how they can support this particular student cohort to be adequately prepared for working in industry. An integral component of preparing these students for a positive experience in the workplace is to engage them in the conversation. In doing so, universities will be well positioned to support these students to be equipped to thrive in professional employment.

Importantly, the study explored the lived experience of a student undertaking work and study in the built environment. Based on this experience, the student developed a model of work readiness. The model incorporates work-ready characteristics required by the student and university based initiatives which underpin development of work-ready characteristics, and is consistent with definitions of work-readiness which refer to the skills and knowledge required to develop the ability to contribute to the professional community and the development of the industry in which they work (RMIT University, 2015).

Key components of the work-ready model are summarised in Figure 1. The grey blocks signify the key components that students require in order to feel work ready, and the white blocks signify initiatives that universities can implement or continue to provide to foster the key components in their students, thus better positioning them to be work ready. The student likens the model to a Life Buoy and considers that application of the model will alleviate the "fear of being thrown in the deep end". The model provides a means for understanding work readiness from a student perspective, and suggests how universities can position themselves to cater for the development of work readiness in their students and graduates.

Figure 1. Work ready model

Work-ready characteristics of students

The four key components which students require to feel work ready are:

Self Confidence: Students have confidence in their ability to contribute to the workplace (Knight and Yorke, 2003). Self-confidence is founded on having the skills required for the job, a positive attitude, motivation, and willingness to perform. This is underpinned by technical knowledge and workplace support.

Sufficient Preparation: Students are well prepared for the industry in which they will be part of and contribute to (RMIT, 2015). They understand how the industry functions, the key issues influencing the industry, and where their role is situated within the industry.

Smooth Transition: Students will develop a pathway from university to industry. This entails choosing a profession, acquiring the relevant skills and knowledge, and planning entry into the workforce. This will help students combat 'reality shock,' as identified by Kramer (1974).

Solid Foundation: Students will attain the technical skills required for success in the workplace. They should have an understanding of the skills and practices applied in the specific industry.

University initiatives supporting the development of work-ready characteristics:

Solid Work Integrated Learning (WIL): Universities encourage the integration of industry in academic learning, make reference to industry in learning, and teach what is valued in industry. It has been found that students who engage in WIL are better placed to achieve employment within their preferred field (Orrell, 2004).

Staff with Industry Experience: Students will benefit from being taught by academics with industry experience, who can draw upon their personal experiences in industry to convey to the students what they can expect to find in the workplace.

Strong Links to Industry: Universities should maximise students' exposure to industry by organising career days, networking events, and mentoring. Students benefit from meeting industry professionals and learning about the various roles in industry, about the industry itself, and about typical professional backgrounds and career journeys of professionals.

Support Systems: Universities can offer services which prepare students to make a successful transition from university to industry, as this transition is often characterised as being highly stressful for students (Davis, 2010). This may entail career counselling, industry information sessions, and facilitating an industry mentor to guide them through the transition process.

CONCLUSION

This research focussed on students who concurrently undertake work and study in the built environment. Given that these students are mid-way through their program of study, it is expected that skills and attributes which contribute to work readiness are yet to be fully formed. Previous research on work readiness has focussed on students who have completed and graduated from their program of study, and knowledge has largely been informed by the perspectives of educators and industry with less emphasis on the voice of the student. This research sought to respond to these limitations by exploring work readiness from the perspective of a student who is mid-way through her program of study in the built environment. The findings of this exploratory research are limited by the single-person sample utilised, therefore findings cannot be generalised to the wider student population. Findings outlined in the paper form stage one of a larger research. The next stage of the research will explore each component of the work ready model using a larger sample of students who concurrently work and study in the built environment. Findings from stage two will help to better understand how curriculum design and learning activities can assist students mid-way their program of study to be work ready. Development and implementation of targeted strategies which enable students to be authentically work ready will benefit both the student and industry.

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ERROR MANAGEMENT CULTURE IN CONSTRUCTION SAFETY: A LITERATURE REVIEW

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ABSTRACT

Human errors are generally defined as unintentional behaviours of employees that may lead to negative outcomes in the workplace. As errors are unavoidable in everyday work activities, in recent years, organisations have implicitly or explicitly adopted some shared practices and procedures of respond to the error and its consequences after an error has occurred. The idea of these practices and procedures refer to the concept of error management culture. In construction safety, although human error is identified as a root cause of accidents, error management culture is still not as well known. The aim of this paper is to present a literature review of research on error management culture in the safety domain, identify knowledge gaps, and suggest recommendations for future research. We reviewed the definitions of errors and the related concepts such as error management and error management culture. We also reviewed the dimensions of error management culture. The results of review contribute to the body of knowledge on safety management culture in construction industry. It also suggests that construction companies should incorporate the error management culture into safety management programs.

Keywords: human errors, error management culture, safety, construction

1. INTRODUCTION

Construction is one of the most hazardous occupations worldwide (Brunette 2004). In fact, construction industry comprised about 7% of the workforce in the world, but contributes to 30-40% fatalities (Sunindijo & Zou 2012).

In many studies, unsafe behaviours of workers are identified as a major cause of accidents in construction environment (Heinrich 1959; Hinze et al. 2005). These behaviours are: (i) violations which involve a conscious intention to break the rules that describe the safe or approved method of performing a particular task or job; (ii) unintentional errors caused by distractions, absentmindedness or incorrect knowledge about safety procedure. Violations are found in relation with social-psychological factors such as attitudes, beliefs, norms and practices (Lawton 1998), thus they are more easily prevented (Frese, M & Keith 2015). In contrast, errors are closely related to cognitive failure such information processing and skills (Lawton 1998). Helmreich (2000) argued that errors happen due to human limitations such as fatigue, workload, fear, cognitive overload, poor interpersonal communications, imperfect information processing and flawed decision making. Thus, many scholars assume that human errors are inevitable in workplace environment (Fedota & Parasuraman 2010).

In recent years, organisations have implicitly or explicitly adopted some shared practices and procedures of respond to the error and its consequences after an error has occurred. The idea of these practices and procedures refer to the concept of error management culture. This paper is aimed at presenting a literature review of research on; firstly, the definitions of errors and the related concepts such as error management and error management culture; secondly, the dimensions of error management culture, identify knowledge gaps, and suggest recommendations for future research.

2. BASIC CONCEPTS ON HUMAN ERROR

Many researches on human factor of accident have tried to categorise the type of unsafety acts that people make during task performance (Wickens et al.). It is believed that categorising unsafe behaviours will help to explain the origin of them within the context and provide the measures to prevent them (Woods 2010). The classification proposed by Rasmussen (1983), and Health and Safety Executive (2009) is illustrated in figure 1.

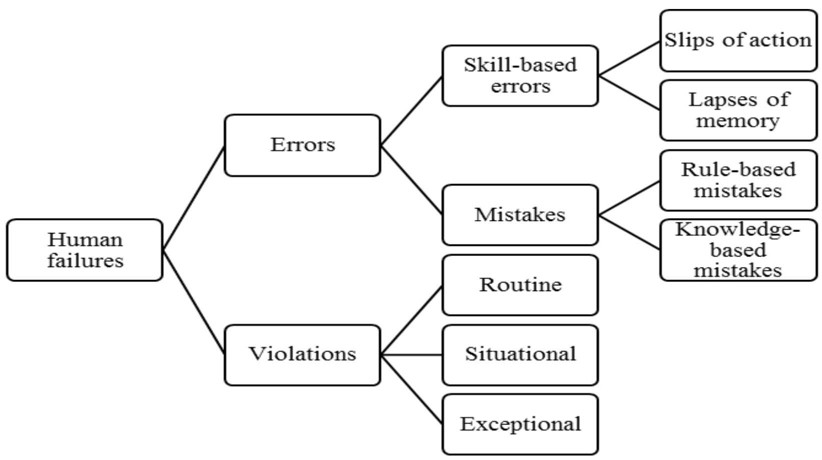

Figure 1: Type of human failure (Health and Safety Executive 2009)

According to Figure 1, there are two types of human failures or unsafe behaviours of workers including unintentional errors and violations.
Unintentional error is an action or a decision which was not intended, involved a deviation from an accepted standard. *Slips* are failures that can be described as implemented actions that were not planned, whereas *lapses* causes operators to forget to carry out actions, to lose the workplace in a task or even to forget what they had intended to do. *Mistakes* are regarded as actions that are incorrect but thought to be correct by the operator carrying them out. In a *rule-based mistake*, operator chooses the incorrect solution to familiar situations due to incorrect rules. In addition, *knowledge-based mistakes* are associated with limitations in human resources and/or incorrect knowledge of the tasks.

Violation is a deliberate deviation from rules, procedures, instructions and regulations. *Routine violations* refer to situations where it has become custom and practice for employees to carry out work activities in ways that are different from those defined in the organisation's operating procedures and guidelines. *Situational violations* refer to situations where procedures and guidelines are disregarded due to working conditions such as time pressure, insufficient staff for workload, unavailable equipment, and weather conditions. *Exceptional violations* are uncommon and occur when something unusual has happened in a process such as during an emergency.

As discussed above, unintentional errors and violations are both deviations from rules, procedures, instructions and regulations. However, violations are different from errors since they involve a conscious intention to break the rules that describe the safe or approved method of executing a particular task; as opposed to errors, which are unintentional made by individuals (Reason et al. 1990). There is also a difference in the psychological pathway to errors and violations. Violations are found in relation with social-psychological factors such as attitudes, beliefs, norms and practices (Lawton 1998). Helmreich (2000) also stated that violations come from a culture of non-compliance, perceptions of invulnerability, or poor procedures. Besides, errors are closely related to cognitive failure such information processing and skills (Lawton 1998). Helmreich (2000) argued that errors happen due to human limitations such as fatigue, workload, fear, cognitive overload, poor interpersonal communications, imperfect information processing and flawed decision making.

In dynamic construction workplace, workers have to adapt continuously with frequent changes in safety knowledge, procedure and methods. Due to the imperfection of psychological capabilities, employees may not quite remember and understand all requirements in the large number of policies and safe work procedures on construction. In addition, many accidents reported that employee who has many years of experience at performing a task can also make unexplained errors (Cañas et al. 2003).

Thus, many scholars assume that human errors are inevitable in workplace environment (Fedota & Parasuraman 2010).

Distinction of errors and its consequences

From a psychological perspective, an error is considered as an action that produces undesired outcomes without referring the nature of its consequence (Homsma et al. 2009). Dyck (2000) argued that the variety of error consequences depends on the situation in which errors happen and that the same errors can result in different negative outcomes. Similarly, in an effort to develop an accident causation model in construction context, Mitropoulos et al. (2005) indicated that errors can create potential for incidents, but do not necessarily lead to accidents. Accident happens once error occurs under the hazardous situations (Mitropoulos et al. 2005). It implies that if errors are detected and corrected or errors occur in a safe environment, accidents will not happen.

From this line of thinking, error should be potential source for learning. For many years, control and learning perspectives have been distinguished and considered to be crucial for long-term success of organisations (Sitkin et al. 1994). Organisations broaden their controls in the way to eliminate errors and its negative consequences in the workplaces (Frese 1991). However, this perspective may prevent organisations from learning since it encourages employees to hide errors. In contrast, under error management approach accept that errors are inevitable in the workplace. Errors give individuals valuable information about how to alter the actions to achieve the goals (van Dyck et al. 2005). Therefore, errors are considered as an opportunity to learn and error management approach is consistent with the principles of organisational learning from errors.

3. ERROR MANAGEMENT CULTURE

Error management approach provides a workplace environment where employees are able to detect errors quickly, report errors, tackle and minimize the negative consequences of errors, and learn from errors to reduce future errors (Brown et al. 1996; Frese 1991, 1995). The organisations practising error management are engaged in exploring how errors occur and discovering the strategies to reduce the likelihood of errors in the future (Guchait et al. 2012). By focus on the positive consequences of errors (e.g., learning), van Dyck et al. (2005) proposed four dimensions of error management practice including learning from errors, thinking about errors, error competence and error communication.

Applying the idea of error management to the organisational level, Dyck (2000) introduced the concept of error management culture. The idea is that members of an organisation can share a system of norms and values as well as common practices and procedures (House et al. 2004) that refer to error management (van Dyck et al. 2005). Employees at all levels of the organisation are appealed to have proactive behaviours such as helping others to resolve errors, communicate openly about errors and learn from errors (Casey & Krauss 2013).

To date, error management and error management culture have been shown to be associated with favourable organisational outcomes such as performance, innovativeness and safety (Keith & Frese 2011). Hofmann and Mark (2006) early perceived error management as one of significant factors of safety climate in nursing sectors. Their findings indicated that a positive safety climate, which involved error management, was considerably related to fewer back injuries and medication errors, and increased patient satisfaction, perceptions of nurse responsiveness, and higher levels of nurse job satisfaction. In construction safety context, Cigularov et al. (2010) is the first empirical study examining the effects of error management in predicting safety performance and outcomes. Their results showed that error management and safety communication are important predictors of safety behaviours and work-related pain. Krauss and Casey (2014) also define error management climate as "employee's perception of the extent to which the organization encourages communication about and management of errors and mistakes in the workplace". They later investigated the relationship between error management climate and other safety concept such as safety communication, safety climate, and safety performance in an international oil and gas company. In firefighting context, the results of Fruhen and Keith (2014) indicate that there is a significant relationship between error management culture and accident occurrence in low and high risk situations. In contrast, error aversion culture which is described as being afraid of committing errors, reacting errors with negative emotion, and likely to cover up errors instead of communicating them to others (Voitker et al. 1999) was found to be positive related to both situations (Fruhen & Keith 2014). These beginning findings of research on error management imply that it is essential to discuss about errors, mistakes of employees and safety incident in complexity workplaces environment (Paul & Maiti 2007). They also raise the question of "what are dimensions of error management culture?"

4. DIMENSIONS OF ERROR MANAGEMENT CULTURE

To measure error management culture, van Dyck et al. (2005) proposed four dimensions: (1) learning from errors (e.g., error is considered as a source for learning) ; (2) thinking about errors (e.g., after error is reported, people try to analyse it); (3) error competence which refer to fixing errors immediately before continuing on with the job; and (4) error communication (e.g., When someone makes an error, he asks others for help or shares it with others so they don't make the same mistake).

Errors learning

The main purpose of learning from errors is improvement activity that reduce the repeated errors or the negative outcomes of error in the future (Carroll et al. 2002). From individual perspective, learning from errors refers to idea of "negative knowledge" which helps to prevent the repeat of errors in the same situations (Gartmeier et al. 2008). Negative knowledge consists of procedural and declarative knowledge related to individuals' performance (Seifried & Höpfer 2012). Thus, negative knowledge is heuristically valuable since individuals can have insight into the reasons for their errors by knowing which way not to perform. The review of Putz et al. (2012) highlighted four stages of errors learning in organisations: (1) error detection, (2) emotion control, (3) error analysis and correction, and (4) dissemination of knowledge.

Error competence

Error competence refers to knowledge or capability of individuals to deal immediately with errors (Rybowiak et al. 1999). Error competence and error learning are different in the term of time-frame. While error learning aims at long-term goal by improving skill, knowledge, attitudes to reduce the possibility of errors in the future, error competence focuses on reducing the adverse outcomes of errors. In construction safety, there are a few studies focusing on teamwork to deal with errors. Mitropoulos et al. (2009) proposed a cognitive model of construction safety which emphasises on three aspects influencing the likelihood of errors in the construction workgroups: (1) workgroup practices, (2) tasks demand, and (3) production practices.

Thinking about errors

From cognitive perspective, error is considered as a consequence of temporary distortion in information processing or cognitive functioning in humans (Parker et al. 1995). When workers make errors, there must be failures in cognition process producing their unexpected behaviours (Zhang & Fang 2013). By expecting errors to happen, employees are encouraged to prepare themselves for errors. In addition, the information processing model can be a guideline for employees to analyse the causes of human errors.

Error communication

In general, communication is used to increase the efficiency of motivational effort (Vinodkumar & Bhasi 2010). Over years, the relationship between safety communication and safety performance has been increasingly proved (Cigularov et al. 2010). Safety communication has been found in the negative association to occupational accidents, injuries or near-misses. Communication or sharing error knowledge is a crucial component of error management culture (Edmondson 1996; van Dyck et al. 2005). Error communication refers to individual's decision to talk openly errors to co-workers and supervisors or report through official incident-reporting systems (Pfeiffer et al. 2010). van Dyck et al. (2005) argued that communication about errors is vital to develop the shared knowledge of errors. Due to communication, the knowledge from error learning allow workers to detect and deal with errors in hazard situation effectively (Cigularov et al. 2010). Therefore, it is necessary to create a workplace environment that encourage open reporting, active questioning and error sharing frequently (Edmondson 1996).

5. CONCLUSION

In conclusion, this review clarifies the concept of errors and error management culture in safety domain. Based on the existing knowledge on construction safety, there is evidence that human errors of construction workers are inevitable in construction safety. Accordingly, to deal with human errors, error management culture is increasingly proposed as a promising measure to improve safety performance in different areas, particularly construction industry. However, the big question found is that how to implement error management culture in construction safety.

With the aim of improving safety performance in construction industry, we propose the need to provide the construction organisations with error management culture. Moreover, there is a need to develop a model of error management culture and to provide the evidence of the relationship between error management culture and safety performance in construction safety.

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THE IMPACT OF INTERNATIONAL WORK PLACEMENTS ON CONSTRUCTION UNDERGRADUATES

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ABSTRACT

As many researchers have reported, there is an increasing trend towards globalisation in the construction industry. Even in Australia, where distance and logistics have long proven to be barriers to international competition, there are now signs that the marketplace for building professionals is often much wider than the national boundaries. In this environment, it is helpful for students to incorporate some inter-cultural immersion as part of their work experience. The Australian Government's New Colombo Plan provides funding for work and study experience for Australian students travelling to the Indo-Pacific region to further their education. This paper reports on the experiences of twenty five construction management students who were able to travel to Hong Kong and Singapore for five or six weeks of mostly unpaid work with large construction companies. The work placements broadened the knowledge of students with regard to the similarities and differences of working in an overseas country. They made useful contacts and were able to include the placement on their resumes when applying for construction management positions on their return to Australia. Their experiences were facilitated by the Australian Institute of Building, Singapore Institute of Building and Hong Kong Institute of Project Managers through their professional networks. It is intended that such exchanges be extended and become a two-way process that will assist with better communication and understanding across the global construction industry.

Keywords: International exchange, work experience, globalization

INTRODUCTION

In 2014, the Australian government established the New Colombo Scheme in order to provide opportunities for Australian undergraduates to study and undertake work placements in the Indo-Pacific region. The program offers funding for scholarships for overseas study, mobility grants for short-term study, internships, mentorships, practicums and research initiatives. The intent is to open cross cultural dialogues and establish connections that will enable future community and business leaders to have direct experience with neighbouring countries. It is believed that these connections will lift Australia's profile in the region and can become a driving force for future prosperity. At the university which is the subject of this study, it was seen as particularly relevant to our student body because we have many students who are the first in their family to attend university. We applied for and received funding for 15 students to go to Hong Kong and Singapore in January and February 2015 and experience work placements with construction firms. A further 10 students went to Hong Kong in January and February 2016. Analysis of the information gathered from the reports written by the students themselves as well as their work placement supervisors is the subject of this paper.

LITERATURE REVIEW

The academic literature on the value of work placements is extensive (Bates 2008; Kelleher et al. 2011; Lester and Costley 2010; Lowe 2006; Mills et al. 2012). There is some variation between disciplines with respect to how important the impact is. Crebert et al. (2004) studied graduates from three different schools at one Australian university to determine the impact of work placements on skills transferability and ongoing generic skills development. The study supported the inclusion of work placements in academic programs both for the development of generic skills as well as for employment prospects and career development. Wilton (2012) drew upon both qualitative and quantitative data on the impact of work placement business and management graduates and found a more complex relationship between work placement and graduate outcomes. He suggests that the quality of the work placement is critical to a successful experience. In a study of psychology students Reddy and Moores (2006) found benefits in the form better time management, confidence and responsibility but questioned whether the benefits for students on unpaid work placements outweighed the costs to themselves and their families.

Over 400 students from a property management degree at a university in the UK were studied by Mansfield (2011). It was found that a statistically significant enhancement in final year marks could be recognised in those students who had undertaken work placements. Differences were observed that related to the gender of the students with less impact being noted in female students. Pillay and Boulton-Lewis (2000) surveyed students in a construction management program at an Australian university and found significant differences in the way students with and without work experience emphasised different aspects of learning. The study found that the complex and multi-faceted nature of learning is better appreciated by those students who have work experience.

Ping et al. (2015) undertook a review of studies into the impact of work placements on construction education. They found that students undertaking part-time work and those in sandwich programs generally performed better than full time students. After controlling for other factors they found that improved academic performance could be attributed to the experience gained in the workforce. It is evident from a diverse range of studies that work placement is likely to benefit students in practical areas but that work experience should be relevant and should also be designed to widen the horizons of the student if it is to be of significant benefit.

RESEARCH METHOD

Case study methodology as described by Yin (2014) is a suitable research methodology to address “how” and “why” research questions especially when the study focus is contemporary rather than historical. The research questions posed for this study are “How would an overseas work placement impact on the confidence, skill sets and employability of construction management students?” (RQ1) and “Why should policy makers subsidise such overseas work placements?” (RQ2). The case study data consists of reports submitted by the students immediately after their return from the placement and employer comments submitted at the end of the placement. It is intended to do future research when all the students have graduated. This will involve unstructured interviews focusing on the impact of the work placement on their careers and self-actualisation. Full ethics approval will be sought before this is commenced.

With the two research questions in mind, content analysis techniques were used to identify themes which occurred repeatedly in the reports and unstructured feedback comments from the students and their employers. As Krippendorff (2013) explains, research methodology knits procedural steps into a fabric of coherent logic which should avoid redundancies while preventing noise from entering the analysis. With this in mind all the documented feedback was examined in light of RQ1 and RQ2 and relevant comments were selected as they related directly to the experience and outcomes for the students. The code words and phrases from the research questions were searched for in the documented evidence. These code words were “confidence”, “skill sets”, “employability” and “policy makers”.

The evaluations and judgements made in the analysis of the documented evidence are necessarily somewhat subjective. It is intended that this is a preliminary study for a more comprehensive research report on the impact of the placements which is to be completed when all the students have graduated.

Nature of placements

Because the intention was to attempt to give the students a life-changing experience, companies and organisations which already had established programs for their own local student interns were preferred. Under the auspices of the Australian Institute of Building contact was made with suitable companies and the program explained. In the first year the involvement of the Department of Foreign Affairs and Trade was of great assistance in assuring the potential partner companies of the bona fides of the scheme. In Hong Kong this was particularly important. A memorandum of understanding signed with the government of Hong Kong was also significant. In Singapore, we were greatly aided by the involvement of the Singapore Institute of Building who recommended suitable companies and made the initial contacts. Table 1 overleaf describes the nature of the placement companies and the number of students accommodated. The placements lasted for six weeks in 2015 and five weeks in 2016. The second group had the shorter duration placement due to reduced funding. Four Hong Kong companies accepted repeat placements in the second year of the program. Funding was not available for Singapore in the second year.

Of the students selected for the placements in 2015, 3 had completed 4th year, 6 had completed 3rd year, 3 had completed 2nd year and 3 had completed 1st year only. The corresponding figures for the 2016 placements were 3 completed 4th year, 1 completed 3rd year, 2 completed 2nd year and 4 completed 1st year. The students' grades in relevant units were considered when deciding the placement allocation. Of the twenty five students selected for the placements, five were female and twenty were male. In most cases the students were working with local students or recent graduates who were also completing internships.

For 16 of the 25 students who undertook the work placements, this was their first serious employment in a construction company. The other 9 had experience in Australia. Two of these took leave with their local employers' approval in order to go on the placement.

Table 1 Placement organizations, tasks and student numbers

	Company description	Work experience tasks	2015	2016
HK1	Builder of highrise residential apartments	5D BIM training; site status reports; site visits	2	2
HK2	Builder, civil constructor, property and infrastructure development company	Site progress photographs; Onsite construction sequencing	2	2
HK3	International company specialising in infrastructure projects throughout Southeast Asia	Coordinate BIM and construction site team; Manage Requests for Information (RIF)	3	2
HK4	Consultant quantity surveyor and project management company	Amend tender documents; Learn Bluebeam software	3	2
HK5	Construction Virtual Prototyping Laboratory	BIM and other software training		2
SG1	Major building and project management company	Onsite assistant to Project Manager	1	
SG2	Integrated property group who construct and manage residential and business properties	Quantity surveying software; 3D modelling; site supervision	1	
SG3	Specialist quantity surveying, estimating and cost management	Cost engineering and pre tender meetings; Autodesk software	1	
SG4	Main contractor for construction and engineering works	Construction scheduling;site supervision; site visits	1	
SG5	Major construction and infrastructure project developer	Site visits; document control	1	

RESULTS AND DISCUSSION

The students were required to complete reports listing their objectives and achievements from the internships, as well as listing the skills they acquired and mentioning any issues or risks that arose on the placement. In general, reports from both the returning students and their employers were very positive.

Student Reports

The most common objectives listed by the students were increasing their employability, broadening their range of work experience and increasing their awareness of another culture. Sample responses include:

> "I hoped to excel over the course of the internship, and apply the knowledge and experience I have gained at university to carry out meaningful, useful work while with my host organization." (SHK9)

> "Prove to myself that I can work in the construction industry and in a corporate environment. Learn what texts books can't teach me." (SSG1)

> "Entering into the International Internship programme my main objective was to expand my skillset and base knowledge in construction as well as experiencing and adjusting to a cross cultural environment." (SHK1)

Students mentioned quite diverse achievements stemming from their time on placement. Some of them listed specific tasks:

> "Prepare and submit daily reports of road conditions and delays.
> Understand the method statements involved in executing the works.
> Prepare and submit weekly reports of site progress.
> Document control and investigative reporting.
> Learn the basics of a new language." (SHK6)

Others described a mixture of tasks and personal development:

> "Gained Competency using Tekla BIM modelling software.
> Strengthened interpersonal skills for communication in the workplace.
> Strengthened understanding of contractual requirements/obligations in relation to Extension of Time (EOT) claims.
> Increased ability to work as part of a team in an office environment (EOT Claim works).

> Gained an understanding of alternative construction technologies & techniques (precast concrete, large diameter bore piles, socket H piles etc.)." (SHK2)

Several students reported on instances where they had suggested changes or developed templates which were then adopted by the work group where they were located. The students' English language skills seemed to be highly valued in their workplace. Most students noticed things that were different in Hong Kong and Singaporean construction practices compared to Australia. Particularly frequently mentioned was the use of bamboo scaffolding and less emphasis on safety for onsite labourers.

In terms of issues and risks, a few students mentioned that they experienced some communication barriers with their co-workers:

> "I believe the biggest issue was the language barrier between us, as English speaking students, and the local Cantonese-speaking population. While this was overcome by some 'creative communication' I believe that living in a foreign city, and working, would have been easier with larger foundation in the local language." (SHK9)

Other students also mentioned the issue of preparedness and suggested that they would have liked more information about the company they were going to:

> "An outline from the company about what is expected and perhaps an outline of what they have planned for the six weeks would be helpful". (SSG1)

Students also reported on numerous difficulties with visas and timelines for visa approval. While the university was able to advise and assist on some of these matters, they are largely beyond the scope of this paper.

Some of summary comments from students were particularly positive:

> "My experience in Singapore was one of the best experiences in my life. It has change the way I think, not only in the construction industry but overall. I enjoyed meeting different people from other cultures and making new friends. I have gained so much knowledge working for a commercial construction company abroad, it has taught me so much and how much more knowledge I need to gain to be successful in my field." (SSG3)

Finally, several students from both the Hong Kong and the Singapore groups mentioned that travel times were an issue and that the companies worked long hours. Some felt that they missed an opportunity to immerse themselves in the wider culture of the country they were visiting:

> "….as part of the internship there should be time allocated (during the programme to further immerse yourself in the location, particularly for relevance to construction management, as longer hours are worked (possibly Saturdays) and it would allow all participants to get the most out of the country and the experience." (SHK1)

There were few negative comments from the students. While this is to be expected given that most students were still yet to complete their undergraduate degrees, it is nevertheless positive for the program organisers. It remains to be seen whether a different perspective can be gained from interviewing the students once they have graduated and have had time to reflect more deeply on the impact of the placements.

Employer comments

It is necessary to put a caveat on the employer comments received about the students. Business culture in both Hong Kong and Singapore is formal in nature and criticisms are unlikely to be expressed directly. Given that qualification it must be said that the reports from employers were overwhelmingly positive.

Straightforward reports include that the student was:

> "… helpful and keen to learn new things and share work load." (HK3)

> "*student* is an energetic person, she is willing to learn and really gives us a good help to ease our heavy workload." (HK4)

The Human Resources Department of one company reported that:

> "…. The interns help out our fast paced projects" (HK3)

While the culture of business communications may lead us to expect that the reports will be polite and complimentary, the evidence that students were accepted for a second year indicates that the internships were a positive experience for the employers also.

CONCLUSION

This paper reports on an ongoing process to send Australian students to the Indo-Pacific region as a means of broadening their cultural perspectives. At the same time, the selected students get the opportunity to observe the similarities and differences between the construction industry in their destination city and that of Australia.

In respect to the first research question: "How would an overseas work placement impact on the confidence, skill sets and employability of construction management students", we have anecdotal evidence that the impact was positive on confidence and employability of all the students involved. The impact on skill sets is yet to be confirmed although several students reported receiving training in software and procedures that have improved their knowledge base. Due to the brief nature of the internship it would be unreasonable to expect a large impact in this area.

The second research question: "Why should policy makers subsidise such overseas work placements", can be answered in terms of the goodwill and network building that resulted from the internships. The positive aspects of the placement had spin offs for relationships between the home university and professional bodies in the placement locations. The networks and contacts developed will be used for future research projects as well as for reciprocal visits from overseas students to Australia.

In general, the international work placement scheme has encouraged students and academic staff from the home university to be more outward looking in terms of the possibilities made available through connections with the Indo-Pacific region. The home university has relatively few overseas students studying construction. In our increasingly globalised, digitalised and industrialised construction industry, this is likely to change with accelerating speed. The more Australian students who develop a connection and some familiarity with the larger region, the more flexible, innovative and agile our relations with our neighbours are likely to be.

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TOWARDS EFFECTIVE IMPLEMENTATION OF ADJUDICATION AS DISPUTE RESOLUTION PROCESS ON PUBLIC SECTOR PROJECTS IN SOUTH AFRICA

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ABSTRACT

The concept of adjudication is no longer new in the South African construction space. The forms of contract in use and that are endorsed by the Construction Industry Development Board (CIDB) incorporate adjudication as a standard form of dispute resolution. However, a careful observation indicates that sufficient attention has not been given to adopting the adjudication provisions by contracting parties on public sector projects. This paper discusses the existing adjudication provisions in the standard forms of contract, review current practices of contractual adjudication and thereafter evaluate adjudication potential in resolving disputes among public sector contracting parties. The paper analyses the current status of adjudication practice in South Africa by systematically reviewing selected articles and documents on both contractual and statutory adjudication with emphasis on the South African construction industry. The analysis of the selected documents reveals that there are adequate provisions for adjudication in the current forms of contract endorsed for usage in the South African construction industry and as such, the adjudication process has the potential to resolve disputes effectively among the public sector contracting parties. The value of the paper is that it alerts the industry to give adequate consideration to factors that can promote more and effective usage of adjudication provisions by public sector contracting parties.

Keywords: adjudication, construction disputes, public sector, South Africa

INTRODUCTION

The importance of the construction industry in any country cannot be overemphasised. One of the indices for measuring the economic development of countries is the rate of construction activities and performance of their construction industry. As such, the construction performance relies on active participation of contracting parties for effective delivery of projects within the stipulated time, cost and quality parameters. Disputes among contracting parties regularly arise, hampering the smooth operation of construction projects and thereby jeopardizing the industry performance. In fact, disputes are associated with poor construction work, project failures, complicated litigations, financial loss in securing legal services and adversarial relationships among construction stakeholders (Harmon, 2003; Kumaraswamy, 1997; Cheung et al., 2002; Cheung and Pang, 2013).

The adversarial relationship on construction projects is often acute, particularly on public sector projects, which can be attributed to the slow uptake of alternative dispute resolution (ADR) mechanisms. These unfavourable relations also impact negatively on the overall cost of construction. Consequently, several construction stakeholders have advocated that something must be done in order to circumvent the situation (Cheung et al., 2006; De Oliviera, 2011). The time-consuming and costly traditional methods of disputes resolution (usually litigation and arbitration) have often discouraged small and emerging contractors from pursuing their legitimate right and as a result, have suffered financially (Lynch, 2011). These challenges and frustrations associated with litigation and arbitration in resolving construction disputes have necessitated an increased demand for ADR and triggered the introduction of adjudication into the construction industry.

THE EMERGENCE OF ADJUDICATION AS AN ADR MECHANISM IN SOUTH AFRICA

The South African construction industry plays a vital role in South Africa's economic and social development. However, the industry is particularly plagued by payment defaults which have been reported to be a chronic problem affecting the delivery chain (Maritz, 2007). The unpredictability of payments has in certain instances resulted in an extremely negative contracting environment (Thumbiran, 2015) and as such, disputes are not uncommon within the industry. Hence, there have been concerns on how to strengthen the industry to face the present and future challenges. One of the efforts to face the challenges led to the promulgation of the White Paper entitled "Creating an Enabling Environment for Reconstruction, Growth and Development in the Construction Industry“ (Department of Public Works, 1999).

The White Paper provided for a scheme that will enable the construction industry to play a more strategic role in the socio-economic growth of the nation. It set out Government's plans and vision for an enabling strategy aimed at enhanced service delivery, greater stability, improved industry performance, value for money and the growth of the emerging sector. It further focused the need for improved public sector capacity to manage the construction delivery process. It also recommended the establishment of an industry caretaker known as the Construction Industry Development Board (CIDB) with the mandate to champion the process of creating an enabling environment in order to promote the industry at large.

Having recognized the entrenchment of ADR procedures for resolving labour disputes in the Labour Relations Act No. 66 of 1995 and the successful application of ADR procedures in the private sector, the CIDB in the 1999 White Paper to the Minister of Public Works, recommended the use of ADR, in particular adjudication, as litigation and arbitration were observed to be time-consuming and costly leading to small and emerging contractors’ vulnerability in the event of disputes arising. Hence, contractual construction adjudication was formally introduced to South Africa through the efforts of the CIDB. The CIDB, as part of their mandate, endorses forms of contract documents for use by public sector clients – these are currently the Federation Internationale Des Ingenieurs Conseils (FIDIC), New Engineering Contract (NEC), Joint Building Contracts Committee (JBCC) and General Condition of Contracts (GCC), all of which make provision for adjudication.

RESEARCH METHODOLOGY

Research design for the study

According to Creswell, (2003: 4) researchers’ need to be satisfied that the information requirements are being met by adopting the most suitable research methodology. Thus, the importance of selecting an appropriate research design cannot be overemphasised. The objectives of this study informed the choice of a qualitative research approach and the interpretive epistemological stance, which seeks to uncover truth by understanding the phenomenon in their real-life context (Creswell, 1998: 15). Following on from the above choices, the qualitative interview will be used in primary data gathering in accordance with the phenomenological approach. The approach allows the researcher to collect information from experts who have direct experiences with the phenomenon under study.

Thus, the data for this study will be collected from recognised professionals who are directly involved in adjudication implementation in the jurisdictions where statutory adjudication as an ADR mechanism is currently being practised. There are two reasons for the choice of a qualitative approach that will be used in this study.

The first is that the research questions considered in this study are types that generate open-ended problems which require novel solutions that are not predetermined by the researcher. As a result, the study requires examination of the views of professionals in jurisdiction(s) where such phenomenon is in operation in order to obtain rich, meaningful, reliable, comprehensive and useful information. Most discourses on research design reveal that a qualitative research approach is always the best and most appropriate for a study of this nature (Creswell, 2009; Yin, 2009; Bryman, 2008; Guba and Lincoln, 1994). This is because qualitative research focuses on exploring what individuals or groups make of social phenomena or interactions in the context of the real world (Creswell, 2009). Hence, complex questions which can be impossible with the quantitative approach can easily be dealt with under qualitative due to its flexibility. In addition, qualitative research provides a host of opportunities for new and innovative discoveries especially in a situation where there is a lack of prior empirical research.

The second reason for the selection of a qualitative approach in this study is a matter of the advantages that this method provides. For instance, the approach is very useful for describing complex phenomena and provides individual case information. It provides understanding and description of people's personal experiences of phenomena and thereby making cross-case comparisons and analysis possible. In effect, the researcher depends on participants' view rather than imposing researchers own preconceptions on the participants (Creswell, 2013). In addition, the hidden knowledge situated in history can be easily revealed (Scotland, 2012: 12). According to Cohen et al., (2007: 19) the social world can only be understood from the standpoint of individuals who are participating in it. Therefore, the adoption of a qualitative approach in this research allows the researcher to probe into questions in order to bring into consciousness hidden facts.

As this is still an on-going study the interviews are at the time of writing this paper not concluded. This paper therefore is limited to the extensive literature review that has already been completed and for that reason can be regarded as a 'desktop study' as at this point in time, which will be followed by the final results after the interviews have been analysed.

General

This paper aims at evaluating the potential of adjudication as an ADR process in resolving disputes among public sector contracting parties in South Africa. In order to achieve the aim, the methodology employed included the examination and analysis of selected documents related to adjudication practice in South Africa. According to (Bowen, 2009) this type of methodology approach is advantageous because it provides the means of tracking changes and development as well as revealing the clear picture of how an organization or a program fares over time. This methodology approach is used regularly in researches with the purpose of providing a future direction on an important issue (Lynch, 2011; Olanipekun, 2015). In order to provide an overview of the South African construction industry and the current status of implementing adjudication as ADR process the study examined selected documents comprising of:

- Journals, books, and published literatures related to adjudication practice in South Africa;

- The CIDB endorsed standard conditions of contracts namely; the FIDIC, NEC, JBCC and GCC.

- Construction Industry Indicators (CIIs), a nationwide annual CIDB Survey. The survey involves the participation of clients and contractors from all nine provinces in South Africa.

Research discussion

The CII survey measures the performance of the construction industry, focusing on clients, contractors and other industry stakeholders. The importance of the survey cannot be underestimated because the survey connotes an aggregated view and perception of different industry stakeholders across the whole South Africa. The findings from the literature survey reveal continuous and increasing deterioration in both payment culture and management of disputes within the South African construction sector (CIDB, 2012; CII, 2007 – 2014). In fact, nothing less than 65% of the subcontractors in South Africa who are supposed to be protected by the adjudication mechanism have claimed to have experienced delayed payment (CIDB, 2013). The subcontractors also reported that this delay in payment has been the root cause of disputes within the South Africa construction industry. Surprisingly, these subcontractors have been rather passive in invoking the adjudication provisions to address the issue. This situation has been particularly worse with public sector construction contracts in South Africa. These findings therefore call for a need to determining the factors constraining the adoption of adjudication provisions among public sector contracting parties.

ADJUDICATION PROVISIONS IN THE STANDARD FORMS OF CONSTRUCTION CONTRACTS

Currently, South Africa has four CIDB endorsed standard forms of construction contracts for both public and private sector construction works. Two of the forms are internationally developed (FIDIC, and NEC3) and the other two are home grown (GCC and JBCC). The contractual adjudication process has found a place in the two home grown standard form of building contracts into which the adjudication process was introduced for the first time in 2004. As with many jurisdictions, the standard forms have undergone some amendments since its introduction into the construction practice in South Africa. The latest versions of the four standard forms are the JBCC 2014 edition 6.1, the GCC 2014 2nd edition (Revised), the NEC3 2005, 3rd edition and the FIDIC 1999 1st edition. In the current versions of the forms, adjudication provisions are found under clause 30 of JBCC; clause 10.5 of GCC, Option W1 of NEC 3 and clause 20 of FIDIC.

Each of the forms adopts a standard adjudication procedure. The GCC makes use of the CIDB adjudication procedures, The JBCC applies its own adjudication rules, the NEC provides for two adjudication procedures (Option W1 and W2) because of United Kingdom (UK) statutory requirements for adjudication. Option W2 is the Act compliant procedure for use in contracts subject to the UK's Act while option W1 is the NEC procedure applicable in South Africa. The FIDIC makes use of its own general conditions and procedural rules for adjudication. It is important to know that all the adjudication procedures needs to align with the principles underpinning adjudication in South Africa. Drawing some comparison from the four forms of contracts, the following points are observable:

Appointment: The parties are to jointly appoint the adjudicator or Dispute Adjudication Board (DAB) by mutual agreement or by a named authority either at the beginning of the contract (standing adjudicator), or when disputes arise (ad hoc adjudication). The adjudicator's agreement is a tripartite agreement and must be co-signed by the employer, contractor and the adjudicator(s).

Terms of appointment and conduct of adjudication: The adjudicator is required to act fairly and impartially in accordance with the rules of natural justice. He is expected to act independently of the parties and treat all matters as confidential.

Procedure: The adjudication process is not to be conducted as arbitration. The adjudicator is permitted to decide on the procedure to be followed in adjudication. He is authorized to use his own initiative to ascertain the facts and laws necessary to determine the dispute. The adjudicator may use his own expert knowledge, order any interrogation, require/limit further submission of documents or decide on the language to use in the adjudication. The adjudicator can also conduct a hearing (though not usually encouraged) or call for meetings, carry out site visits and inspections as he/she considers being appropriate, carry out any test and experiment and can appoint an independent expert upon receiving the consent of the parties.

Determination: The adjudicator is to reach a fair, rapid and inexpensive determination of a dispute arising under the contract. The decision of the adjudicator shall be in writing, containing the reasons for his/her decisions if requested by any of the parties. He/she shall determine the amount that any of the parties is liable to pay to the other, the date the payment is to be given and other matters regarding the rights and obligations of the parties. The adjudicator's decision is binding and the parties must give effect to it regardless of any intention to take the adjudicator's decision on review or arbitration.

Payment: The parties shall implement the adjudicator's decision without delay whether or not the dispute is to be referred to legal proceedings or arbitration.

Looking at the provisions of the different forms of contract, the findings of (Maiketso and Maritz, 2009) that there are sufficient contractual provisions for effective practice of adjudication in the CIDB recommended forms of contract can be regarded as valid.

THE CURRENT PRACTICES OF ADJUDICATION AS ADR PROCESS IN SOUTH AFRICA

As a matter of practice within the South African construction industry, the obligation to adjudicate is based on the contractual agreement between the parties as recorded in the construction contract. This is different from the practice in the UK where adjudication is a creation of legislation, through the introduction of Housing Grant, Construction and Regeneration (HGCR) Act (1996) (HGCRA, 1996). Contractual adjudication was not widely used during pre-statutory era in the UK and elsewhere because its usage depends on the negotiating strength of the parties (Gaitskell, 2007, Kennedy et al., 2010). This had led to the advocacy that adjudication has to be compulsory in order to have real impact so that powerful contracting parties would not strike it out from the contract they make.

In addition to the aforementioned limitations is the problem that arises when adjudication is not being adopted as a primary resolution mechanism. For instance, in Hong Kong, just like the case in South Africa, there is no statutory right to adjudicate. Adjudication is just one of the three tiered dispute resolution mechanisms which can only be invoked by agreement between the contracting parties. Therefore, the take up of adjudication has been limited due to the fact that it can only be adopted at secondary level following mediation (Hill and Wall, 2008). However, this limitation has been addressed in many countries by making adjudication a creation of law. Following UK HGCR Act (1996), countries like Australia, New Zealand, and Singapore etc. have enacted similar legislation to back up the adjudication practice. At present, there is a concerted effort within the South African construction industry to shift from contract based to statute based adjudication practices.

It is noteworthy that, despite all limitations associated with contractual adjudication, it has been adopted in the resolution of disputes in South Africa. Recent studies show that adjudication was effective in the cases where it has been employed (Hattingh and Maritz, 2014; Massey, 2014). Even in the few cases where contracting parties had gone to court after adjudication (e.g. *Basil Read (Pty) Ltd v Regent Devco (Pty) Ltd; Tubular Holdings (Pty)Ltd v DBT Technologies;* and *Esor Africa (Pty) v Bombela Civils*), it was observed that most of the court rulings had aligned with the adjudicators' original determinations. In relation to this, the recent courts' support and robust approach in enforcing adjudicators' decisions has positively contributed to the increasing penetration of ad hoc adjudication into South African construction practice (Hattingh and Maritz, 2014).

SUMMARY

Various authors have revealed that there is a growing preference for adjudication (Du Preez, 2013; Van der Merwe, 2009). For instance, many construction stakeholders would prefer the inclusion of adjudication as the priority in resolving a dispute before arbitration (Bvumbe and Thwala, 2011). In addition, it has been revealed that the construction industry stakeholders agreed that the introduction of adjudication will significantly reduce the time-consuming and costly arbitration and litigation processes.

However, a reflection of prevalent trends in the construction industry has revealed that the practice of adjudication in South Africa as an ADR process is limited to the private sector. This observation can be proved in two ways. Firstly, by the numerous and increased complaints on payment default and other disputes on particularly public sector projects (CIDB, 2012) as confirmed in the CIDB CII survey results from 2007 to 2012. Secondly, by analysing those cases that ended up in court after they were determined by the adjudication process. Out of six cases that got to court between 2010 and 2014, five of the disputes were either between private employer and contractor, main contractor and sub-contractor and main sub-contractor and another sub-contractor. The only exception was the case between *Freeman August Wilhelm NO, Mathebula; Trihani Sitos de Sitos NO v Eskom Holdings Ltd* of which Eskom is a public client. It can therefore be inferred that the public sector rarely invoke adjudication as an ADR process for its disputes. Litigation has remained the prevailing dispute resolution technique among public sector contracting parties in South Africa (Bvumbe and Thwala, 2011; Du Preez and Verster, 2013).

FUTURE DIRECTIONS

The research review on adjudication practices in South Africa has identified future research directions as illustrated in Figure 1, and explained below.

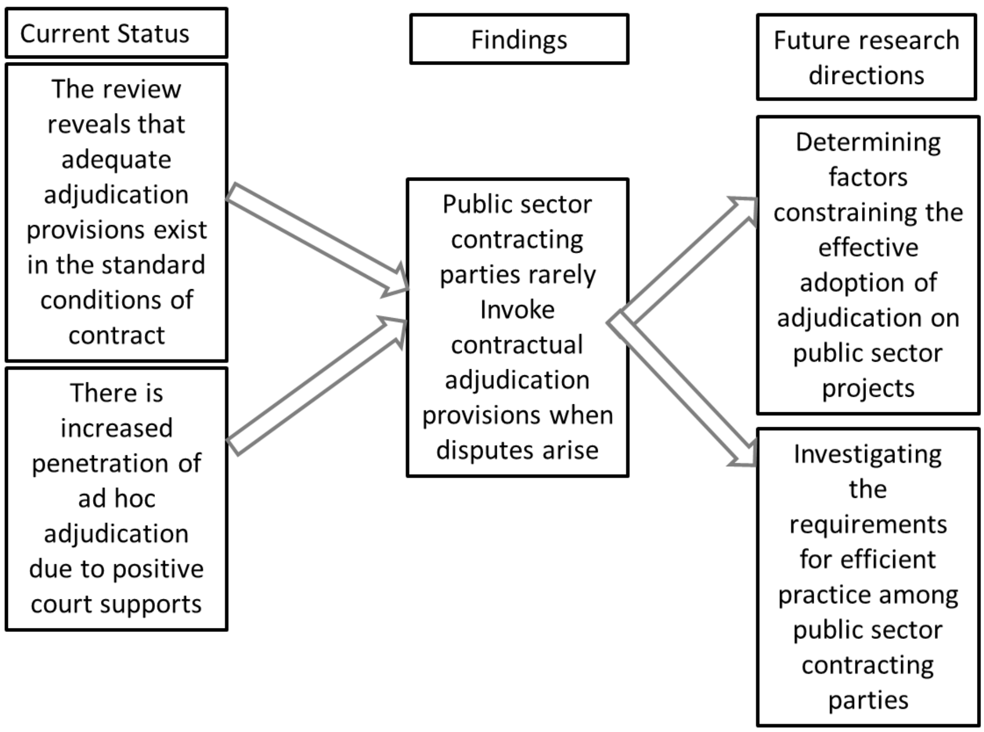

Figure 1: Current status and future direction on adjudication practice among public sector construction contracting parties.
(Adapted from Olanipekun, 2015)

In line with the plan to introduce statutory adjudication in South Africa, the CIDB has recently prepared amended adjudication regulations that were gazetted for public comments in the Government Gazette Notice 482 of 2015 (Thumbiran, 2015). Once enacted, adjudication would carry legal enforcement within the South African construction industry. This development promises a better and greater result for the industry as far as dispute resolution is concerned. However, the potential inherent in the process of statutory adjudication would only be realized if the constraining factors to its effective usage are recognized and appropriate application measures are put in place. In effect, the empirical evidence of what should be done to achieve effective usage and pragmatic functionality of the practice of adjudication should be provided. The knowledge and outcome of such research will be of great benefit to all construction stakeholders.

CONCLUSION

The literature reveals that contractual adjudication is no longer new in South Africa. The courts in South Africa have acknowledged the importance of this ADR alternative and have shown a robust approach towards enforcing adjudication decisions. However, the public sector has not tapped into the advantages of this mechanism. There are sufficient adjudication provisions in the forms of contract conditions capable of mitigating dispute problems among public sector contracting parties, but the public sector needs to address its own constraints and confronts its limitations creatively in order to tap into the advantages of adjudication. The benefits and advantages of the present contractual adjudication and the proposed statutory adjudication can only be fully realized provided adequate consideration is given to the special circumstances and limitations surrounding public sector contracts. Further research is therefore important on how to implement statutory adjudication of disputes effectively on public sector projects.

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FRAMEWORK FOR ESTIMATION OF PROFITABILITY FOR HIGH-RISE RESIDENTIAL PROJECTS

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ABSTRACT

Profitability is one of the governing factors for a contractor to win a project and execute it as per the applicable standards. Considering the present scenario of the Indian construction industry, high-rise residential contracts are suffering from significant amount of cost and time overrun leading to losses incurred by construction companies. This reflects the requirement of a holistic profit estimation model to understand the dissimilarities between the planned and actual estimates and to account for market conditions. Profit is considered as a percentage of the estimated cost. In estimating the profit size, there are many challenges and uncertainties involved and prediction of these complications that affect the profitability is a challenging task. In residential projects, direct costs incurred on labour, material, plant and machinery have limited variation; it is the profit size that becomes the key differentiator from one contractor to another. There are many variables and conditions such as complexity, competition, work capacity etc. that are to be considered while computing the profit size, as any wrong prediction in considering these attributes can lead to heavy losses in the project or conversely an unsuccessful bid. In making estimation of profit more reliable, a mathematical model is needed for prudent decision making. This paper focusses on identifying the associated attributes and uncertain conditions which affect the profit size with the help of a case studies, determine the weightage of parameters in the estimation of profit size by using Analytic Hierarchy Process (AHP), and compute the size of profit by using linear regression models. Outcome of this paper is a cohesive framework to help estimators in computing the profit size more logically and correctly for high-rise residential project in the Indian context. The developed framework is applied on a residential high-rise project to understand the applicability of the model.

Keywords: Profitability, High-rise, construction, attributes, residential

INTRODUCTION

Construction sector in India is dynamic and highly competitive. Different processes and models are existing to estimate the cost of a construction projects. Construction cost estimate consists of three important components namely direct cost, indirect cost and mark-up. Direct cost, as defined by Association for the Advancement of Cost Engineering (AACE), consists of costs that are directly attributable to completion of project such as labour, material and equipment etc., (AACE® International Recommended Practice No. 10S-90, TCM Framework: General Reference (All Sections), 2016). Indirect cost consists of costs that are not directly attributable to completion of project but they are required for orderly completion of project such as supervision, staff salaries, security etc. Mark-up consists of profit, risk and contingency and general overheads. Profit is the reward taken by the contractor for the risks invested (Jha, 2011). General overheads contain the expenses incurred for maintaining the resources of regional/head offices setup. Risk and contingencies quantifies the uncertainties involved in the project. Mark-up when applied as a percentage of bid price is termed as OFF-TOP (Jha, 2011).

Most of the contracts in India are awarded through the comparative selection process of choosing the lowest bidder and this emphasises the need for accurate estimation of tender price to win the construction project. Components such as direct and indirect cost are more or less uniform for all the contractors and deciding factor generally would be the off-top/profit loaded on the overall estimated cost. As stated by Irem, et al. (2007) "*Estimation of profit is an unstructured decision problem that is usually solved by intuition*". There is a level of complexity involved in the estimation of the profit and the resultant mark-up as it depends on experience, expertise and a multitude of attributes. Success of construction projects depends on the capability of the contractor to consider appropriate off-top percentage to win enough jobs and to execute them profitably (Irem, et al., 2007). There are numerous attributes to be considered in deciding the profit for a high-rise residential construction projects. This paper focusses on this aspect in the Indian context. This paper applies a collective approach (Polat, et al., 2015) of identifying the influencing attributes for profitability through literature review and case studies, framework of attributes with relative weightages among identified attributes through AHP and a regression model to predict the profit size for the upcoming projects. Actual data of 12 high-rise construction projects is collected and utilised in the development of the regression model.

RESEARCH METHODOLOGY

The proposed framework for determining profitability consists of the following key components:

1. Identification of general and high-rise residential construction project specific attributes affecting profitability from a construction companies point of view

2. Determination of relative importance of the associated attributes using the AHP approach and to develop a framework containing these influencing attributes

3. Computation of project score for the identified project by incorporating the importance levels in the developed framework

4. Development of a regression model linking estimated profit and project score and determination of profit for a high-rise residential project

Parameters affecting profitability of high-rise residential construction projects are extracted from literature review and from the cost overrun attributes identified for 12 Indian high-rise residential construction projects. These identified parameters are grouped under two categories i.e. general and high-rise project specific. Weightage of identified attributes is determined by AHP approach—an effective tool introduced by Thomas Saaty in 1980 to solve multi criteria attribute analysis (Saaty, 1980; Palcic & Lalic, 2009). Identified parameters are grouped under primary, secondary and tertiary hierarchical levels. To determine relative importance among attributes, pair wise comparison on every hierarchic level and every level of the entire framework is carried out on Saaty scale from 1-9 (1 being equal importance among attributes and 9 being one attribute absolutely more important than the other attribute). Matrix of attributes is normalised to determine the weightage of attributes at every hierarchical level. Performance of the AHP matrix is checked by calculating the consistency ratio (Saaty, 1980). Twelve constructed high-rise residential projects are identified for the study. Scores ranging from 0-10 are assigned to each attribute (0 being no impact in the project and 10 being highest impact in the executed project) for each of the identified project. Assigned score for each attribute is multiplied with the weightage obtained in AHP and rolled up to obtain project complexity score for all the identified projects as per the equation given below:

S (Project Complexity Score)= $\sum_{i=1}^{n} w_i \times A_i$**................. (Equation 1)**

Wherein w_i is the identified weightage of i^{th} attribute and A_i is the score of the i^{th} attribute for the identified project.

Regression analysis is utilised to establish the relationship between independent and dependent variables. Dependent variable in this context is the estimated profit and independent variable is the project complexity score derived from equation 1.

P=k.S+c.. (Equation 2)

Wherein P denotes the estimated profit, S denotes the project complexity score for the identified project, k and c are regression coefficients.

Regression model is applied on a residential project to correlate the results obtained with the actual values predicted in the estimated cost. Entire framework for determination of profitability is shown in Figure 1.

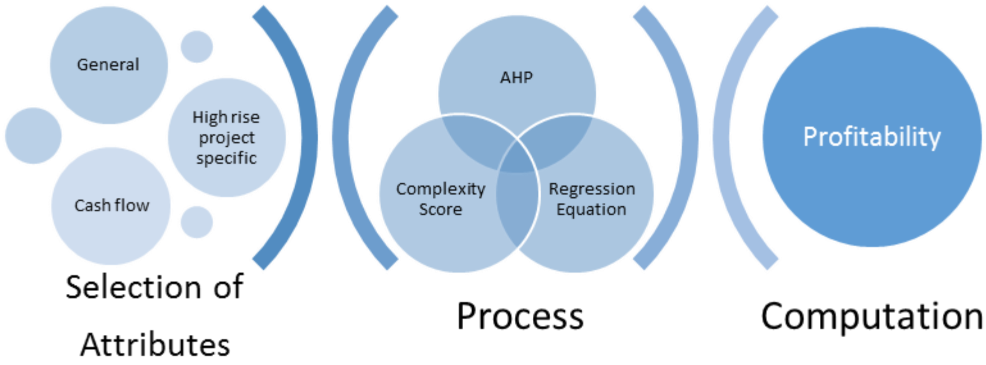

Figure 1: Framework for estimation of profitability

ATTRIBUTES INFLUENCING PROFIT SIZE

There are several attributes that influence profit size for a high-rise residential construction project. Several researchers have worked on listing out attributes affecting profit size but not specific to high-rise residential construction projects. A reliable estimate of mark-up is essential for successful bid proposals (M. Marzouk, 2002). It is a tricky scenario that the markup percentage should be low to ensure that the project is bagged by the contractor and the mark-up should be sufficiently high so that contractor can realise reasonable profit ((Lee & Chang, 2004); (Dikmen, et al., 2007)). It is very difficult to predict uncertainties that would result in decrease of profitability. This can be handled by a thorough cost and risk analysis of construction projects that are executed (Yoon, et al., 2014). Hence, this study considers the reasons for cost overrun spent on high rise residential construction projects as the tertiary level of attributes to be investigated for profitability. One way to look at profitability attributes is to look at the primary reasons for cost and time overruns on projects that are already executed. Similar views are presented by (Au & Hendrickson, 1986) and they are confined to cash flow arrangements. This paper proposes to analyse reasons for cost and time overrun at all the work breakdown structure levels of the executed high-rise residential construction.

This paper extends the scope to cover all the attributes that lead to cost overrun in high-rise residential construction projects through an analysis of 12 Indian projects. Analysis of cost overrun attributes for these projects shows that there are some repetitive attributes that occur in almost all the projects which are shown in Figure 2. These factors have resulted in loss of profitability considered in all these 12 high rise residential construction projects.

Considering the high-rise residential construction projects examined and available literature namely (Liu & Ling, 2005); (Dikmen, et al., 2007); (Hou, et al., 2011); (K & Sreekumar, 2014); (Yoon, et al., 2014); (Polat, et al., 2015); (Patil & Bhangale, 2016); framework of influencing attributes is presented in Figure 3.

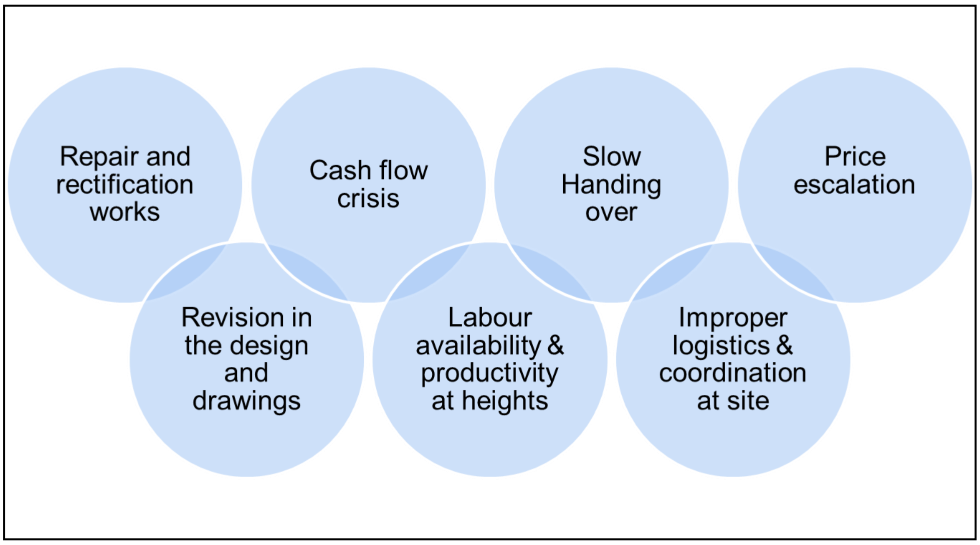

Figure 2: Attributes causing cost-overrun in high-rise residential projects

These attributes are bifurcated in two main categories namely general attributes and high-rise project specific attributes. General attributes are subdivided into organisation and owner related and project related.

- Organization and owner related: Attributes related to the organizational policies and needs and owner organization policies are presented here
- Project related: Attributes related to scope and setup are presented here

High-rise attributes are classified into four sub-categories namely

- Design and Construction attributes: Concerns related to issuance of drawings, finalization of designs, site related are presented here
- Quality and safety attributes: Factors related to quality and safety requirements in high rise projects are presented here
- Cost attributes: Factors related to cash flow, contractual clauses, inflation are presented here
- Resource attributes: Factors related to men, material and equipment are presented here

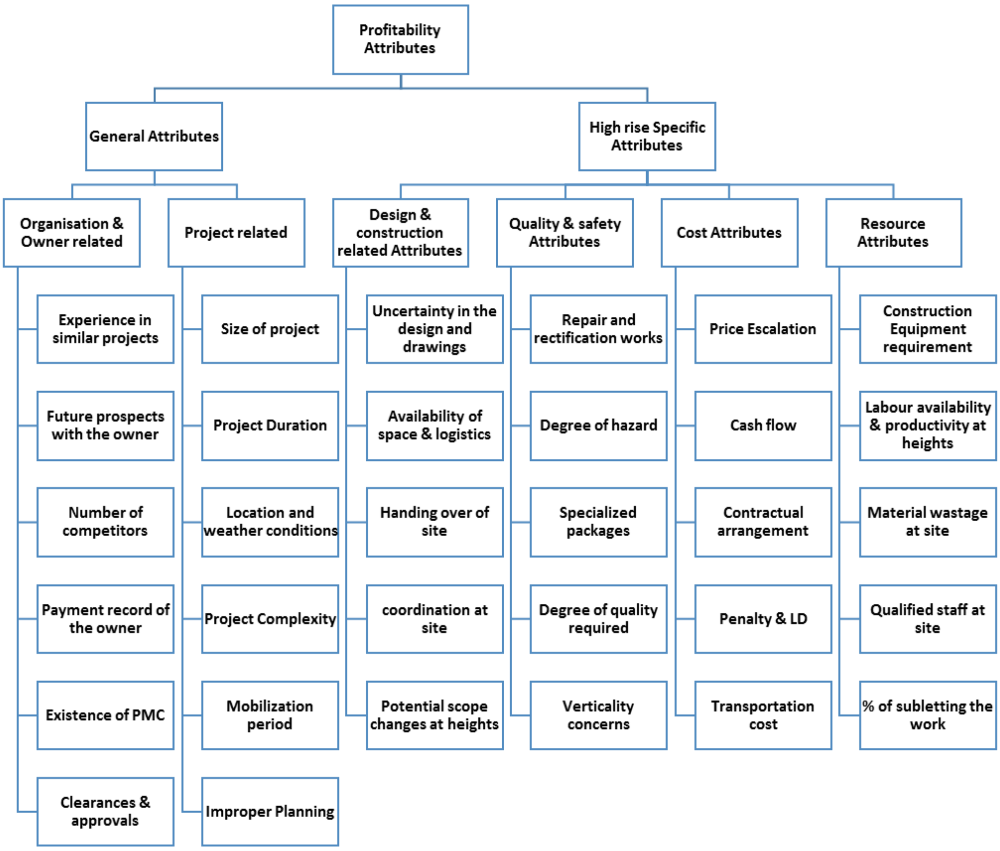

Figure 3: Matrix of Attributes

AHP MODEL DEVELOPMENT

Identified attributes affecting the profitability of high-rise residential construction projects are framed under different hierarchical levels pertaining to general and high rise project specific attributes as presented in Figure 3. In the development of model, weights of tertiary, secondary and primary attributes are calculated using AHP technique by collecting responses from estimators working in the identified 12 high rise residential construction projects. Pair wise calculations, normalising matrix and consistency checks are conducted in Microsoft Excel and the entire framework with weightages is presented in Table 1. Developed model as shown in Table 1 identifies ***E2 Cash flow crisis, F2 Labour availability and productivity at heights, E1 Price Escalation, C2 Availability of space and logistics*** and ***C1 Uncertainty in the design and drawings*** as the attributes impacting the profitability to a great extent in high-rise residential projects. Estimators were asked to assign scores to each of the 32 tertiary level attributes for the identified 12 High-rise residential construction projects executed on a rating scale of 0-10, 0 being no impact in the project and 10 being highest impact in the executed project. Scores given by the estimators are multiplied with the corresponding weightages and summed up to compute project complexity score for each high rise residential project. Computed project complexity scores are presented in Table 2.

Table 1 Framework of attributes affecting profitability in High rise projects with weightages obtained from AHP

Primary Attribute	General Attributes			**19%**	High rise Specific Attributes							**81%**
Secondary Attribute	Organization & Owner related	**12%**	Project related	**7%**	Design & construction related attributes	**23%**	Quality & safety attributes	**8%**	Cost attributes	**31%**	Resource attributes	**20%**
Tertiary Attributes	Experience in similar projects	**35%**	Size of project	**5%**	Uncertainty in the design and drawings	**31%**	Repair and rectification works	**35%**	Price Escalation	**24%**	Construction Equipment requirement	**10%**
	Future prospects with the owner	**17%**	Project Duration	**13%**	Availability of space & logistics	**30%**	Degree of hazard	**30%**	Cash flow crisis	**48%**	Labour availability & productivity at heights	**49%**
	Number of competitors	**14%**	Location and weather conditions	**3%**	Handing over of site in Phases	**7%**	Specialized packages	**3%**	Contractual arrangement	**15%**	Material wastage at site	**14%**
	Payment record of the owner	**21%**	Project Complexity	**42%**	coordination at site	**3%**	Degree of quality required	**22%**	Penalty & LD	**9%**	Qualified staff at site	**15%**
	Existence of PMC	**2%**	Mobilization period	**25%**	Potential scope changes at heights	**29%**	Verticality concerns	**10%**	Transportation cost	**5%**	% of subletting the work	**12%**
	Clearances & approvals	**11%**	Improper Planning	**11%**								

Table 2 Assigned scores of importance to profitability attributes in 12 High rise projects

Attributes affecting Profitability	%	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
General Attributes A: Organization & Owner related	**12%**	**4**	**6**	**6**	**5**	**6**	**6**	**8**	**6**	**7**	**6**	**5**	**6**
A1: Experience in similar projects	35%	5	4	8	6	5	5	8	7	8	7	5	5
A2: Future prospects with the owner	17%	5	7	5	6	9	7	7	3	7	6	6	6
A3: Number of competitors	14%	3	6	5	4	3	6	6	5	5	5	5	6
A4: Payment record of the owner	21%	4	7	5	5	9	7	9	6	9	5	6	7
A5: Existence of PMC	2%	4	7	8	5	9	5	5	5	5	6	7	6
A6: Clearances & approvals	11%	5	7	4	6	5	7	8	6	5	7	5	5
B: Project related	**7%**	**4**	**5**	**8**	**5**	**4**	**6**	**7**	**5**	**5**	**7**	**5**	**6**
B1: Size of project	5%	7	3	5	6	7	3	8	6	7	8	6	6
B2: Project Duration	13%	7	6	8	4	7	4	8	6	6	7	5	5
B3: Location and weather conditions	3%	7	3	5	4	7	4	7	5	4	4	3	4
B4: Project Complexity	42%	3	5	9	5	3	6	6	6	5	7	5	6
B5: Mobilization period	25%	3	3	6	4	3	6	6	4	4	6	6	6
B6: Improper Planning	11%	4	7	8	5	4	8	8	5	7	7	6	6
High rise Specific Attributes C: Design & construction related Attributes	**23%**	**7**	**6**	**7**	**6**	**7**	**7**	**5**	**8**	**7**	**8**	**5**	**8**
C1: Uncertainty in the design and drawings	31%	8	6	5	5	8	7	9	8	8	8	3	8
C2: Availability of space & logistics	30%	7	9	9	7	7	9	4	8	6	7	9	8
C3: Handing over of site in phases	7%	6	3	5	8	6	7	2	8	9	8	9	8
C4: coordination at site	3%	4	4	6	6	4	6	3	7	5	8	9	9
C5: Potential scope changes at heights	29%	7	3	8	7	7	5	2	8	8	8	3	8
D: Quality & safety Attributes	**8%**	**7**	**8**	**8**	**7**	**9**	**8**	**8**	**7**	**6**	**8**	**7**	**6**
D1: Repair and rectification works	35%	9	9	7	7	9	8	7	7	7	9	6	7
D2: Degree of hazard	30%	6	8	9	7	9	8	7	7	6	8	6	6

D3: Specialized packages	3%	4	8	8	3	4	4	7	8	5	9	8	8
D4: Degree of quality required	22%	6	8	8	8	9	7	9	7	6	8	9	6
D5: Verticality concerns	10%	9	9	9	8	8	7	9	8	7	9	9	6
E: Cost Attributes	**31%**	**7**	**8**	**6**	**5**	**5**	**6**	**9**	**5**	**7**	**6**	**9**	**8**
E1: Price Escalation	24%	8	7	5	6	9	6	9	8	6	7	9	8
E2: Cash flow Crisis	48%	8	8	7	5	3	5	9	4	8	6	9	7
E3: Contractual arrangement	15%	4	8	5	7	3	7	9	4	7	7	8	8
E4: Penalty & LD	9%	3	7	8	4	4	7	9	5	5	6	8	8
E5: Transportation cost	5%	4	7	4	6	6	6	9	5	5	7	7	8
F: Resource Attributes	**20%**	**6**	**5**	**7**	**7**	**7**	**7**	**8**	**8**	**7**	**8**	**7**	**8**
F1: Construction Equipment requirement	10%	4	6	5	5	5	8	8	8	6	8	6	8
F2: Labour availability & productivity at heights	49%	8	6	8	9	8	8	7	9	8	9	7	9
F3: Material wastage at site	14%	6	7	4	4	7	7	8	8	6	8	8	8
F4: Qualified staff at site	15%	5	3	7	5	5	6	8	8	7	7	5	6
F5: % of subletting the work	12%	3	2	7	4	4	5	8	6	5	8	7	5
PROJECT COMPLEXITY SCORE		**6.33**	**6.38**	**6.74**	**6.01**	**6.07**	**6.50**	**7.34**	**6.60**	**6.94**	**7.22**	**6.81**	**7.28**

RESULTS – REGRESSION MODEL & PERFORMANCE

Project complexity scores obtained in Table 2 are considered as independent variables and actual profit obtained in these 12 projects is considered as dependent variable to perform regression analysis in order to formulate relation between project complexity score and estimated profit size as defined in$P=k.S+c$…………………………………………………………….. (Equation 2. Analysis is carried out using MS Excel with regress-it plugin and the following equation is formulated.

Predicted Profit size = 0.325 - 0.032*Project Complexity Score…….. (Equation 3)

The equation of the straight line as shown in Figure 4: Linear Regression Plot between Profit size and Project Scoreis estimated using the 12 observations in this dataset. This shows that Profit size and Project complexity score consisting of 32 attributes are inversely proportional to each other. A significance test that the slope is zero resulted in a t-value of -10.5841. The significance level of this t-test is 0.0000. Since 0.0000 < 0.0500, the hypothesis that the slope is zero is rejected. The estimated slope is -0.0322.

Utilising equation 3, estimated profit size for the 12 high rise residential projects are calculated and results are presented in Table 3. Performance is tested through computation of correlation coefficient (R), root mean square error (RMSE), mean absolute percentage error (MAPE), and coefficient of determination (R2), for the developed regression model. Values are presented in Table 3.

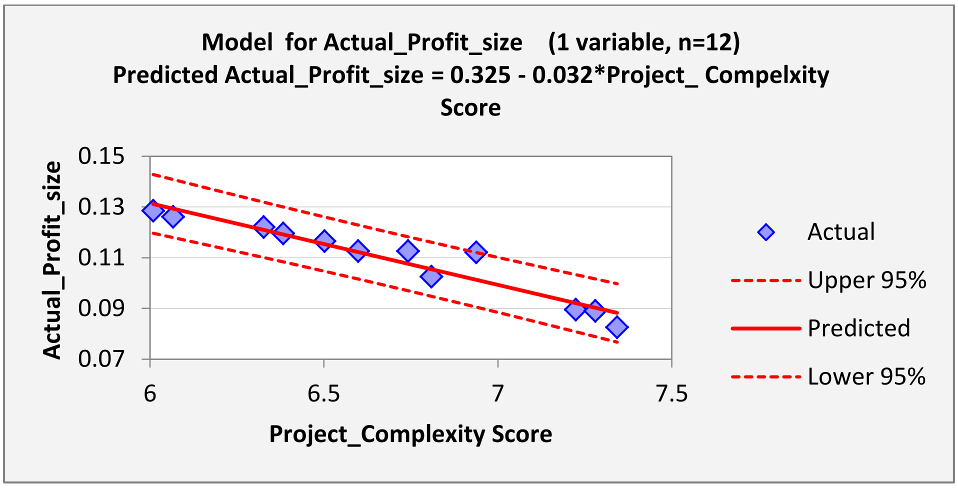

Figure 4: Linear Regression Plot between Profit size and Project Score

Table 3: Regression Analysis results

Project	Project Complexity Score	Actual Profit size	Predicted Profit Size	Performance Results	
High Rise Project 1	6.3269	0.1220	0.1210		
Project 2	6.3831	0.1195	0.1192		
Project 3	6.7424	0.1125	0.1076		
Project 4	6.0094	0.1285	0.1312	**(R) Correlation Coefficient**	**-0.958**
Project 5	6.0663	0.1260	0.1294	**R-squared**	**0.918**
Project 6	6.5022	0.1165	0.1153	**Adjusted R-squared**	**0.910**
Project 7	7.3430	0.0825	0.0882	**RMSE**	**0.00418**
Project 8	6.5983	0.1125	0.1122	**MAPE**	**2.92%**
Project 9	6.9381	0.1120	0.1013		
Project 10	7.2245	0.0895	0.0920		
Project 11	6.8093	0.1025	0.1054		
Project 12	7.2807	0.0890	0.0902		

Correlation coefficient of 0.958 conveys that the relationship between profit size and project score is linear in nature. MAPE value of 2.92%, which is less than 10%, infers that the developed model is acceptable and accurate for application. RMSE value confirms that the regression model is satisfactory in terms of error rate. A value of 0.918 for coefficient of determination concludes that the project score highly correlates with the estimated profit size. The developed regression equation is applied to a high-rise residential construction project consisting of 3 towers with a profile of 3 Basements + 7 Podiums+52 typical floors to correlate the estimate profit size and actual profit size. Characteristics of the project are listed below:

- Payment record of the owner is very fluctuating,
- Handing over of site in a phased manner with ample amount of delays
- Potential scope changes at higher floors due to design issues
- Payments are linked to clearance of Non Conformance Reports
- Labour productivity is reduced at heights
- % of Subletting work is very low and no risk is involved in it
- No PMC is involved in the project

Project score is computed (as calculated in Table 2) and found to be 6.55. Estimated profit size is calculated using the equation:

Predicted Profit size = 0.325 - 0.032*Project Complexity Score…….. (Equation 3) = 0.1152=11.52%

Actual profit size considered for the project is 11.95% and it concludes that the error of model is 4% which is acceptable. Model is limited to residential high rise projects from an Indian perspective and the attributes can vary with respect to organisation and location.

CONCLUSIONS

This study applied AHP and regression analysis to estimate the profit size based on series of attributes quantified by a Project complexity score. Attributes are identified based on the reasons stated for cost overrun in several projects and literature available. Out of several attributes identified, Price escalation, Potential scope changes at heights, productivity at heights, logistics proved to be dominant attributes affecting profitability of high rise residential projects. Developed model is applied on a high rise residential project and found that it yields results with 95% accuracy provided the importance levels are filled as per the project considered. This proposed model can serve as a decision aid in estimating profit size thereby relaxing construction management professionals from the constraint of imposing perceptions in making decisions. This model has considered all the attributes influencing the profitability in High rise residential construction. Procedure adopted is a generic one and it can be varied to suit to the conditions prevalent in a particular project. In spite of decision tools like the one developed in this paper, actual profit size estimation involves emotional pressure for the contractor during the negotiation stage. Profitability models can only guide the estimators to ensure that the negotiations doesn't go beyond the minimum mark-up level.

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BEYOND CONSTRUCTION…..A CROSS-DISCIPLINARY APPROACH TO IMPROVED LEARNING AND TEACHING IN BUILT ENVIRONMENT DEGREES

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ABSTRACT

More than 3.4 million people die each year from water, sanitation and hygiene-related causes. Lack of access to clean water and sanitation kills those most vulnerable in the third world. Leadership in managing cross-disciplinary teams is required to present economical, viable community-based solutions. This project utilised the skills of undergraduates across different disciplines of construction, project management, engineering, design, and communication, to work alongside industry mentors in a team to design, build and present an innovative, sustainable water sanitation solution for a Bangladesh community. The semester-long project enabled undergraduate students to develop skills in client relationships, teamwork, and communication as well as discipline skills of project management and construction. The real-world problem necessitated a paradigm shift away from discipline-based knowledge transference towards skills for the future. The project utilised approaches such as negotiated curriculum and assessment; self-directed, flexible participation in learning; use of social media as a learning tool and cross-disciplinary teamwork. Results from student surveys and interviews indicate that this project directly enhanced students' work-readiness skills and recognition of the importance of problem solving using cross-disciplinary understandings. Students reported greater self-confidence for tackling future workplace challenges. The results also illustrate strong levels of student satisfaction with the cross-disciplinary approach and the importance of skills in client relationships. The project and its outcomes have implications for how learning and teaching occurs in built environment disciplines and has the potential to create significant impact on the calibre of future built environment graduates.

Keywords: built environment, cross-disciplinary, work-readiness

INTRODUCTION

More than 3.4 million people die each year from water sanitation and hygiene-related causes. Nearly all deaths, 99 percent, occur in the developing world, with lack of access to clean water and sanitation killing those most vulnerable in their communities(Health Habitat, 2014) With 780 million people worldwide lacking access to an improved water source (or approximately one in nine people in the world), this is a pressing and complex global issue. Of critical importance is the need for emerging graduates to understand such global issues and problems and to practice, utilize and reflect upon the relevance of their skills in seeking solutions. Solutions to such issues require leadership, innovation, design and team approaches based upon strong cross-disciplinary skills.

Whilst Australian tertiary institutions list a range of skills as graduate attributes, there is often little evidence of the development of cross-disciplinary skills in tertiary courses in the built environment (Bridgstock, 2009). Yet the demand for a well qualified cross-disciplinary future workforce is increasing. The Organisation for Economic Co-operation and Development (2012) identifies the supply of skilled cross-disciplinary professionals, as an urgent global problem. This increasing global demand for "new" graduates with cross-disciplinary experience and knowledge is a result of a number of factors:

- the growing use and impact of information technologies inter-woven across all disciplines;
- the high rate of innovation fuelling rapid application of advances in cross-disciplinary products and processes;
- the growth in more complex global interacting problems (climate change, global security, environmental management, food and water supply etc); and
- the shift to more knowledge-intensive industries and services, not reliant upon single discipline responses.

Literature Review

Educational trends in learning and teaching of all tertiary disciplines focus upon the need for industry-related approaches to student learning, that maximise opportunities for future employment and lifelong learning (OECD, 2014). There is evidence that best practice approaches to learning and teaching ensure that students not only acquire knowledge, but also learn how to apply and adapt this knowledge to a variety of contexts (OCS, 2014). In parallel with this learning, students are expected to acquire generic skills of working in cross-disciplinary teams and projects. However built environment learning and teaching remains, for the most part, discipline-content entrenched. In many cases, built environment courses are taught through discipline-based examples which are not reflective of real-life industry problems. In many cases, built environment disciplines are seen as opportunities to induct students into the content of the discipline, not as opportunities to develop cross-disciplinary skills or develop solutions to complex future problems. Many cross-disciplinary projects remain at the fringes of the curriculum, often in the "project, competition or challenge" arena, and are not capitalised upon at the institutional level or at the national level for the benefit of other tertiary built environment students and staff.

Increasingly the needs of employers and future global work opportunities do not recognise boundaries of discipline-specific education. Preparing students for new ways of dealing with growing bodies of knowledge that no longer fit neatly into a discipline programme creates enormous challenges for tertiary institutions organized along strict built environment discipline lines. Global industries require individuals with skills and knowledge across a range of disciplines. If teamwork is undertaken in built environment courses, it is often between other built environment students. Teams are rarely cross-disciplinary. Providing access to teamwork only between other built environment students and discipline-entrenched tertiary learning is limiting options for future graduates. Embedding cross-disciplinary approaches into core undergraduate built environment discipline curricula is for most universities unfamiliar territory.

Cross-disciplinary teaching can have a positive effect upon students' achievement, satisfaction and employability (Pang & Good, 2000). There is also sound pedagogy behind cross-disciplinary courses, with advocates finding that such courses capture students' intellectual interest (Lattuca et al. 2004), prepare students for work by developing higher-order cognitive skills (Kavanagh, 2011), and increase students' tolerance for ambiguity, sensitivity to ethical issues, and creativity (Newell, 1994).

This paper examines the introduction of a cross-disciplinary course, the Water Innovation Challenge (WIC) Project Course, into the built environment discipline and other disciplines, at RMIT University in 2014/5.

Research Method

The Water Innovation Challenge Project Course created opportunities for staff and students from four different discipline-based RMIT schools to work alongside industry practitioners in a multi-skilled team to design, build and present innovative water sanitation solutions for a selected Bangladesh community. The project client responsible for the community selection and installation was Health Habitat, a global Non-Government Organisation operating across many third world countries. The project objectives were:

- To realise a viable water sanitation solution for a Bangladesh community
- To meet client needs in tender documentation (CAD, Budgeting, solutions etc), solution presentation etc and practical showcase to demonstrate the solutions.
- -to showcase cross-disciplinary learning across a range of disciplines, including built environment.

The project course was conducted intensively over an eight week period in semester one. A total of 16 students were invited from science, engineering, built environment and health degrees and certificate 4 in plumbing services. Upon completion, students were awarded credit in their own programmes and, where necessary, engaged in negotiated assessments in their discipline degrees. A total of 16 students enrolled into the project course. Four of the students were selected from the total student group to present the final tender and sanitation solution to Health Habitat (the NGO client) in Singapore as part of a Worldskills Challenge event. Staff involved in the project course represented engineering, health, construction/project management, plumbing, media and IT disciplines. Staff and students were given a brief and information by the client. They worked in one large team with needs-based sub-groups formed and reformed as the project progressed.

The project course capitalised upon the RMIT tertiary advantage of being a multi-sector institution with students and staff from VE and HE working alongside each other. The project course required new approaches to learning and teaching and student engagement, moving away from discipline-based content and learning to cross-disciplinary problem solving. These approaches were based upon current models of pedagogy and problem-based learning (Kuenzi, 2008; Rice, 2011; Devlin & O'Shea, 2012).

Scehduled sessions were organised around themes of the project (local resources, CAD, public health, costings etc) and students worked together in a cross-disciplinary group. Session times were flexible. Smaller teams/subsets of the project team were formed, reformed and disbanded as the project scope demanded. Although a formal class time and place once a week was set, attendance was not compulsory. There was flexible participation in the learning with new staff and post-graduate students joining the group as skill needs dictated e.g. editors, writers, cartoonist, CAD operators.

Social media was used as a communication and document control tool. A Google site, Facebook page and drop box were used as a virtual "meeting place" and "exchange". Evaluation and feedback was built into the learning process, with set time devoted each week to evaluation of the design and development processes. This opportunity for reflective practice enabled students to scaffold their learning each week and focus upon emerging barriers to completion.

Milestones were created by the group. These milestones formed the assessment for the courses, with reflective journals and final documentation/solution to client, forming most of the assessment. Academic staff acted as a resource and organised industry speakers and other sources of information. Students worked on self-arranged themes and met with the client a number of times (including skype) over the semester. All students completed the tender to presentation stage. Four of the students were selected from the total group to present the final tender and sanitation solution to the client, Health Habitat.

Students' negotiated credit and assessment in their own discipline programmes based upon their contribution to the project. This concept of negotiated assessment guides students in their learning and allows them to exhibit control of their learning programme. This negotiated assessment was aided by staff interventions where necessary

All students from each discipline were able to participate, and learning and teaching practices were deliberately inclusive to enable full participation Students involved in the WIC Project came from diverse backgrounds with differing levels of knowledge, skills and abilities. The organisation of the project allowed all students to participate in the team work. Staff mentoring assisted all students in achieving outcomes. Inclusive practices included mentoring, virtual support and peer mentoring.

Results and Discussion

Students in this project were surveyed and a smaller number (6) participated in semi-structured interviews asking them to elaborate on the survey questions. The collection of this data took place at the end of the semester. Their interview responses and their answers to the written survey were recorded. Table 1 (below) shows a summary of the survey responses.

Table 1: Student responses to survey questions*

Survey Question	**Yes**	**No**	**Don't Know**
Did you like working with students from different disciplines and levels of study?	95%	0%	5%
Did you think that this project has prepared you for work once you graduate?	85%	0%	15%
Would you undertake similar types of cross-disciplinary projects/courses in the future?	100%	0%	0%

*(response rate: 67%; n=13)

These results indicate the success of the cross-disciplinary project course. This project was distinctively innovative in the development of built environment graduates for the future. The first distinction lies in bringing together a cross-disciplinary cohort from a range of disciplines to examine the problem from new perspectives, to value the skills of others and to utilise the learning of others in solving new problems. As identified earlier in the paper, the critical need for tertiary students to work in cross-disciplinary teams and explore the interconnection between future skills and knowledge requirements of industry must be enhanced (Lyons, Quinn, 2014). In this project course students were provided with this opportunity. As one student responded:

> "It allowed me to develop and work in an environment that would reflect the real world and I have learnt so much about working with others in a team project."

In the student surveys when asked "Did you like working with students from different disciplines and levels of study?" 95% of the respondents said that they liked working with students from different disciplines. This satisfaction level mirrors earlier findings by researchers into the value of integrated approaches in teaching cross-disciplinary courses (Pang & Good, 2000; Kavanagh, 2011). This understanding of the need for new knowledge and cross-disciplinary team approaches was readily embraced by nearly all the students:

> "The team itself included individuals of diverse experience and background. This provided a simulation of how engineering problems are faced in the real world. The experience was invaluable."

Another student commented that:

> "A variety of different knowledge backgrounds allowed the team to understand situations from different perspectives."

This was further evidenced by their comments upon their learning:

> "I like to learn from people from other fields to expand my knowledge and maybe change my view of things."

Another student responded with,

> "It's much more closely aligned to how industry operates, which is something that is not often addressed in normal studies."

However not all students were comfortable with being in a cross-disciplinary team with 5% responding negatively to the question of working in cross-disciplinary teams. There are challenges to this type of pedagogy. These include creating a suitable learning environment, differences in discipline approaches to problem-solving, different levels of commencing knowledge and communication across the team. Some students described how working in a cross-disciplinary team was a personal challenge, and they felt uncomfortable with the learning approach. Student comments outline these challenges:

> "It was OK but it was hard co-ordinating people from different courses, and I didn't like it."

> And: "It took me by surprise. A lot of it was left up to us to understand….we had to make sense of what was happening."

This "uncomfortableness" with the learning approach and the challenge of cross-disciplinary team members, is one that can be overcome, as students grow towards an understanding of their role in a cross-disciplinary team and their ability to contribute. As Kavanagh & Cokley (2011) note, the communication of potential hurdles and team challenges can solve much initial student wariness, but the importance of acquiring new skills in cross-disciplinary understandings should not be negated by such challenges.

Through this real-world water sanitation problem, the students were able to access, filter and critically engage with new knowledge and new ways of knowing. When surveyed with the question: Did you think that this course has prepared you for work once you graduate, 85% of the students believed that the course had prepared them for work upon graduation. Students commented that:

> "It showed me how to work effectively in a team for a real-world project"

> "It was a steep learning curve for me- not all are from my field, so I didn't know how to deal with that at first, but in the end I was really confident working & leading."

Other students demonstrated their desire to "extend themselves beyond their comfort zone" and place themselves in situations where they were "forced" to lead:

> "This project has really prepared me for work. I had to exhibit leadership, time management skills and most of all, incorporate client requirements into our design"

The project course also directly enhanced the student experience and their overall engagement. This was evidenced by their comments upon completion:

> "This was an awesome learning experience"

> "I have learnt so much about working with others in a team project with real deadlines"

In this project the built environment academic staff engaged with the students as professional peers, collaborating on activities. This is in contrast to approaches in other courses which are traditionally seen as opportunities to induct students into the content of the discipline, not as opportunities to develop solutions to complex cross-disciplinary problems (Rice, 2011). In this project, the collaboration was not "teaching" but more closely resembled a face-to-face dialogue between two sets of learners each prepared to teach the other something new. This approach resulted in built environment staff and students at all stages of experience and knowledge entering 'into a co-learning relationship guided by action and reflection' (Huesca, 2003). One student commented:

> "It was certainly different, and effective, we always discuss ideas and share knowledge with others, even staff!".

A final difference was that the challenges were real global issues, along with the client. The purpose and objectives of the project were clear to all and students involved. The students noted this understanding of purpose, illustrating their understanding and knowledge of the design/tender/presentation processes involved in real-world projects:

> "One of the most significant opportunities that this course has given me to this point is the chance to use my skills learnt thus far in designing and implementing a solution to a real-world problem in a disadvantaged community. Most employers require the demonstration of working in teams. The exposure to a variety of disciplines and skill levels is much more reflective of the workplace and as such I feel it was highly valuable."

This project was unique in that it addressed a critical need in built environment education: cross-disciplinary team work. Students were aware of the value of the project course:

> "This project has really prepared me for work. I had to exhibit leadership, time management skills and most of all, incorporate client requirements into our design"

The project course has resulted in significant impacts within the university, the sector and the government. It has been a true demonstration of RMIT's strategic plan of being a tertiary institution that is *"urban, global and connected."* (RMIT, 2011 – 2015). Over 60 students from health, engineering, science, construction management and VE associate degrees have applied to be involved in the next semester project. New staff will be involved in the next semester project course, including two early career academic staff. Students and staff made a presentation at the Singapore Water Innovation Conference and Expo 2014 and the staff involved were awarded an innovation teaching award at RMIT university in 2015.

Much of current discipline-entrenched built environment learning and teaching has not equipped tertiary students to adequately tackle problems requiring cross-disciplinary solutions. All of the students, both in the surveys and the interviews, noted their lack of discipline preparation in working in a cross-disciplinary team and their lack of ability to move beyond their discipline boundaries to solve problems and to apply knowledge in new ways. They indicated that their discipline group work had not prepared them well for the challenges of working with people from diverse industries. However all of the students surveyed enjoyed the project course as an engaging experience and over three-quarters of them felt they learnt more through involvement with other disciplines. Of concern was the fact that all of the students involved in this project course felt that cross-disciplinary work for real clients was unique in their education to date in the university. The skills gained through cross-disciplinary teamwork and meeting real client deadlines and expectations were the most obvious of skills and knowledge identified by the students.

As with all action research studies there are limitations to the results. Firstly, this research has only examined the outcomes from the project course at one university. In addition, the sample sizes in this project course was very small due to the nature of both the project and the rigidity of built environment curricula. The project course was an elective for discipline students, so the cohort did consist of a large number of students who had elected to be there. Participating students may not be representative of students in other educational institutions. Consequently, generalising findings to other student groups should be done cautiously.

A second limitation relates to the duration of the projects, as well as to students' overall experience as learners in a higher education setting. Whilst there were some final year students involved, there were also a number of first year students. When the students were surveyed and asked if they felt they had learnt valuable work skills for the future, 15% of them were undecided and responded "don't know" to the survey question. Those who clarified their response typically said that it was too early in their university programme to have a sense of graduation benefits. For example one student commented that:

> "It has definitely been beneficial in simulating real-world experiences, however first year is a little too soon to tell."

Finally the sustainability of such learning is the challenge for built environment cross-disciplinary approaches. There is a need for senior leadership to provide greater cross-discipline co-operation and recognition and support of these approaches in tertiary institutions. The irony is that for many of the students involved in this project, they already understand this need, with 81% of them responding positively to the question of future cross-disciplinary study. As one student summed it up: "I would take classes like this again because it is so interesting and useful for the future."

It is the very limitations discussed above that may provide avenues for future research such as the broader involvement of wider ranges of disciplines, the broadening of the student diversity and the embedding or sustainability of these project courses over time. Finally there may be opportunities to explore future employment patterns of students undertaking cross-disciplinary built environment courses and their career pathways. Such research would provide valuable windows into the role of cross-disciplinary learning in career aspirations of built environment graduates.

Conclusions

This project involved only a small number of students and staff from the lead university- this is an obvious limitation. However, it is evident from this small study that student skills in cross-disciplinary teamwork, communication and problem-solving can be developed and nurtured. There is also evidence that students were more engaged and motivated in cross-disciplinary learning activities.

Expanding student options and providing work-relevant cross-disciplinary learning and teaching in built environment degrees is fundamental to meeting Australia's future needs, as well as providing social and individual satisfaction. The development of capacity and senior leadership that nurtures and creates collaboration across disciplines and fosters and grows confidence amongst academic staff in promoting these cross-disciplinary projects and curricula is also required for the sustainability of these approaches. There is an urgent need to develop undergraduate skills in applying the interconnectedness of knowledge across disciplines. Doing this will necessitate a change of thinking about the value and curriculum place of cross-disciplinary, global approaches to learning and teaching in built environment disciplines.

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CONSTRUCTION PROFESSIONALS' PERCEPTION OF SUSTAINABILITY IN DEVELOPING COUNTRIES

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ABSTRACT

Sustainability has been defined in various ways within the academic literature. Definitions vary depending on the country of origin and the disciplinary focus of the author(s). Some view sustainability as a process, while others see it as the management of a process to ensure its longevity. Within the construction industry, sustainability has also been the subject of much debate. Decisions made by construction professionals about sustainability are likely to be based on their perceptions. A perception is the way a person understands something and no two people perceive the same situation in exactly the same way. Much of the literature about sustainability draws on the experiences and perceptions of researchers in developed countries. However, the challenges facing those in developing countries are arguably very different. This paper provides background to a study that seeks to establish construction professionals' perceptions of sustainability in developing countries. It reviews existing literature from both developed and developing countries to identify research gaps. The paper concludes by identifying questions that will provide an insight into perceptions of sustainability among construction professionals in developing countries.

Keywords: construction industry, developing countries, perceptions, professionals, sustainability

1.0 INTRODUCTION

Sustainability is the continuity of a system over a period of time. it encompasses environmental, economic and social factors (Nwokoro &

Onukwube, 2015). These interpretations can be linked to the fact that there is no common definition for the term. Various disciplines understand sustainability in different ways (Jailani, Reed, & James, 2015). The World Commission on Environment and Development's longstanding definition states that sustainable development is the 'development that meets the need of the present without compromising the ability of future generations to meet their own need' (WCED, 1987, p. 66). The terms sustainability and sustainable development (SD) are used interchangeably and at times interpreted in the same way. Although some researchers (Du Plessis, 2002; Hill & Bowen, 1997) have argued that there is a difference between the two terms, their aims are similar: to decrease the negative effects of mankind on the environment as much as possible.

Across developing countries, particularly in Africa and Asia, infrastructural development is currently soaring as a result of rapid urbanisation. This implies more construction activities and although they negatively affect the environment (Abidin, 2010; A. Dania, J Kehinde & K. Bala, 2007), they proffer opportunities to build sustainably. Construction professionals may be the professionals responsible for the provision of more sustainable buildings. However, the literature shows that they remain unsure of what sustainability entails. Some view sustainability as a process, while others see it as the management of a process or system to ensure its longevity. The debate about the meaning and achievement of sustainability is still current owing to differing professionals' views (Du Plessis, 2001). Perceptions play important roles in decision-making and contribute to decision makers' attitudes (Arif, Syal, Florez, Castro, & Irizarry, 2013). That is, one's perception influences one's attitude. Since perception affects decision-making, it is imperative to establish construction professionals' perceptions of sustainability.

The paper provides background to a study that seeks to establish construction professionals' perceptions of sustainability in developing countries. It reviews existing literature from both developed and developing countries to identify research gaps. It builds on a similar study (Emmanuel et al., 2014) that assessed *'professionals' perception of sustainability performance of infrastructural projects in Nigeria'* and the work of Abidin (2010) and Babawale and Oyalowo (2011) who examined the perceptions of a construction professional. This will contribute to the body of information supporting this piece of research.

2.0 LITERATURE REVIEW

The concept of sustainability is well established and has been accepted by various organisations, individuals, governments, businesses and institutions around the world (Ofori, Briffett IV, Gang, & Ranasinghe, 2000; Yao, 2009). The World Commission on Environment and Development's (WCED) definition is viewed by some factions of the scientific community as being too basic (Oskamp, 2002). For example, Pearce (2005) defines sustainability as something that accommodates conventional financial concerns, as well as environmental and social effects that are referred to as the 'triple bottom line'. Du Plessis (2002, p. 6) defines sustainability as '*the condition or state which would allow the continued existence of Homo sapiens, and provide a safe, healthy and productive life in harmony with nature and local cultural and spiritual values'*. Furthermore, Du Plessis emphasises the comfort of humankind in all ramifications and relates it to culture and environment. More so, Neuman and Churchill (2011), describe it in a theoretical and mathematical term as a process sustained over time without exceeding the innate ability of support from its environment. These definitions suggest that opinions about sustainability differ, are personal (Kemp & Martens, 2007) and may be problematic (Leiserowitz, Kates, & Parris, 2006). The literature also reveals that sustainability is a broad term that is not instinctively understood and well-communicated (Newport, Chesnes, & Lindner, 2003). Arif, Syal, Florez, Castro & Irizarry (2013) consider it to be a concept without an accepted definition and with no simple definition or graphical representation. It lacks a defining, vivid image or particular focusing event (Leiserowitz et al., 2006). From the aforementioned studies, it is clear that no single definition of sustainability exists but its meaning, importance and principles are highly topical (Emmanuel et al., 2014). For the purpose of this study, sustainability is defined as the action taken to strike a balance between social, economic and environmental factors in achieving the present and future demands of humans.

The decisions of construction professionals during conceptual, construction and post construction stages affect the overall success of a project (Abidin, 2010). Their technical advice and decisions are informed by their qualifications and experience and these are filtered through their perceptions (Babawale and Oyalowo, 2011). Perceptions therefore play important roles in decision-making and contribute to decision makers' attitudes (Arif et al., 2013) which translate into behaviours. Perceptions are the ways in which a person understands something and no two people perceive the same situation in exactly the same way. According to Rao (2008), perception is a process by which individuals organise and interpret what their sensory nerves perceives in order to give meaning to their environment. It is a process of interpreting present stimulus based on past experience (Sharma, 2013). This implies that there is no perception without past experience. A person's attitudes, personality, motives, interest, experience, and expectations are personal characteristics that affect their perceptions (Rao, 2008). Our experiences, interests and expectations are drivers of our perceptions. Awareness of our perceptions and what drives them is key to being successful (Rao, 2008).

Recognising the need for changes in human values, attitudes and behaviour is key to achieving a sustainable transition to meet human needs and prevent environmental hazards (Development, 1999). Du Plessis (2007) argues that behavioural changes occur through personal commitment. Behavioural change is by choice and not by force. It is necessary for achieving the goals of SD. Literature (Du Plessis, 2007; Pitt et al., 2009) shows that SC begins with a positive attitude and behaviour. According to Gan, Zuo, Ye, Skitmore, and Xiong (2015), attitudes, perceptions and understanding of the principles of sustainability promote SC. They identified professionals' misperceptions of sustainability as one of the challenges of the industry in Southeast Asia. Ashley, Blackwood, Butler, Davies, Jowitt, & Smith (2003) assert that many construction professionals do not understand sustainability which makes it difficult for them to implement. Also, Dania et al. (2007) found practicing Nigerian construction professionals were lax in incorporating sustainable concepts in their projects. Based on their experience, exposure and successful implementation of sustainability principles in developed countries, it seems that their construction professionals have a better understanding than those in developing countries. The question is: What perceptions of sustainability do construction professionals in developing countries hold that are different from their counterparts in developed countries?

3.0 METHODOLOGY

This section discusses the methodology adopted for this study. It identifies the researchers' worldviews and the philosophical framework adopted.

Concepts are perceived in different ways. The way individuals interpret the world around them varies and depends on several causative factors (Creswell, 2007). We all have inherent assumptions as well as prejudices about the world: different views exist in different fields and in different minds (Fitzgerald and Howcroft, 1998) and within research these are referred to as worldviews. According to Samples (2007), quoting Nash's (1988) definition, a worldview is *a conceptual scheme by which we consciously place or fit everything we believe and by which we interpret and judge reality'.*

Creswell (2009) identifies four worldviews which are positivist, constructivist, advocacy/participatory and pragmatist. In the same vein, Wilson (2001) describes the paradigms in research as Ontology, Epistemology, Methodology and Axiology. Wilson (2001, p.175) defines a paradigm as *"a set of beliefs about the world and about gaining knowledge that goes together to guide people's actions as to how they are going to go about doing their research".* These beliefs guide actions in research (Guba, 1990). Determining the worldview to adopt in a particular field of research depends on the objects being studied (Valerdi & Davidz, 2009).

This study seeks to establish construction professionals' perceptions of sustainability. Based on Honore's (1997) argument that our beliefs, decisions, assumptions and modes of problem solving affect our worldview, it is important to understand professionals' worldviews as well as ours. This is in agreement with Bishop, Higgins, Casella and Contos (2002, p.611) who state that, *"understanding worldviews of both targeted community and ourselves is imperative if we are going to do more good than harm".* The worldviews of professionals from different countries are presumed to be different which represents different realities. Thus, this study has adopted an ontological paradigm of relativism. This is the belief that multiple realities exist as subjective constructions of the mind (Fitzgerald and Howcroft, 1998). Perceptions here represent the multiple realities held by professionals.

Having identified the nature of reality (ontology) (Hudson and Ozanne, 1998), it is important to discuss how we think about reality. Reality literally refer to how things really are and not imaginations. Since the study is concerned with how construction professionals perceive sustainability, we have adopted the epistemological paradigms of interpretivism (constructivism) and subjectivism. These are philosophical frameworks that reveal the researchers' position on the subject matter. According to Petersen and Gencel (2013, p.1) *"interpretivist seek for subjective reality, constructed by how human beings see and interpret the world around in their respective context".* In this case, construction professionals are the subjects while their perceptions are the realities. Their perceptions of sustainability will be the findings to be interpreted by the researchers. The interaction between researchers and the research situation in this case agrees with subjectivism (Fitzgerald and Howcroft, 1998). The study therefore relies on the participants' (construction professionals) views of the situation (sustainability) being investigated (Creswell, 2003, p.8).

Inductive reasoning is when specific instances are used to arrive at overall generalisations (Fitzgerald and Howcroft, 1998). This is applicable to this study as the perceptions of sustainability obtained from a set of construction professionals in one developing country will be used to generalize conclusions of the findings in other developing countries. More so, the findings will assist in theory conception for further studies. This is distinct from deductive reasoning where general results are used to achieve specific instances (Fitzgerald and Howcroft, 1998). A phenomenological approach is adopted within this research.

According to Van Manen (1990), phenomenology implies people's perceptions of an object or event and not the object or event being independent of the people. It attempts to harness people's understanding of a particular situation, their perceptions and perspectives. Phenomenologists use questions like *"what does it mean to"* or *"what is it like to"* in finding answers to questions posed by their study (Nicholls, 2009b). The focal point of this study is to understand construction professionals' perceptions of sustainability, which aligns with the idea of phenomenology. Therefore, the varied perceptions of professionals will be used to make some generalisations of sustainability in developing countries.

Based on our worldview, philosophical framework, form of reasoning and methodology, our study is qualitative in nature. Interviews were deemed suitable for this study because they are useful in obtaining detailed information about participants' feelings, perceptions and opinions about a topic. This method involves finding and understanding the meaning of central themes through exploratory questions.

The study proposes a semi-structured interview owing to the complex nature of the main theme and to allow for further probing. Semi structured interviews utilise a set of broad questions and themes (Nicholls, 2009a). For this study, Nigerian construction professionals shall be interviewed. These are the principal players employed by clients in construction projects. Being the key informants in this study, they will be recruited through a search of their respective professional bodies' websites, including the Nigerian Institutes of Architects, the Nigerian Institute of Builders and the Nigerian Society of Engineers. Ethics approval will be sought from the ethics committee of the University of Newcastle, Australia.

The following question guide with questions adapted from literature is proposed to reveal the stance of construction professionals.

i. What is your understanding of the word "sustainability"?
ii. What are your feelings about sustainability?
iii. What influenced your feelings about sustainability?
iv. What sustainability issues do you think are the most important and why?
v. How does your personal efforts affect these issues?
vi. What sustainable construction principles are you aware or familiar with?
vii. Do you think it is worthwhile to incorporate sustainable construction? If no, why? If yes, please expatiate.

The expected outcomes of this study are set in the context of developing counties. They will enable a detailed description of the factors that influence construction professionals' perceptions of sustainability and their understanding of the principles of sustainable construction. These outcomes will influence their decisions, and contribute to studies which inform debates and activities about the implementation of sustainable construction in developing countries.

5.0 CONCLUSIONS

This study has reviewed relevant literature and identified research gaps which form a foundation for this research. The paper has identified the lack of common definition of sustainability in the construction industry. It has also indicated that there are no perceptions without experience and that these experiences influence perceptions. The question, what perceptions do professionals in the construction industry in developing countries hold about sustainability was raised in the paper. The proposed methodology which encompassed the research philosophy (Constructivism), phenomenological and inductive approaches and interview method was introduced in conjunction with questions that will be presented to participants to provide insights into construction professionals' perceptions of sustainability in developing countries. These should, in turn, encourage a common understanding of the term, and may alert other communities to nuances of interpretation. In time, this should lead to the practical application of sustainability concepts in construction projects. Such moves would contribute to an industry with sustainability conscious professionals and an environment with a smaller ecological footprints. This study is significant as it will support and enrich the meagre existing data about construction professionals' perceptions of sustainability in developing countries.

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INVESTIGATING THE USE OF SUSTAINABLE TECHNOLOGIES IN EXISTING BUILDINGS FOR ENERGY EFFICIENCY

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ABSTRACT

The overall energy efficiency of existing buildings may be improved by the installation of sustainable technologies (STs). This paper investigates STs adopted to improve energy consumption, and identifies which class of technology has been mostly used to improve energy efficiency. To achieve this aim, existing buildings were evaluated on the basis of the type of STs installed during retrofitting to achieve energy efficiency. The research approach is a survey of professionals in the construction industry. A questionnaire was designed based upon literature and current available information on the various sustainable technologies used to improve energy performance of existing building through renovation actions. Through the survey, various STs installed in various types of building were recorded and analysed. The results show that close to 80% of the STs installed during retrofitting are those targeting the lighting and control systems, energy efficient insulation systems for old buildings, sensors, energy management systems and smart meters. The rest are double glazing, natural ventilation, energy efficient fans, energy efficient hot water systems, and water efficient systems. However, less than 10% targeted the building façade, ventilation, and air conditioning (HVAC) and solar systems.

Keywords: existing buildings, energy efficiency, environmental sustainability, retrofitting, sustainable technology

INTRODUCTION

In Australia, the Department of Climate Change and Energy Efficiency (DCCEE) in 2012 reported that energy consumption in existing buildings had increased sharply and was projected to increase by over 20% from 136 PJ to 169 PJ before 2020. According to Russell-Smith et al.,(2015) existing buildings are among the largest energy consumers and GHG emitters in many developed economies. Felipi (2014) is of the view that large number of existing buildings are characterised by low energy performances. Therefore, rapid improvement of energy efficiency in existing buildings is essential for timely reduction of energy use. These actions are becoming necessary against the backdrop that, awareness about the effects of construction and its related activities on the environment has grown greatly over the years (Glasson et al.,2013; Zhang and Wen 2008). The adoption of energy efficient measures by small and medium manufacturing companies is on the rise (Aaki et al., 2013; Muthulingam et al., 2013). This is because retrofits can routinely achieve 25-70 % savings in total energy use (Levine et al., 2007; Harvey, 2009).

Many research studies have focused on the elemental components of buildings in terms of renovations to improve energy performance. These components include walls, windows, doors, HVAC systems, lighting etc. Furthermore, research studies focused on analysing the building materials and systems for exterior wall systems such as Trombe wall innovations (Dabaieh and Elbably, 2015; Zhou and Pang, 2015). Many more have been undertaken to evaluate energy performance through the implementation of various sustainability measures in buildings such as energy efficient lighting (Mahlia et al., 2011), and financial and energy impacts of compact fluorescent light bulbs (Houri and Khoury, 2010). HVAC systems and energy efficiency (Fong et al., 2007; Jayamaha, 2007; Teke and Timur, 2014) energy and environmental assessment benefits construction materials and components used during retrofits (Ardente et al., 2011).

However these studies rarely indicate sustainable technologies introduced during renovations of existing buildings, especially in Australia. Also there is no single research study that has focused on identifying all the major STs used to improve energy efficiency. Therefore this paper is concerned with investigating existing sustainable technologies available and used to improve energy performance. The main purpose is to investigate the extent to which STs are adopted to improve energy efficiency and environmental sustainability performance of existing buildings through renovations.

BACKGROUND

The basis of technology actually started with simple tools and systems. In the opinion of Grübler (1992) technology is a system or tool that enables users to develop new ideas. Being a system and a tool means its helps in achieving some amount of work done with ease. Aryes (1994) agrees to some extent with Grübler (1992), the point of departure relates to a shift from simple tools to a phenomenon. According to Aryes (1994) technology can be considered as the application of ideas together with other possible methods to change raw or unprocessed concept to a more useful condition capable of achieving the needed results. It is helpful to merge these definitions. Thus the actual mergence was provided by Weaver et al. (2000). Technology is a means that helps humans to change the functions and how those functions improve other facilities to make them more relevant (Weaver et al., 2000).

Arthur (2009) further summarises all the earlier definitions into a single generalised position by classifying technology as a means to an end. Accordingly Arthur (2009) stated that a technology is a bridge connecting different possibilities, that is, technology is a "means to a purpose". Generally, technology can be viewed from two basic perspectives. That is, those that are designed to achieve and maintain high environmental sustainability and those designed to perform otherwise. Those that are focused on energy performance thereby contributing less to the effects of the available minimal natural resources classified as sustainable technologies.

A sustainable technology should be capable of presenting and providing what is needed without negative effects on the environment (Weaver et al., 2000). Mulder (2006) stated that sustainable technology can be a system or technique built to reduce significantly the impact of energy demand in buildings with the sole purpose of achieving environmental sustainability. However there are benchmarks these technologies are expected to meet. Any technology that exceeds the benchmark of conventional systems in reducing energy can be classified as a sustainable technology (Syed, 2012). Sustainable technologies fall under four major headings:

- Energy efficient technologies-façade, shading, orientation, lighting systems, air-conditioning systems etc.
- Renewable energy systems-Solar, wind, geothermal, biogas etc.
- Water systems-recycling etc.
- Climate change- supercritical and ultra-supercritical boilers and advanced combined-cycle gas turbines etc.

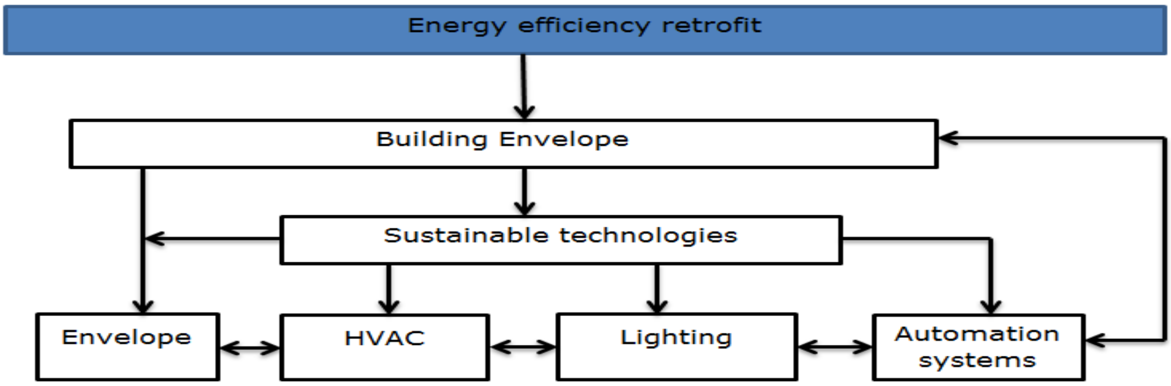

Fig. 1: Framework of sustainable technology application

Energy efficient technologies for existing building renovation

These are technologies addressing the building façade, lighting installations, natural ventilation, daylighting systems, shading, orientation, lighting systems, air-conditioning systems, high performing building envelope systems etc. to improve energy performance of buildings. Improvement in energy consumption of existing buildings has been explored extensively, especially where sustainable technologies are focused on improving building envelope and heating, ventilating, and air conditioning (HVAC) systems.

The lighting system is an integral part of a building's architectural design, and interacts with the shape of each room, its furnishings, and the level of natural light. Mahila et al., (2011) considered a number of alternatives needed to improve energy savings. The first is by replacing electromagnetic ballast with electronic ballast. The second alternative is to reduce wattage by converting T8 18W and 36W down to T8 17W and 32W. The final option is retrofitting with T5 adapters which convert energy guzzling T8 bulbs to new T5 energy saving. The results show that, the T5 technology is suitable compared to T8 electronic and HPT8 system. By retrofitting 100% of an existing T8 system with a T5 system, close to 40% energy savings can be achieved. However, T8 electronic and HPT8 system saved only 17% and 31% respectively compared to T8 standard system (Mahila et al., 2011).

Improvement of the envelope is important in ensuring high energy savings. This is because significant heat transfer into buildings does so through the envelope. Retrofitting with Trombe wall is one method capable of yielding a drop in energy consumption. Energy conservation in a honey storage building with Trombe wall for winter heating application was studied by Chel et al., (2008). The investigation concluded that there was a potential for energy conservation up to 3312 kWh/year and associated reduction in CO_2 emissions of 33 tonne/year using a Trombe wall (Chel et al., 2008). The rate of heat transfer is controlled because the wall acts as an insulator as well. A combination of these factors contributes to a drop of heat transmission hence the demand for energy is reduced drastically (Chel et al., 2008).

Güçyeter and Günaydın (2012) monitored an existing building for a year and used the data to evaluate and optimize envelope retrofit strategies through a calibrated simulation. They suggested Low-E glazing improvement to replace existing glass panes as the first strategy. Second and third strategies involve Low-E replacement intervention and replacement of frames with vinyl frames respectively. The third retrofit strategy offers an annual reduction in heating energy consumption by 21.82%. The first and second provide decrease in space heating consumption with 10.64% and 11.12%, respectively (Güçyeter and Günaydın, 2012).

Space cooling consumption reduces for all three strategies with 19.76%, 19.60%, and 19.36%, respectively, for S1, S2, and S3. According to results of simulated retrofit strategies, S3 has the most substantial decrease in annual energy consumption with a reduction of 34,911 kW h. In comparison to base-case results, total consumption for space conditioning decreases by 21.04% (Güçyeter and Günaydın, 2012). Ascione et al., (2014) investigated electric energy reduction by minimising infiltration, replacement of windows, increment of thermal insulation of the building envelope (i.e., vertical wall and roof slab) and addition of thermal inertia through the installation of phase change wallboards. Through the adoption of these technologies a reduction of annual electric energy demands of about 24% was achieved. By using these techniques, the study showed that energy improvement in existing buildings is possible (Ascione et al., 2014). There is no lack of studies on energy efficiency retrofitting of existing buildings. However, a vast majority these studies rely on a few STs with lack of focus. Very limited research studies focused on identifying all the major STs required for energy efficiency and there is little effort on examining retrofitted buildings for energy efficiency.

RESEARCH METHOD

Questionnaire survey and design

This research adopts a questionnaire survey to collect quantitative data about the use of sustainable technologies to improve energy efficiency of existing buildings. This agrees with similar renovation studies by Ma et al., (2012). A questionnaire was designed based upon literature and current information on the various sustainable technologies used to improve energy performance of existing building through renovation. The questionnaire was divided into two main parts. Part I is related to general information of respondents. This includes working experience of respondents, projects undertaken in the past 10 years and the total value of renovations done in the past 5 years by respondents. The maximum value of past projects was 60 million dollars with the least, 20 million dollars. Part II focused on sustainable technologies adopted to improve energy efficiency of existing buildings. Sustainable technologies were categorised into five major groups: lighting, HVAC, automation, façade and building management systems. Retrofitted buildings over a period of 5 years were investigated. Before distributing the questionnaire, a small pilot study was conducted using 12 consultants to verify the completeness of the questionnaire.

The questionnaire of 29 STs was carefully designed from previous preliminary investigations conducted in the literature. Architects, project managers, facility managers, building services engineers and quantity surveyors were randomly selected from professionals registered with various professional bodies in Australia and included based on extensive experience in renovation works with sustainable technologies. Stratified random sampling was used to determine the sample of the study. The target population was grouped under each profession. That is architects, services engineers, mechanical engineers and project managers etc. were grouped differently. Thereafter the population of each profession was subsampled to arrive at the sample for the study. These professionals work with different clients concerning various types of buildings: residential, commercial, office, retail facilities and historical buildings. They were selected as the target group to complete the questionnaires. The online survey tool 'Survey Monkey' was used to gather data which was analysed using SPSS.

ANALYSIS OF RESULTS

In all 350 sets of questionnaires were distributed, 86 responses were received of which 80 were complete and used for further analysis. It was established that 78% of respondents were male and the remaining 22% female. Eighty percent (80%) of respondents had more than ten years of professional experience in the construction industry while 90% of respondents had more than five years of professional experience in renovations with sustainable technologies. This makes them well-equipped to respond to the questions. In relation to their profession, 34% were architects, 23% project managers, 30% engineers, 10% facility managers and 7% quantity surveyors. In all 40% had undergraduate degrees, 45% postgraduate degrees and the rest, diploma certificates.

Sustainable technologies used to improve energy efficiency

A number of technologies were considered in the first part of the analysis. Fig. 1 shows details of their application in improving energy efficiency of existing buildings.

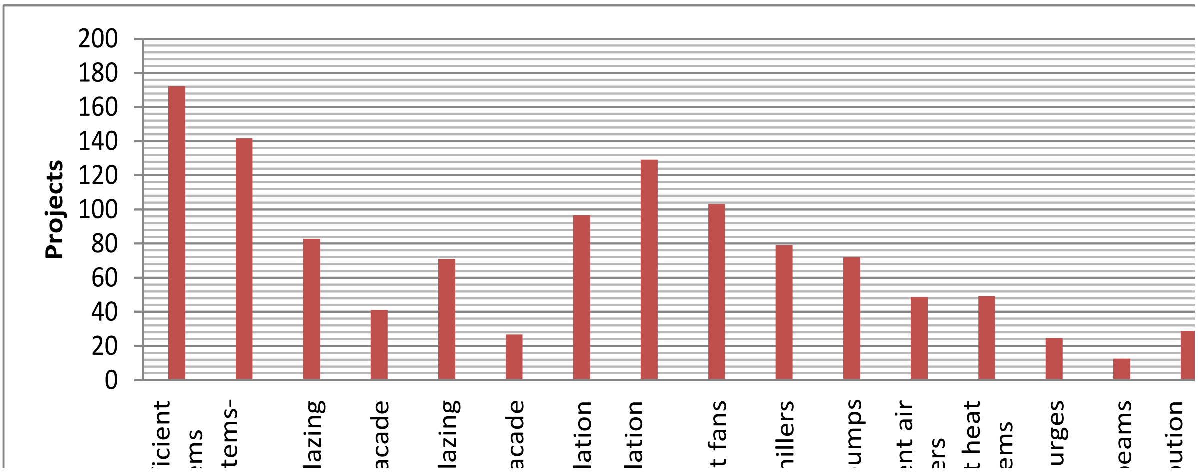

Fig.2: Overall sustainable technologies

Fig.2 presents all the technologies considered for the study. They include high energy efficient light systems, lighting control systems, double glazing and double skin façade, Low-E glazing and façade, daytime natural ventilation, energy efficient insulation systems, fans, chillers and pumps. The rest are energy efficient air economisers, heat recovery systems, night purge, chilled beams, underfloor air distribution systems, cooling towers, natural cooling systems, and solar power systems. In addition there are solar hot water systems, energy efficient hot water systems, water efficient technologies, smart meters, motion sensors, building management systems, phase change materials, wind turbines, heat pumps and water recycling technologies.

Main sustainable technologies adopted during retrofitting

All the STs identified were reduced to those that are extensively used during renovation of existing buildings, as Fig.3 shows.

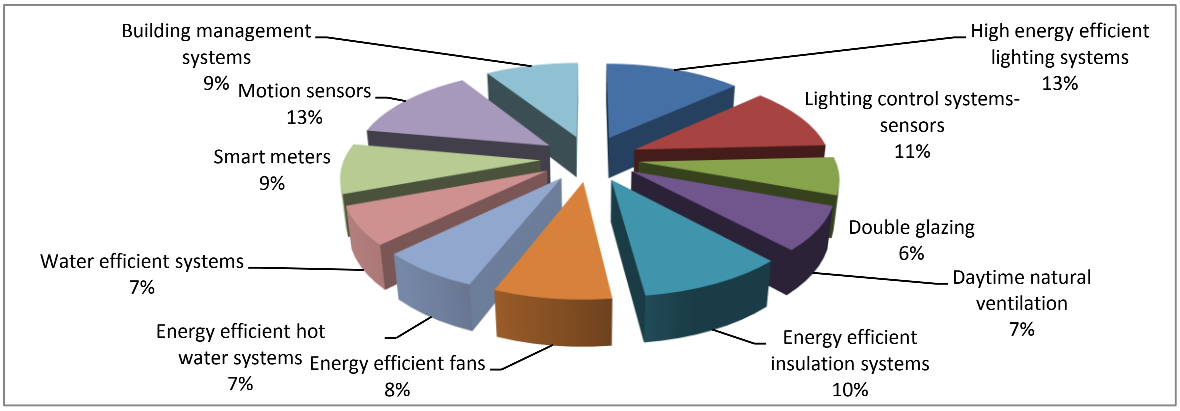

Fig.3: Key sustainable technologies

The results indicate that 13% of existing buildings were improved with high energy efficient lighting systems, another 13% improved with motion sensors, 11% improved with lighting control systems, and 10% improved with energy efficient insulation systems. The rest are smart meters used to improve 9% of existing buildings, 8% improved with energy efficient fans, 7%, 6%, 7% and another 7% for energy efficient hot water systems, double glazing, daytime natural ventilation and water efficient systems respectively.

DISCUSSION OF RESULTS

The use of sustainable technologies to improve energy performance targets five main areas. These include lighting systems, HVAC systems, building envelope, energy automation and management systems and renewable technologies. A lighting retrofit involves replacing inefficient lighting systems with efficient ones. Electricity savings over time is significant with a good return on the investment. Indeed this result agrees with earlier studies undertaken by Mahila et al., (2011). Lighting retrofit can reduce energy consumption by over 50%. In some cases high energy savings of more than 50% can be achieved (Claridge et al.,1994).The high rate of usage is also possible because of low initial cost and a good payback time. Cost is vital in any decision to retrofit with sustainable technology. High cost of retrofitting is a huge barrier to energy efficiency improvement of existing buildings. However having a good payback system is a motivation towards energy improvement through sustainable technologies (Mahlia et al., 2011; Mahlia et al., 2005). Apart from energy savings and low cost as well as very good payback time lighting retrofits also improve CO_2 emission into the environment. This therefore improves reduction in climate change (Mahlia et al.,2005).

Injecting high amount of energy efficient lighting systems into an existing building demands a corresponding increase in sensors. Building automation systems provide a significant opportunity for building owners, operators, and energy service companies to consider controls upgrades to improve the overall energy efficiency and to improve environmental sustainability. This means that existing buildings with many sustainable technologies and high occupant density, the use of sensors is most suitable. Such a condition supports high energy savings because space and technologies are better controlled and regulated. Thus effective improvements of energy efficiency of existing buildings demand the adoption and application of sensors (Kintner-Meyer, 2005). The adoption and application come with cost implications. Compared with other sustainable technologies the use of sensors presents a very good financial outcome in the short and long terms (Kintner-Meyer et al.,2002).

Heat transfers in existing building plays a major role in energy demand. The rate of heat transfer can be controlled using effective and efficient insulation technologies. These technologies are capable of reducing heat transfer in and out of the building. There is high amount of savings on the initial cost and to some extent the overall cost as well. Thermal insulation measures in buildings with previously non-insulated building envelopes (walls, roofs or cellars) are profitable in most cases (Jakob,2006). So there is a motivation to adopt a less expensive technology capable of reducing energy consumption. Again building owners, operators, and energy service companies are able to invest savings into other sectors such as envelope and HVAC improvements due to expected energy gains during extended periods of use. The results further show that increased investment in high performing insulation technologies leads to low heat transfer in or out of buildings thereby reducing energy consumption. This because there is a strong relationship between high performing insulation systems and energy savings (Kneifel, 2010).

The HVAC systems are the major part of electrical energy consumption in spite of their ability to control temperature, humidity and air quality inside buildings. Also the building envelope is an important element of heat transfer into buildings. It is therefore expected that energy efficiency retrofits target technologies in these major areas. In many instances their adoption are constrained by the initial capital investment. Thus most clients consider the decision to invest huge capital into an old building uneconomical. In situations where they are installed, the estimated pay-back periods are unpromising. These are the likely reasons why clients tend to focus on the less expensive STs with good pay-back periods.

CONCLUSIONS

Previous studies placed emphasis on the HVAC system has the best target of building energy efficiency retrofit. This study shows that although HVAC (especially cooling and ventilating) systems are the major part of electrical energy consumption decisions to renovate existing buildings for improved energy efficiency are not targeting those systems. This study examined many sustainable technologies used to improve energy efficiency of existing buildings through a survey. Sustainable technologies were examined under five main categories-HVAC systems, lighting systems, building envelope, building management systems and building automation technologies. The study considered existing buildings retrofitted with these five major technologies in the past 5 years. Based on the results and discussions, the main conclusions are as follows; building improvements with sustainable technologies are focused on energy efficient lighting systems. This is followed by building automation systems, the insulation technologies and building management systems. There is little evidence to show that the building envelope, solar and HVAC systems are among the most important areas improved for energy efficiency.

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ENABLING RADICAL INNOVATION IN BUILDING: AUSTRALIA'S NATIONAL CONSTRUCTION CODE

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ABSTRACT

The National Construction Code (NCC) is a performance-based code (PBC) for building and plumbing. There are two pathways for achieving compliance with the NCC's mandatory Performance Requirements; (i) developing a performance solution, or (ii) following a prescriptive solution (Deemed-to-Satisfy - DtS). Typically, performance solutions are unique designs proposed as achieving compliance with respective Performance Requirements; whereas prescriptive solutions are generic solutions deemed by regulators as complying with respective Performance Requirements. A recent study has identified that there is a potential productivity gain of $750m pa by increasing the use of performance solutions within the Australian building and plumbing industry (Centre for International Economics, 2012). While the NCC has been a PBC since 1996, there is still an over-reliance on prescriptive solutions, one of the reasons for which has been the difficulty in quantifying Performance Requirements (Meacham et al., 2002). This has resulted in designers and practitioners not being confident in using some Performance Requirements. The Australian Building Codes Board (ABCB) is currently undertaking a suite of projects to help increase the use of performance solutions. The aim of these projects is to help increase productivity and innovation within the building and plumbing industry through enabling the development of tailored innovative performance solutions. This paper describes how the NCC can facilitate this innovation within the building and plumbing industry.

Keywords: Building Code, Performance-based, Quantification, Regulation

INTRODUCTION

A performance-based building code (PBC) allows the freedom for architects, engineers, building designers, developers and builders to create innovative building solutions.

The Australian Building Codes Board (ABCB) has been the author of Building Code of Australia (BCA), later the Plumbing Code of Australia (PCA) and the National Construction Code (NCC), since 1992. In 1996, the BCA shifted from a prescriptive code, to a PBC, however, the uptake of the performance culture has been slow, which has inhibited the potential for innovation within the industry.

BACKGROUND

Performance-based regulation is not a new concept, with examples dating back nearly 4000 years, to the code of Hammurabi (Gross, 1996). However, in modern building regulation PBCs has only been in force in Australia for approximately 20 years, with varied success.

The fundamental principle of PBCs is to allow the development of innovative solutions by regulating building outcomes as opposed to providing the way and means of building (Gross, 1996). A PBC facilitates this through a series of mandatory statements which are qualitative in nature. These qualitative statements describe the building occupant's needs rather than setting a quantitative metric for compliance.

An example of this is the performance requirement in room heights: "A habitable room or space must have sufficient height that does not unduly interfere with its intended function" (ABCB, 2016). This statement, while describing what occupants require, provides no direction on how it is achieved. Quantitative measures for compliance have typically been situated within the deemed-to-satisfy (DtS) or prescriptive provisions, for example "Ceilings heights must be not less than 2.4m in a habitable room" (ABCB, 2016).

In 2012, the ABCB commissioned the Centre for International Economics (CIE) to undertake a review of building regulatory reform since the establishment of the Building Code of Australia (BCA). The report determined that the implementation of a PBC had delivered a benefit of approximately $780m to the economy up to that point. It also identified that there was the potential for similar productivity gains through further increases in the use of performance solutions (CIE, 2012).

The findings have led to significant changes to the latest edition of the NCC to facilitate the increased use of performance, with complementary education programs and further technical changes underway.

METHODOLOGY OF REVIEW

The authors have over 20 years combined experience in developing PBC and guidance material. This in combination with a literature review and online stakeholder surveys, have been used for this review of the NCC's ability to enable innovation.

HOW PBC ENABLES INNOVATION

Many countries have shifted building regulation to a PBC, however, to date no country has a full set of performance-based procedures (Becker, 2008) to support these codes. The shift was driven by the need for flexibility within regulation as well as to facilitate innovation within construction while still maintaining health, safety and amenity levels (Gross, 1996).

To see how performance-based design can facilitate innovation, it is worthwhile examining two industry sectors that have embraced performance. Firstly, it is widely acknowledged that the field of structural engineering is an example of a mature industry operating within the performance framework (Becker, 2008). The second industry is the relatively new discipline of fire engineering. The CIE (2012) states that the vast majority of performance solutions within the commercial sector are for fire safety measures.

Performance requirements for structural engineering are relatively consistent throughout the world and typically consistent with a simple statement regarding structural adequacy. Structural performance requirements typically use references to design standards, such as Eurocode, America Society of Civil Engineers standards and Australian Standards, to outline the compliance procedure. These standards outline serviceability and strength criteria, design loads and material properties. With this framework, the designer has the key input information and is then free to develop a structural solution tailored to each circumstance.

This approach has led to structural engineers being able to freely develop innovative solutions, whether it is through adaptive material use or allowing the creation of radical architectural forms.

In regards to fire engineering, the uptake of performance solutions is being driven by the heavy costs associated with the prescriptive requirements of codes (CIE, 2012). By incorporating performance solutions into the fire safety measures of a building, fire engineers have been able to develop innovative approaches to fire safety tailored to the specific building. An example of this is the Museum of Old and New Art in Tasmania. By incorporating a performance solution for the fire systems, the facility was able to have large open galleries which exceed the compartment spaces allowed within the DtS provisions of the NCC.

These two areas of successful adoption of performance solutions give an insight into the ability of PBC to facilitate the adoption of innovative practice.

The PBC itself does not prescribe for innovative approaches to be adopted. However, they do provide a clear framework that allows practitioners, builders, owners, etc. to tailor a building solution to meet their specific requirements. Whereas prescriptive solutions are restrictive by nature as they cannot contain every possible permutation of building design. In an industry that has a prescriptive mind-set, the risk is that instead of innovation occurring, there will be a desire to force building solutions into the set of prescriptive rules within regulation.

Performance solutions allow designers, builders or researchers to explore a specific circumstance and develop an approach that may contain many examples of innovation e.g. materials, construction practices or adaptive uses of space.

The NCC and Innovation

Despite performance solutions promoting greater flexibility, innovative approaches and solutions, there is still a heavy reliance on prescriptive solutions (Meacham et al., 2002). Anecdotal evidence collected from a survey of NCC users conducted by the ABCB in 2013, suggests that industry still has an entrenched prescriptive mind-set. This mind-set can be said to be inhibiting innovation within the building, and plumbing sectors and risks being ill-equipped to respond to the rapid changes in technology and construction practices.

As stated previously, the NCC (and formerly the BCA) has been a PBC since 1996. Increasing responsiveness to innovation has been one of the key drivers (Greenwood, 2007) to the introduction of the PBC, and this has been shown to have succeeded. In interviews conducted by Greenwood (2007), 20% of respondents stated that innovation was the predominant reason for undertaking performance solutions.

As mentioned previously, fire engineering is one of the principal areas where performance solutions are currently implemented (CIE, 2012). The change in Australia from a prescriptive code to a PBC in 1996 created a framework to allow performance solutions. While this was driven mostly by cost, it had the added benefit of fostering innovation within this sector.

One of the key reasons the NCC allows for this level of innovation is that it has a set of clearly stated objectives (Greenwood, 2007). The introduction of verification methods into the code has also formalised analytical methods (Greenwood, 2007) to aid in assessing compliance of performance solutions, though there is still more work to be done in this area.

NCC REFORMS TO INCREASE PERFORMANCE

The disconnect between industry's willingness to adopt performance solutions and regulators reluctance to move to a performance framework may be attributed to the flexibility a PBC offers. Whilst being a benefit when designing a performance solution, it may make assessing compliance exceptionally difficult (Meacham, 2010). Beller et al. (2003) stated that one of the major problems to be solved with the implementation of a PBC was developing the appropriate link between qualitative statements and quantitative criteria. Unfortunately, the work to develop appropriate quantified measures or linkages to the qualitative compliance statements is still ongoing (Meacham, 2010 and Fleischmann, 2011).

In Australia, the uptake of performance solutions has significant benefits for the economy and there is the potential for similar productivity gains with further increases in the use of performance-based designs (CIE 2012). As a result of these findings, the ABCB has commenced a series of reforms to the NCC and supporting material to help foster a performance culture within the sector, with the aim of increasing innovation and productivity in building, and plumbing and drainage solutions.

In doing so it is recognised that the use of performance solutions will have greater appeal and utility to different parts of the building and plumbing industry, and that deemed to satisfy remain a valid form of demonstrating compliance with the Performance Requirements.

As part of these reforms, three issues were identified to address.

- ***Breaking down the prescriptive mind-set***
- ***Capacity building***
- ***Qualitative performance requirements***

The response to these issues can be summarised into two main reforms:

- Education of NCC users (breaking prescriptive mind-set and capacity building); and
- Technical code reform (quantification of performance requirements).

The ABCB believes that by addressing these two areas, major inroads to increasing the use of performance can be made. While the technical aspects do pose a major barrier, the education of NCC users is seen as the critical element and one that can start to be immediately addressed.

Gross (1996) stated that educational institutions introduce students to the philosophy of the performance but provide little instruction in its real life application. While this observation was made in 1996, there has been little change within the industry to suggest any this is no longer true.

In order to assist the shift in culture to increase capacity for performance solutions and change NCC user's mind-set, the ABCB has undertaken to create new guidance and educational material for practitioners and educational institutions to promote performance-based design.

Adopting a Performance Mind-set

In 2015, the ABCB released a document entitled "Performance Requirements extracted from the National Construction Code 2015" (ABCB, 2015). While this document was only released as guidance, its intention was to highlight that the NCC performance requirements are the mandatory technical requirements.

The 2016 release titled the "Consolidated Requirements" (ABCB, 2016) was the next generation of this simplified document and included the addition of a consolidated form of the general provisions from the three volumes of the NCC. This step highlighted the importance of the general requirements, that they support the performance requirements, and together they comprise the mandatory NCC requirements. The title change also further reinforced the idea that these are the mandatory requirements of the code.

In addition to the release of the "Consolidated Requirements", further changes were made to the general provisions in the NCC to emphasise performance solutions as a compliance pathway. These changes included revising and simplifying the NCC compliance structure and changing terminology.

The revision of the NCC compliance structure is illustrated in the diagram below (see Figure 1).

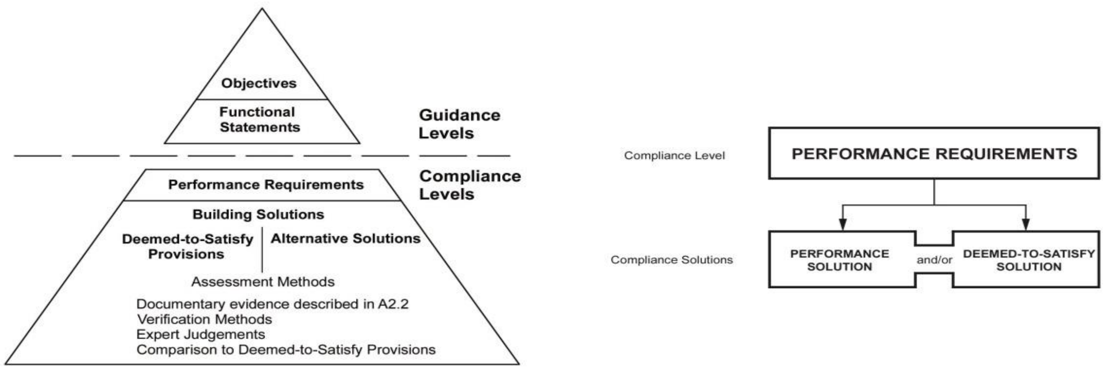

Figure 1 NCC Compliance Structures (NCC 2015 left, NCC 2016 right)

(Source: ABCB, 2015 & 2016)

This change makes the identification between guidance and compliance levels clearer (by removing the guidance level from the structure). It reinforces and strengthens the message that the performance requirements are the mandatory level of the NCC technical requirements and that performance solutions and DtS solutions are equally acceptable compliance pathways. This also brings the code into line with other building code compliance structures internationally, such as New Zealand, as illustrated in Figure 2 below.

Changing terminology, by renaming the defined term "alternative solution" to "performance solution", also reinforces that they serve as a key pathway to compliance of an equal weight to the DtS provisions. As opposed to the view of some, that they are an alternative to when the DtS provisions do not work.

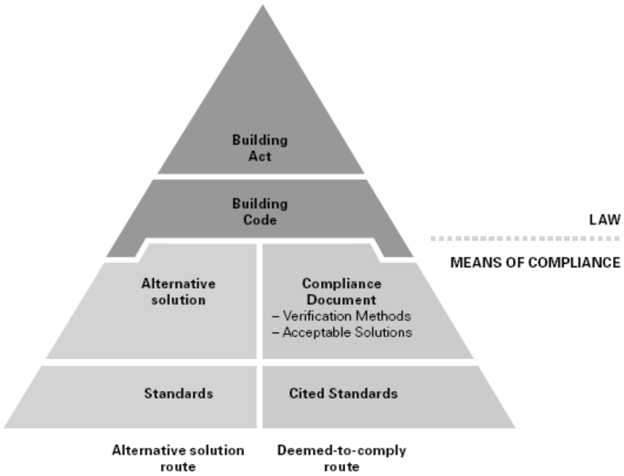

Figure 2 New Zealand Building Regulation Framework

(Source: Ministry of Business, Innovation & Employment 2007)

Building Performance Capacity

User surveys revealed that understanding of performance solutions, the NCC compliance structure and the benefits of a PBC is less than desirable. As a result, the ABCB has commenced development of better information and tools to help with the education of NCC users.

Several key items of this strategy developed to date include:

- ***Developing a simplified guidance document to undertake a Performance Solution***
- ***Infographics which better illustrate the choice to meet the NCC Performance Requirements***
- ***Regularly publishing technical articles***

- ***Improving tertiary resource kits to cover performance-based design***

The ABCB created this information to supplement the material previously developed (such as non-mandatory handbooks) and to guide current and future industry participants. It is also envisaged that the tertiary education sector adopt these materials within their courses in order to increase students' understanding of a performance based NCC prior to them entering the workforce.

Quantification of Performance Requirements

While education is seen as the critical element in changing the psyche of NCC users, additional technical changes have to be incorporated into the NCC to allow for easier development of solutions and reviewing of compliance. This is being achieved by quantification of the NCC performance requirements.

In its ultimate sense, quantification of performance requirements can be achieved by inserting high level metrics within the performance requirements. Beller et al. (2003) states that one of the problems with having quantitative statements within mandatory provisions is that law is not expected to change significantly over time, while the tools, methods and information available to designers can change significantly, resulting in the quantitative metrics being obsolete, and a change required to the mandatory provisions.

As a result of this, the ABCB has adopted the approach of developing verification methods (VM) as one method for quantification. While this isn't strictly quantification in its purest form, it is seen as an effective method. A VM contains quantified information that designers and regulators can use to verify compliance, but still maintains the performance requirement as changes to them should be kept at a minimum. It also has the added benefit of not restricting the designer, in so much as if the VM does not appropriately cater for their building a full performance solution may still be developed.

As a result of the CIE report, a renewed effort on quantification of the level of performance is being conducted by the ABCB. This has resulted in eight VMs being incorporated within the NCC, across all three volumes, since 2014. These VMs cover a range of topic (such as structural reliability, weatherproofing and ventilation) and use varied approaches to quantify and foster an increased use of performance.

The ABCB's aim is to quantify all the performance requirements, where possible, either within the performance requirement or via a VM. Priority areas of fire safety (including bushfires), plumbing, health and safety and energy efficiency are well progressed and the remaining work scheduled for consideration in NCC 2019.

BROADENING THE USE OF PERFORMANCE-BASED CODES IN EDUCATION

As previously discussed, education is the key aspect of increasing performance-based design and therefore increasing innovation within the built environment. With the aid of technical measures (quantification) an agile and innovative industry can be fostered within Australia.

As stated in the Inter-jurisdictional Regulators Collaboration Committee (IRCC) discussion paper, "Guidelines for the introduction of performance-based building regulations" (1998), without specific education programs the likelihood of practitioners keeping abreast of significant changes is extremely low.

Results of user surveys conducted by the ABCB suggests that the NCC, and in particular the performance-based designs solutions, is not covered in detail in tertiary education programs. The ABCB has identified this as a key area for the shift in culture.

Introducing the idea of performance to students at the tertiary level, particularly in bachelor degrees, would be a significant step towards creating an innovative and performance mind-set within the industry. In the design related streams, such as Architecture and Engineering, it would introduce future practitioners to the concept of performance, and make them aware that it is an equivalent pathway to compliance as the DtS. It would help to foster creative and innovative building solutions from the outset, rather than as a last minute fix when there are problems with DtS solutions. This would particularly be the case if critical review of case studies (IRCC, 1998) were adopted as part of coursework.

While this is not a simple topic to be adopted within coursework, including performance solutions as a normal part of coursework would go a long way towards capacity building and engendering a performance mind-set.

The other avenue where merit can be gained in performance is post-graduate studies. The concept of performance is ideal to be studied and researched within post-graduate courses. The development of true performance solutions requires practitioners to be able to innovate and critically analyse the objectives and functions of each performance requirement to develop a solution that both suits the building design as well as achieving an acceptable level of health, safety, amenity and sustainability. While the ABCB is at the forefront of developing a quantified PBC in Australia, universities could also be involved in, and leading, this work if they were to incorporate performance based studies within their under-graduate and post-graduate studies.

CONCLUSION

The NCC has been a PBC since 1996. During this 20-year period, the NCC has delivered approximately $780 million annually in productivity gains arising out of being performance based (CIE, 2012).

The ABCB, through its authoring of the NCC and associated guidance material, is attempting to promote a performance culture and facilitate innovation within the building and plumbing industry. This is primarily being done through a combination of mindset change and capacity building initiatives, along with quantification of the performance requirements.

However, the ABCB alone cannot significantly influence the next generation of practitioners. The education industry plays a key role in developing a performance mind-set for the future generations, enabling openness to innovative solutions.

By shifting to a performance mind-set, further substantial productivity gains should be realised through the development of innovative building solutions, as well as position the sector for the inevitable disruptive technologies and construction practices that are emerging and can-not be responded to satisfactorily through rigid prescriptive responses.

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ENCOURAGING, ALLOWING AND CATCHING INNOVATION IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

Despite the construction industry's reputation for low innovation, there is a considerable amount of innovation that occurs in the sector. Negative opinions of construction innovation are often misinformed by data and methodologies designed to measure innovation in other sectors and by a misunderstanding of the realities of innovation in the construction industry. Through interviews with fifty eight thought-leaders from across the Australian and UK construction industries it is shown that contemporary ideas around 'systemising' innovation do not sit comfortably with the way that innovation happens in reality in construction. A new model is proposed which shows that innovation in construction is a dynamic process which needs to move in response to the different stages of the construction process. This new model is important in filling a conceptual gap in the way that innovation in construction is understood.

Keywords: Dynamic, construction, innovation, model

INTRODUCTION

Innovation is the creation of new products, services or business processes that create wealth or social welfare (OECD 2010). Gambatese and Hallowell (2011) have pointed out that the traditional way to judge an industry's or firm's innovation record is on the basis of statistics such as formal R&D investment and patent numbers and that this has ensured that much of the innovation that occurs in the construction sector goes un-noticed. Cutler's (2008) review of Australia's national innovation system recognized this problem, noting that formal R&D accounts for only one third of total business expenditure on innovation, that innovation occurs in many different ways in business and that this need to be better recognized in national innovation statistics. So the widespread perception, based on traditional innovation metrics, that construction is a rather backward, low innovation industry is potentially misleading. Indeed, other research has begun to question this simplistic perspective, revealing that a considerable amount of innovation does occur in the construction industry, even though it is often 'hidden' from view (Abbot et al 2007). The above discussion shows that to rely on traditional measures of R&D investment to judge the construction industry's innovation performance with other industries is potentially deceiving and that alternative models are needed to conceptualize the way that innovation actually occurs in construction. To this end, the aim of this paper is to develop a new model of construction innovation drawing from contemporary innovation literature and interviews with fifty eight senior thought leaders in the UK and Australian construction industries.

CONTEMPORARAY INNOVATION THEORY

In contrast to early models of innovation which saw it is a highly linear and structured 'supply–push' process, contemporary models of innovation proposed by researchers see it as a non-linear, 'demand-pull' process, driven by the collaborative co-creation of new knowledge in integrated supply and demand chains (Muller and Becker 2012). These new models of innovation show that modern innovative companies develop a 'systematic' innovation capability and view themselves as a flexible portfolio of resources which they can bring to bear on promising opportunities. According to Samson (2011), the secret to 'systemizing innovation' lie in securing six main principles of organisation: customer-focus; collectively challenging orthodoxies; dedicated resources; measuring innovation return on investment; recognizing and rewarding innovation and; accountability for innovation. Recent research into innovation in the construction industry also reflects these themes. Researchers such as Walker and Rowlinson (2008) have pointed to the potential of collaborative models of business and project organization to stimulate innovation by building trust and teamwork between project members. Another aspect of contemporary innovation research is the importance of developing an innovation 'culture' to guide behaviour (Sutton 2001, Robbins et al 2003), which has also been noted by numerous researchers within construction (Brandon and Shu-Ling 2008). There is also an important and contentious 'external' dimension to innovation research revolving around the role of governments and customers in the innovation process (Hilmer and Field 2011). This view is supported by Gambatese and Hallowell (2011) whose research into the factors that influence innovation in the construction sector pointed to the importance of client support in valuing and driving innovation. Similarly, Egbu (2008) and Barrett (2008) argue that clients can come together and through their combined purchasing power help the industry create a consensus around a meaningful shared vision and a way to implement it. Clients have a major role to play in the way that the construction market operates and they should can aspire to be better clients by demanding innovation, by avoiding cut-throat competition and by creating a trusting and stable environment for innovation to occur through equitable risk distribution and a longer-term 'value-driven' view of their building investment over its entire life-cycle rather than seeing it as a short-term 'construction cost'.

However, Loosemore and Phua's (2011) analysis of corporate social responsibility in construction showed that many clients are simply not prepared to pay for innovation. Furthermore, Brandon and Shu-Ling (2008) argue that relying on clients as drivers of innovation is a 'cop out' by the industry. However, as Manley et al (2006) points out, the construction sector serves a wide variety of clients with an equally wide variety of needs and that some clients are more able to play a role in the innovation process than others. Sexton et al (2008) argue that a client's role in the construction innovation process varies from 'passive' to 'balanced' to 'dominant' depending on the attributes of the client involved. Like Manley et al (2006), they found that repeat clients have the interest and ability to actively engage in driving innovation in the industry while inexperienced, one-off clients do not.

METHOD

Using ideas of contemporary innovation described above, fifty eight recognized innovators and thought-leaders from the construction sector were interviewed for their views on their relevance in practice (see Table 1 for sample structure).

Table 1 Sample structure

Respondent	**No**
Politicians (POL)	2
Senior policy advisers and public servants (SPA)	8
Senior academics (Professors)	2
Professional Associations/Advisory/Lobbying bodies (LOB)	3
Designers/Architects/Engineers (DES)	12
Contractors (CON)	12
Subcontractors (SUB)	4
Manufacturers (MAN)	5
Other (Professional: Project Managers, Planners, QS, Unions, Property developers, Facility managers etc) (OTHER)	10
TOTAL	58

The interviews, which often ran to two hours were semi-structured. While specific questions around the relevance of contemporary theories were discussed, respondents were also allowed to tell their own stories of innovation in the construction industry, allowing us to develop new streams in our understanding of how innovation works in construction, outside established models and concepts. The data was analysed using narrative analysis and the results below are presented in a narrative because this research was exploratory and did not seek to test the relationship between any independent and dependent variables. As Meisel (2011: 2023) notes, the power of narrative is in translating respondent accounts into data that people can comprehend and as Flyvbjerg (2011: 310) argues, "the force of example" is underestimated in scientific research and when done well, contain no greater bias toward verification of the researcher's preconceived notions than other methods of inquiry". Clearly, from over one hundred hours of interview data, it is not possible to recount everything that was said in this paper. So what is presented below are the main points which were issues of agreement across all the interviews.

DISCUSSION OF RESULTS

The results below have been organized into the three stages of innovation which could be discerned from the interview transcripts. The references after every quotation refer to the relevant respondent group in Table 1. For example, RESP #3 POL refers to Politicians and the #3 to respondent number 3 in that sample etc.

Encouraging innovation

Respondents universally agreed with Samson's (2011) assertion that an organization has to be systematically 'set up' for innovation but there were divergent opinions of how this is best done. However, while there was a sense that strategy was important, there was also a feeling that innovation is often portrayed too "romantically" (RESP #3 POL), through "rose painted glasses" (RESP #7 POL) ….. "everyone needs to take an honestly pill" (RESP #7 POL). There was also widespread agreement that innovation needs to be defined, the reasons need to be identified and benefits need to be spelt out for employees and that having a formal innovation strategy was key to giving people "permission to innovate" and "communicating that innovation matters" (RESP #43 OTHER). Thus the primary role of strategy was seen as creating a "pre-disposition to innovation" (RESP #46 OTHER), to formalize the process in some way, to place it at the center of business priorities and to resource it properly. But at the same time, there was also agreement that while strategy must start at the top, innovation didn't have its own separate strategy to provide employees in lower reaches with a high degree of flexibility to move within the wider goals set by leaders….. "you say what you want to be and what you want to achieve and then let people figure out how to get there"… "you can't innovate by going on course innovation 101… it's all about people seeing and acting on opportunities" (RESP #9 Policy)…"Entrepreneurs don't run a process.. they just do it.. They do what needs to be done" (RESP #19 CON). This supports Green et al's (2008) finding that rather than being highly pre-planned, construction firm strategies tend to emerge from the bottom-up, as a collective but contested endeavour of many people (often unsanctioned) from across different parts of a construction firm. While broad strategies are often developed at board level, they merely represent guidelines for action rather than strictly implemented action-plans. The above was qualified further by numerous references to the importance of leadership in the innovation process, which for many was much more important than having a formal strategy…... "People need to see the organization does new things – visibility is critical….you can't tell people…you need to show them" (RESP #37 SUB). Without leadership "innovation doesn't get an agenda or quantum" and "is directionless" (RESP #52 OTHER). In a refinement to the literature on the drivers of innovation in construction, respondents indicated that innovations in construction were generated from two main sources: up-front competition to win jobs and; the down-stream need to deal with a problem on a project and deliver it safely, on time and within budget. As one respondent said, "Up front innovation is about winning the job and is driven by the need to beat the competition. But once you have the job it switches to how to deliver the project faster and more efficiently" (RESP #17 CON). As one respondent said, "Innovation at a project level must be practical…..You can't have too much creativity on site since the concrete has to be poured. There are basic things that need to be done and time is so tight that there is little time for creativity in doing things differently……where the innovation happens on site is in dealing with problems to keep the program and budget on target. This is a different type of innovation – it is reactive not proactive" (RESP #19 CON). In support of Egbu (2008), Barrett (2008) and Gambatese and Hallowell (2011) clients were seen to play a critical role in the innovation process. However, it was widely felt that most construction clients are not open to innovation or prepared to pay for it… "most clients are completely irrelevant to innovation. They have no interest in it what so ever. Unless of course it can reduce costs .. then they have a great desire for innovation" (RESP #57 OTHER). The challenge it would seem is the education of clients and the development of tools to allow them to see the value of innovation to their core business. Clients are critical because if there is no one to sell to, then most people won't innovate. As one of our respondents said, "If clients do not want energy efficient buildings then the industry won't build them. Similarly, if a firm isn't focused on innovation and set-up to innovate then incentives will have little impact in encouraging them to do so" (RESP #22 SUB). Finally, good government policy was widely seen as critical to stimulating innovation .. "setting the enabling environment in which innovation can occur" (RESP #7 Policy). However, in discussing the role of governments in driving innovation, there was universal agreement that the primary reward for innovation must come from the market not from government. However, in contrast to Loosemore and Holliday's (2012) assertion that regulation is important to innovation in construction, the main role of government was to reduce red and green tape and provide a stable environment to invest.

Allowing innovation

Mirroring Muller and Becker's (2012) description of leading firms in other industries, there was agreement that innovation primarily revolves around people of many types, at different stages of a construction project… "there is a need for people who can think outside the square and people who think inside the square" (RESP #4 MAN). However, there was broad consensus that a drive for greater flexibility in the industry over many years has resulted in them being forced into casualized labour, reducing their ability to participate in workplace issues. As one respondent said, "The structure of employment in the construction industry is all about lowering costs and providing flexibility rather than being about innovation. Contrast this with the manufacturing sector where in a factory of one hundred workers there are all sorts of opportunities for them to contribute ideas and to talk to managers" (RESP #8 POL)…. "it's a race to the bottom" (RESP #56 OTHER). These findings support Barrett et al (2008) and Sexton et al (2008) who have identified the dominance of the subcontracting business model as a major difference between construction and other industries, in terms of its innovation performance. Respondents agreed that by causing an under-investment in training and development, subcontracting has effectively freezed the intellectual development of the industry. As one respondent said.. "The basic skills levels of workers in other industries are far higher generally than they are in construction. The knowledge base of workers in construction has hardly developed in the last twenty years because of the subcontracting revolution" (RESP #21 CON). While the concept of collaboration was widely considered as critical for innovation, many agreed that this was often unachievable in practice …"Collaboration is just a word… there is nothing new in this..". (RESP #7 POL)….. "collaboration in construction is a huge challenge …… collaboration between the few big firms is almost impossible" (RESP ##32 SUB). For true collaboration to happen in construction, most argued that it was important to be involved early in the design process where solutions can be jointly developed. Most of the respondents talked about "going on a journey" with each other (RESP #57 OTHER) and that "early on the door is fully open to innovation.. but this is a highly protected place to be and most people are faced with a firmly closed door" (RESP #35 SUB). Our findings support the views of Leiringer (2006) and Walker and Rowlinson (2008) that show that procurement reform is crucial to the innovation process. However, despite the rhetoric of collaboration, it also shows that in many projects there are numerous organizational and cultural barriers to prevent this happening.Finally, while technology (BIM was repeatedly identified) most saw many challenges in introducing such technologies into the construction sector. In particular, there are the long established ways of working which have become institutionalized into the industry to change and then there are major problems in up-skilling the supply chain in using this technology. As one respondent noted, "Construction is still fundamentally an industry based on relationships and people working together closely in a highly problem solving environment. So it is important to see technology not as a standalone piece but as part of a much larger organizational ecosystem and it generally won't work if it is treated in isolation from the rest of the business" (RESP #56 OTHER).

Catching innovation

The results indicate that the models of systematic innovation proposed by mainstream researchers such as Sampson (2011) do not reflect the way that ideas become accepted into the construction industry. As one respondent said…"a lot of innovation doesn't happen like this. Sometimes it's just solving a problem and you have a client…" (RESP #12 DES). There was also the view that clients are generally reluctant to invest in systematic innovation and that the industry needs to be better at selling its new ideas … "companies must better learn which client buttons to press" (RESP #43 OTHER). Many respondents also felt that this is the most critical and yet most difficult phase of the whole process, where many firms seem to struggle. Some thought that very few firms have a strategic view of marketing their innovations. Furthermore, most companies don't have systems to systematically spot, assess and develop good ideas. So it often comes down the determination and passion of individuals to push their ideas through to reality. This ensures that many good ideas and people are lost from the industry….."our sustainability strategy started with one person pushing it and never giving up. He was often knocked back but had a passion for it and eventually convinced everyone it was important" (RESP #42 CON). Timing was also seen as critical to this phase of the innovation process. As one respondent said, "unless there is a need at project level to either to win a bid or resolve a problem then it won't happen" (RESP #31 SUB). However, most acknowledged that there were very few willing clients who were prepared to test and prototype a new idea on their project. And clients didn't appear to have clear methodologies for valuing innovation. Submitting a con-conforming bid was therefore a major risk. As one respondent said.. "There is always resistance, because new ideas involve change and the undoing of old systems and ways of doing things. Few people want to take the risk of trying something new and failing. There is no shortage of ideas in the industry but it is the opportunity for application which is often missing. It takes a courageous person to bring a new idea to fruition" (RESP #46 OTHER).

CONCLUSION

The aim of this paper was to deepen understanding of how innovation happens in construction firms. The findings support but also contrast many aspects of the mainstream innovation literature. In particular, our findings show that the idea of 'systemising' innovation does not sit comfortably with the way that innovation happens. Rather, the data shows that the organization of innovation in construction is a dynamic process of solving problems on site as they arise. Our findings also support the crucial role of clients but at the same time indicate that few clients are prepared to pay for innovation. Firms will not innovate if their ideas are not valued in the market and if the costs of development cannot be amortized across multiple projects. This is where the role of government, so resisted by our respondents would appear to be crucial in driving innovation. Without a market for innovation, regulation is the only catalyst for change. The structural and organizational barriers to innovation are well understood. Future research should focus on how we undo them. Our research shows that clients lie at the heart of this problem as does the subcontracting model of organizing construction work.

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SOCIAL PROCUREMENT AS A DRIVER OF SOCIAL INNOVATION IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

Developments in the field of social procurement mean that in the future, firms tendering for major construction and infrastructure projects will need to demonstrate social innovation as well as technical innovation in project delivery. There has been very little, if any, research into social procurement and innovation inside the construction sector and there is little understanding of how prepared the construction industry is to engage with these fundamental changes in procurement practices. To address this question, the results of interviews with social entrepreneurs operating in the construction industry are reported. The results show that to engage effectively with the emerging social procurement agenda, changes to traditional internal procurement practices will be needed to allow construction firms to better engage with the social enterprise sector, overcome widespread negative perceptions of social enterprises in their supply chains and challenge traditional notions of value driving procurement decisions which are invariably tied to price.

Keywords: Construction, procurement, social innovation

INTRODUCTION

Social procurement is the process by which organisations use traditional procurement processes to create 'social value' in the communities which they operate, beyond the simple purchasing of products and services required for core business functions (Bonwick 2014). Social procurement has a long history going back to the nineteenth century, but recent momentum has been added by Australia social procurement policies such as the Indigenous Procurement Policy (2015) which requires firms tendering for government contracts to employ a certain percentage of Indigenous businesses in their supply chain. This new trend means that it is almost certain that in the future, construction firms and consultants which tender on publically funded projects will be required to demonstrate that they will contribute to their project communities as well as complete on time and within budget. As Construction Manager (2014) notes, "Increasingly, putting up the building on time and to budget is the easy part. Local authorities and other public clients are seeking to ensure that investments in their neighbourhoods don't just deliver great new facilities, but the process of constructing them provides local jobs and training too"

Within the above context, the aim of this paper is to explore the current barriers to social procurement through interviews with social entrepreneurs who operate in the construction sector.

SOCIAL PROCUREMENT IN CONSTRUCTION PROJECTS

Barraket and Weissman's (2009) review of academic and policy literature in social procurement argues that advances in the field can be broadly located within a 'relational approach' to public procurement. Newman and Burkett (2012) argued that an effective social procurement strategy should have four key dimensions: a policy focus which articulates commitments and approaches to social procurement, spending targets on social enterprises and requirements for relevant parts of the business to consider social value in procurement decisions); a contract focus (which involves incorporating social value requirements into tender documents and contracts); a supplier focus (which involves engaging with organizations which can deliver social value); and a market development focus (which involves building supply chain capacity where it doesn't exist). However, the vast majority, if not all, of the existing social procurement research has been undertaken in a permanent business context whereas in the construction industry, there is the added challenge of developing a social procurement strategy in a temporary organisational setting, where supply chain relationships are much more transient and dynamic in nature.

While there is at present no specific research on social procurement in the construction industry, there is some unrelated research which suggests the industry is not well equipped to meet the new requirements of social procurement initiatives outlined above. Murray et al (2011) and Loosemore and Phua (2011) show that CSR initiatives started at head office level often fail to achieve purchase on site where the imperatives of delivery drive behaviour. Furthermore, in the field of responsible sourcing, Glass (2012) show that many firms in the construction industry lag behind those other industries in understanding and reporting their social impacts and those of their supply chain. Finally, there has been no research into the nature, scope and challenges of social enterprises operating in the construction industry. Recent research in the UK (Villeneuve-Smith and Chung 2013), in Australia (Barraket et al 2010) and in the US (Clark and Ucak 2006) shows that social enterprises are very poorly represented in the construction sector and that they tend to be very small organisations operating at the bottom of the supply chain on smaller projects and tasks. It is likely that in operating in this industry position, that they will experience numerous barriers to entry and growth similar to other small to medium sized enterprises. As pointed out above, many of these barriers lie in the established cultures, norms, structures, rules, procedures and relationships which govern the construction industry. However, Kernot and McNeill's (2011) analysis of thirty three successful social enterprises in Australia reveal that there may also be internal governance challenges as well. Their research exposed many internal and external barriers to growth which included: generating finance to grow, overcoming natural resistance to change; overcoming negative perceptions of social enterprises; lack of resources to compete with mainstream businesses; recruitment problems, complex staffing needs and HR support issues; challenges in establishing long-term partnerships seen as crucial for success; and demonstrating and reporting social impact. However, this research was not sector-specific and there is a need to understand if the construction industry, as a major potential employer of these organisations, poses it own unique challenges and barriers to entry.

METHOD

To explore these challenges, interviews were undertaken with the leaders of twelve social enterprises operating in the construction industry (see Table 1). The social enterprises were selected from a number of established social enterprise directories in the UK and on the basis of their experience of working in the construction sector and the respondents as senior people most involved and informed about this process, as nominated by the senior executives of each business.

Semi-structured interviews were chosen to collect data because of the small number of social enterprises operating in construction, because of the exploratory nature of this research and because the intention was to first develop an in-depth understanding of challenges to inform future empirical work. There is currently no empirical work in this area in the construction industry, which is in stark contrast to social enterprise research outside of construction (Barraket et al 2016). The interviews typically lasted for one hour and were guided by three simple questions: brief background of the business; drivers of social enterprise in the construction sector; external risks associated with the construction sector; and internal risks in running a social enterprise in the construction sector? The qualitative interview data were analysed using narrative analysis after the transcripts were presented back to respondents to confirm their validity. Narrative methods are based on the idea that knowledge is held in stories (written and verbal) and conversations (formal and informal) that can be relayed, stored, and retrieved (Reissman 2008).

Table 1 Sample

Respondent		Description of social enterprise
1	Criminal Justice Lead	Recruits and trains offenders and ex-offenders by providing jobs in the construction industry.
2	Director	Provides facilities and estate management services, drawing its staff from public housing tenants who are disadvantaged in the labour market.
3	Managing Director	Waste timber recycling which employs local disadvantaged and unemployed people.
4	Managing Director	Creates job and training opportunities for unemployed by delivering construction trades services such as plastering, tiling and painting etc.
5	Operations Manager	A crewing and logistics social enterprise which employs people with a history of homelessness.
6	Director	Delivers commercial and residential grounds maintenance, horticultural and waste services by employing people with mental health conditions.
7	Sales Executive	Provides employment opportunities for disabled people through manufacturer and installation of windows, doors, kitchens and bathrooms.
8	Managing Director	Helps young people from disadvantaged backgrounds get training, education and employment opportunities in the construction industry.
9	Managing Director	A recruitment agency that specialises in construction menial workers, trades and professionals from disadvantaged backgrounds.
10	Managing Director	Iinfluencing planning to improve housing and regeneration strategy to create training and employment opportunities for local disadvantaged people.
11	*Executive Director*	*W*orks to prevent and alleviate youth homelessness and unemployment through property maintenance services.
12	Director	Wood waste collection and recycling services to the construction industry employing disadvantaged people in its local community.

DISCUSSION OF RESULTS

In supporting the results of research in other industries such as Le Page (2014) our results show that resistance to social procurement in the construction sector is likely to be driven by a lack of knowledge about the potential trade-offs of employing social enterprises with other construction project goals (such as project cost, time, safety and quality). While there is currently little research on what types of trade-offs social enterprises might involve, recent research by Richard and Loosemore (2015) suggests that the highly competitive and price-focused nature of construction means that construction procurement professionals are unlikely to change existing suppliers and subcontractors for smaller social enterprises with potentially higher prices, lower reliability and lower service standards than large companies. As one of our respondents stated:

> "There is a perception problem driven by a poor understanding of what social enterprises do and how they operate. We are not seen as professional. A major challenge is convincing clients that the quality and value of what we deliver will be exactly the same as any other contractor. People don't yet have confidence in us".

Our results also align with Erridge (2007) who argued that in most industries the concept of 'value' is still dominated by market based language (value for money). Again, this is supported by Richard and Loosemore's (2015) research on narrow conceptions of value in the construction sector which suggests that there is likely to be an assumption (even if not backed by empirical evidence) that the pursuit of socio economic goals comes in procurement decisions will come with increased risk, cost, reduced transparency and possible illegality around probity and open competition.

> "The industry needs to shift its focus away from only price and learn to better value and appreciate the social value which social enterprises can bring. The industry knows monetary value but not social value".

Another potential challenge which emerged from the data which aligned with Bonwick's (2014) research in other industries was that the field of social procurement in its infancy and that many construction firms will naturally hold back until the hard (and costly) lessons have been learnt by the industry's first-movers.

> “We have been disappointed with the construction companies that we have encountered so far in terms of developing any working relationship. We targeted two or three large firms on the basis that they could give us a crumb of their contracts and that it would be good for their corporate responsibility reputations and reporting. There appears to be a lot of rhetoric and fantastic opportunities that have been on offer have turned out to be miniscule and almost an insult to us as a business, albeit one that is very small”.

Our results also show that changes to traditional procurement practices are required to engage with the social procurement agenda. For example, large work packages on construction projects which are beyond the capacity of small social enterprises will need to be unbundled and tendering processes and pre-qualification systems simplified to allow them to tender for work.

> “There are many hoops to jump through and procurement systems are complex and burdensome. When your income is only 1% of your turnover and your turnover is only a few hundred thousand pounds, you can’t afford to pay to be on tender lists or tender for many jobs without a guarantee of work”.

Construction firms also need to ensure that social procurement initiatives developed in head office get implemented on site. This often fails to happen because of different priorities, unengaged project managers and highly traditional supply chains.

> “Being a very new company, there is a huge amount of interest from the big construction companies. However, while the people at the top of the tower are saying yes, it’s much harder to get buy-in from the estimators, quantity surveyors and site people who have to implement projects. They are driven by different objectives and often haven’t been involved in higher decisions or educated about what we do”.

The results also indicate that negative perceptions of social enterprises in the construction sector, particularly at a project-level, need to change by working with and supporting social enterprises and by better education within clients, companies and supply chains about their potential benefits.

> “We have had to become a bit choosey in who we work with. Trust is often missing‟.

> "There is a will to engage in the construction sector in the best companies but building a solid trusting relationship is hard".

Finally and importantly, the findings also show that there are two sides to the coin and that social enterprises working in the construction industry also need to adapt and change if they are engage more effectively with the construction sector. In particular, since many social enterprises are founded by people from outside the construction industry they can often be unaware of the many unique organisational, procedural, regulatory and cultural barriers that they will encounter.

> "The construction sector has its unique ways of working. Social enterprises that have spun-out of construction firms have a real advantage over social enterprises which don't have a construction background. Most social enterprises won't have the construction industry savvy and have to learn on the job".

The results also indicate that social enterprises need to be focused on being highly commercial so that they can compete on the same price, quality and reliability of service as any other established supplier.

> "Critical to [the social enterprise's] growth has been its determination to be bluntly commercial. It's critical to recognize that our clients need something other than to feel-good about employing a social enterprise. Bounce Back seeks to align its objectives with its client's objectives and to help them win jobs".

Finally, it is clear from the results that construction-focussed social enterprises must become better at measuring, monetising, reporting and communicating the social value they can bring to construction projects. This is a common problem faced by many other social enterprises in other industry sectors (McNeill 2011).

> "Social enterprises are poor at communicating that they provide community benefit at no additional cost. This is partly because most social enterprises are not very good at measuring their social impact".

"Measuring and communicating our social value is an ongoing challenge. Some companies love it and others are not interested".

CONCLUSION

The aim of this paper was to explore the current barriers to social procurement in the construction industry. Through interviews with leaders of twelve social enterprises operating in the construction industry, the results indicate that numerous changes to existing industry attitudes and procurement practices are needed to align with new social procurement imperatives from clients. Barriers include: negative perceptions of social enterprises; rhetoric of CSR in the construction industry; resistance to change; existing procurement practices; lack of engagement between social enterprises and construction; regulations; client silos; fragmented nature of the construction industry and construction industry culture. Social enterprises also need to implement changes to their business models, knowledge and skills sets if they are to operate effectively in the construction industry. Critical barriers include: size and scope of activities; not having an effective strategy; communicating social value; not being construction sector savvy; running a small business; resourcing; and forming effective and supportive ppartnerships. There are clearly many barriers to address in integrating new types of social businesses into a highly competitive industry underpinned by strong path dependencies and established relationships with hard-nosed industry incumbents. While this research is the first to explore the emerging construction social enterprise sector, there are clearly important limitations to this exploratory research. First the social enterprises interviewed were based in the UK and there is a need to discover if experiences are country-specific. Second, the limited sample size, while necessary for in-depth research, means that there is a need for wider sampling across a broad range of social enterprise types. Finally, this research was conducted in a period of boom and the experiences of social enterprises during a recession are likely to be very different, since they operate at the bottom of supply chains in highly geared and risky environments. It is therefore important to undertake further work in different economic contexts.

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SOCIAL ENTERPRISE IN CONSTRUCTION: EXPLORING ITS ROLE IN REDUCING AUSTRALIA'S UNEMPLOYMENT PROBLEM

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ABSTRACT

More than one in eight young people in Australia are unemployed. The construction industry directly employs about 9% of the working population and is Australia's largest employer of young people. New government social procurement policies and guidelines require construction companies to demonstrate they are contributing to Australia's unemployment problem by engaging more with social enterprises operating in the sector. Social enterprise represents a potentially innovative solution to this challenge but little is known about the potential role ssocial enterprises can play in addressing youth unemployment. By combining systems theory with the concept of shared value, this paper presents the first critical literature review of construction social enterprises and youth unemployment and offers a new conceptualisation and methodology which will be used to guide a major empirical study into this important area in the future.

Keywords: Australia, construction, unemployment, social innovation

INTRODUCTION

Recent government figures show that youth unemployment is a serious and enduring problem in Australian society. The Youth unemployment rate (15 to 24 year olds) was 13.4% in May 2015 compared to 6% in the wider population (Department of Employment 2015) which represents about 40% of total unemployment in Australia. Youth unemployment is as high as 21% in some regions and under-employment is as high as 60% (Brotherhood of St Laurence 2014). This should be of deep concern to policy-makers and to the broader community. Research by Strandh et al (2014) shows that youth unemployment has a long-term scarring effect which impacts negatively on an individual's mental and physical health and well-being, self-esteem and life expectations which in-turn translates into lower rates of pay and a higher risk of unemployment and homelessness compared to the general population. These social and economic impacts are felt by wider society for many decades in the form of higher levels of crime, drug and alcohol addiction, suicide and lower levels of skills, education, productivity and innovation in the wider economy (Elliot et al 2012).

Youth unemployment is just one of many complex social challenges which have proved resistant to change using traditional government welfare interventions, creating calls for a paradigm shift which brings more entrepreneurial thinking to the table (Bonwick 2014). To this end, mirroring wider international trends, the Australian government is using new social procurement initiatives to encourage construction firms tendering for new contracts to employ social enterprises as a potentially innovative, cost effective and sustainable solution to many social challenges, particularly in areas such as unemployment (Mason and Barraket 2015). While definitions of social enterprise are still contested, the defining characteristic is a business with the dual mission of combining commercial profit-making activity to generate revenue with the pursuit of social goals (Doherty et al 2014). Their value in the context of youth unemployment is that they specialise in providing training and employment opportunities for disadvantaged groups such as unemployed youth.

The aim of this paper is to develop a better understanding of the potential of social enterprise in the construction industry to address Australia's persistently high youth unemployment problem. Specifically, this paper will explore the potential value of 'systems theory' and ' 'shared value' as potential conceptual tools to investigate the role of construction social enterprise to reduce youth unemployment in Australia, by addressing the following detailed research questions around: Employment pathways (What is the trajectory of moving an unemployed young person to sustainable employment in the construction industry and what role might social enterprises in the construction sector play in that pathway); Business generation (What lessons can we learn from successful social enterprises working in the construction industry to inform the strategies of future social enterprises to reduce youth unemployment); and Advocacy (What is the shared value proposition between social enterprises addressing youth unemployment and construction industry stakeholders).

THE ROLE OF SOCIAL ENTERPRISE IN REDUCING YOUTH UNEMPLOYMENT

The most recent survey of Australia's social enterprise sector showed that Australian social enterprises operate in every industry of our economy, fulfil a diversity of missions and serve a wide variety of beneficiaries (Barraket et al 2010). By far the most dominant foci (around 45%) was on creating employment opportunities for young people. However, the construction industry was significantly underrepresented (around 2% of Australia's social enterprise sector) despite offering enormous untapped opportunities for social enterprises to address youth unemployment. The construction sector directly employs around 1.01 million people which is about 9% of the Australian working population (ABS 2015) and has experienced strong employment growth of 2.4% per year over the last 10 years which is above the average all-industry rate of 1.8%. In 2014-15 construction employment grew 4.6% and is predicted to grow 13% to 2019, well above the average rate of 10% (Career Industry Council of Australia 2015). Importantly, the construction sector also has a relatively young workforce with 43.3% of workers aged 15-34 years compared to 38.8% for all industries and the industry is Australia's largest employer of young full time workers at 152,000 or 17.7% of all full time workers aged 15-24. Importantly, one third of all construction occupations were in shortage in 2014 and 50% are predicted to be in shortage over the next 5 years.

While there is currently no accurate up-to-date data about the numbers of construction-related social enterprises in Australia, the 'Social Enterprise Finder' directory hosted by Social Traders in Australia (an online directory of over 5,000 Australian social enterprises) lists only 50 social enterprises in the construction, property management and maintenance, facilities management, urban design/renewal and landscaping space. This represents a tiny proportion of the 207,000 enterprises operating in construction as identified by the Australian Bureau of Statistics, the highest of any Australian industry sector (ABS 2015a). Furthermore, analysis of these enterprises indicates that those relatively few social enterprises trading in construction typically operate a long way down the construction supply chain in a notoriously high risk/low return environment where long-term established business relationships determine employment opportunities and where low price is the over-riding employment criteria (Richard and Loosemore 2015). Recent research by Close and Loosemore (2014) shows that as one moves down the construction supply chain, social objectives represent an increasing risk and distraction from getting the job done within very tight time and cost constraints. More recently, Loosemore and Higgon (2015) analysis of social enterprise in the construction industry shows that there are many cultural, attitudinal and institutional barriers (both formal and informal) which make it very difficult for social enterprises to break into existing construction supply chains and to build their businesses in the construction sector.

While there is an accumulating body of research into social enterprise, apart from Loosemore and Higgon's (2015) recent work, there has been no research into social enterprise in the construction sector. Mainstream social enterprise research remains largely generic and ignores the effects of sector-specific norms, cultures and institutions. So it is difficult to translate insights from this body of knowledge to the construction industry. Similarly in the field of construction management research, of the 7239 articles listed in the Association of Researchers in Construction Management data base of publications in leading construction management journals, there is only one cursory reference to social enterprise. Furthermore there is has been no construction research that specifically addresses the potential contribution the industry could make to addressing youth unemployment. Rather, construction research addressing social issues has been entirely dominated by investigations into the human resource management, sustainability, responsible sourcing and corporate social responsibility initiatives of 'for-profit' firms which are driven by primarily economic goals (Dainty and Murray 2008).

CONCEPTUAL FRAMEWORK AND METHOD

Systems theory and the concept of shared value are used in this study to explore the value of construction social enterprise in addressing Australia's youth unemployment problem. Central to systems theory is the concept of a system, which is a configuration of parts acting collectively, connected and joined together by a web of relationships (Stichweh 2011). Systems theory is valuable as a conceptual framework for this research because it recognises that youth unemployment solutions are provided by a complex and interdependent social system of multiple actors which have overlapping and often conflicting values and interests. This means that in arriving at solutions, construction social enterprises cannot be treated in isolation from these other actors and are not the only answer (Stichweh 2011). Therefore, any research into this problem through the eyes of social enterprise needs to consider interactions with other actors in the system. As the recent CEDA (2015) report showed, complex social challenges like youth unemployment require a suite of solutions, some direct and some intermediated by NGOs and private organisations. As Dorrance and Hughes (1996, xiii) point out, "the complex causes and effects of youth unemployment mean that there is no one single solution" and the problem needs to be tackled on a range of fronts. Construction social enterprise is therefore likely to be a significant part of the solution and we do not yet know how big that part could be. Therefore, any investigation of social enterprises as a youth unemployment intervention must be considered within the varying motives and stakeholders which drive the wider system in which it is imbedded. For example, while government social procurement policies might require construction firms to engage social enterprises in their supply chains in response to changes in social welfare budgets and philosophies, private firms and their shareholders and supply chains operate under very different imperatives and constraints (economic, cultural, social and technological) from those driving government and the emerging social enterprise economy. To address social problems like youth unemployment, these dynamic and often conflicting complexities need to be untangled and understood in order to define and align missions, governance, thinking and strategies to make the collective change and impact that delivers the positive youth unemployment outcomes as well as organisational outcomes. This alignment of interests to bring about change in youth unemployment is where the concept of shared value can add further conceptual granularity to an analysis (Porter and Kramer 2011).

While in its early stages of development, the concept of 'shared value' is also useful as a complementary framework for its emphasis on the mutuality of interests between business and society and because it questions the trade-off that is often assumed to exist between business and social enterprise activities (Porter and Kramer 2011). This concept challenges traditional notions of corporate social responsibility which dominate the construction industry which ignore the mutuality of interests between business and social issues such as youth unemployment. As Loosemore and Phua's (2011) research showed, firms in the construction sector are commercial profit-making entities and will only be motivated to address issues like youth unemployment if it also helps their bottom-line. Given the construction industry is Australia's largest employer of young people and given it is facing imminent skills shortages, the concept of shared value holds significant potential to highlight overlaps of interests between construction businesses and social enterprises in addressing youth unemployment. Furthermore, there is also considerable research which points to the inherent uncompetitiveness of the social enterprise business model which is a significant concern for their integration into a highly competitive industry like construction. As Doherty et al (2014) points out, the hybridity and blended value proposition of social enterprises poses considerable challenges in resolving the inherent tensions and conflicts which can exist in balancing economic and social goals. What might be good for society might not be best for the business and vice versa. The question of how social enterprises resolve these inherent dilemmas within their business model is as yet unresolved in the social enterprise literature and Loosemore and Higgon (2015) argue that this is currently the economic dilemma of social enterprise in the construction industry. In employing the concept of shared value, Porter and Kramer (2011) suggest that construction organizations can pursue shared value opportunities in three mains ways: re-designing products and services to benefit communities and at the same time increase market share/profitability; making improvements to internal operations along the value chain which improves efficiency and also benefits society; improving the external environment through strengthening local suppliers or subcontractors etc. which also improves profit and productivity. Social procurement and enterprise falls under the last strategy and if construction social enterprise is to have any value as a youth unemployment intervention, then there needs to be a better understanding of how they can bring benefits to the construction firms which employ them.

Epistemologically the adoption of systems theory and shared value concepts requires an interpretivist research approach which is able to understand and reconcile the varied sub-system perspectives in arriving at a shared value solution to youth unemployment in the social enterprise system. This in-turn requires the use of qualitative 'meaning-oriented' methods which provides an depth of insight into various stakeholder positions and perspectives in the social value chain. To this end, a multiple case study approach using a variety of qualitative and quantitative methods to triangulate the various stakeholder perspectives represented is likely to be the best approach to explore this issue (Yin, 2009). The case studies will be construction projects which use social enterprises so that the experiences of social enterprises working in construction from both a demand and supply perspective can be explored. Given recent legislation in Australia like the Indigenous Procurement Policy, which requires all firms tendering for public sector contracts to employ a proportion of Indigenous Businesses, the sample should also include Indigenous businesses. This is also important because Indigenous youth unemployment in Australia is significantly higher than the national average. The commonwealth government's recent Closing the Gap Report (2015) showed that between 2008 and 2012-13 there has been an increase of 6.9% in the employment gap between Indigenous and non-Indigenous working age people (up from 21.2 to 28.1 percentage points). The gap in regional areas is especially large with Indigenous employment rates vary sharply by remoteness area. Given the variations in youth unemployment across Australia, case studies will need to be selected from urban, regional and remote areas, and the social and Indigenous enterprises will also need to be sampled depending on their experience of working in the construction industry and their record, experience of employing unemployed youth and their potential capacity for employing unemployed youth. It is important to recognize that not all social enterprises and Indigenous businesses address youth unemployment issues (Loosemore and Higgon 2015). Furthermore, acknowledging that all organisations move through different stages of maturity (Greiner and Schein 1988), the sampling process should also ensure that these are not newly established social enterprises and are at similar stages of development and maturity. This organisational data could be easily collected through a preliminary survey.

The research project should be undertaken in three main stages. Stage one should explore the research questions around potential *youth employment pathways* using a longitudinal exploration of outcomes for young people from unemployed backgrounds engaged within case study social enterprises should be undertaken. As a recent CEDA (2015: 8), to address entrenched disadvantage in society there needs to be "a focus on the development of good longitudinal data … and more in depth research to understand the dynamics …. of disadvantage" . To this end, longitudinal data should be collected from unemployed youth using a variety of mechanisms which could include in-depth interviews, shadowing and diaries of daily employment experiences. opportunities, and capabilities (work and life skills) imparted. Stage two should explore the research questions around *business generation* using in depth interviews and should be conducted with founders, leaders, directors and senior representatives from each of our selected social enterprises. Respondents should be purposefully sampled based on them having played a key role in establishing the social enterprise and spearheading their construction industry business development strategy. The respondents will also have needed to have worked in other industries and be able to make reliable comparisons between construction and those industries. Stage three should explore the research questions around *advocacy* and in line with the systems approach, interviews should also be conducted with other social enterprise system stakeholders who are potential and actual employers of social enterprises from throughout the construction supply chain. Respondents will need to include senior representatives from public sector and private clients, facilities managers, major contractors, subcontractors and consultants which provide design and other services to the construction sector. All of these groups have the potential to employ social enterprises, either directly or indirectly. To supplement the interview data, data will also need to be collected through documentary analysis of procurement systems and tender documentation and information supplied by respondents about their social enterprises business strategies and activities.

CONTRIBUTION

The ideas presented above are important because they will provide the first empirical investigation of the potential of social enterprise to address Australia's growing and intransigent youth unemployment problem. While Awogbenle and Iwuamadi (2010) argue that entrepreneurship is a potentially important intervention to address unemployment and while Seddon et al (2014) demonstrate the potential benefits of social enterprise interventions in increasing the future employability of socially excluded people in the UK, there is no empirical evidence around the specific benefits of social enterprise to youth unemployment. Empirical data on the potential of social enterprise to address social issues such as youth unemployment is badly needed. The current policy focus on social enterprise is inherently political and controversial and for many critics is simply a rhetorical smoke-screen for dismantling of the welfare state and justifying programs which have made deep cuts to welfare (Doherty et al 2014). For others, social enterprise is seen as a further step towards the outsourcing and privatisation of welfare services, motivated by reducing costs rather than ensuring better quality services to communities (Alcock et al 2013). Furthermore, as Nicholl's (2010:620) discourse analysis shows, the profile of the "hero entrepreneur" dominates much of the literature and while there are a number of studies that look at failures in social enterprise (Wronka 2013), current research lacks a critical turn and the perspective is normally the social enterprise itself rather than the beneficiary or up-stream employer of a social enterprise. Indeed, Bruin and Lewis (2015: 130) have recently raised concerns around the appropriation of social enterprises and indicate that the value of social enterprise as "counter-hegemonic force that can achieve meaningful social change is mediated by the context in which it develops. For example, social enterprises may arise as a necessary response to changes in their regulatory and institutional environment, as change agents within the hegemonic context in which they find themselves, as a localised entrepreneurial solution to an intractable local problem, or the social outcome can take a sub-salient role to the entrepreneurial dynamic. By problematizing for the first time, the opportunities and challenges of social enterprise to address youth unemployment in a construction industry context, this research would also significantly advance research in both construction management and social enterprise and enable our partners, government policy-makers and other international construction firms to develop innovative, sustainable and targeted market-based responses to youth unemployment.

Importantly, as well as making an industry contribution, this project would answer the need for more scholarship in this field by providing a stronger theoretical foundation based in systems theory and the concept of shared value. As Nicholls (2010) and Doherty et al (2014) point out, social enterprise research is in a pre-paradigmatic state. While there are some recent attempts to conceptualise social enterprise (Dufays and Huybrechts 2014) and while there is an accumulating body of 'practice-based' research, the field of social enterprise still lacks an established epistemology and theoretical base. As Haugh (2012:10) argues, "research that extends or creates new theory offers the greatest potential for building the legitimacy of social enterprise research".

CONCLUSION

The aim of this paper was to develop a better understanding of the potential of social enterprise to address Australia's persistently high youth unemployment problem. Youth unemployment has been shown to be an insidious and persistent social problem for Australia which has long-term economic, social and health consequences for those affected. The discussions in this paper illustrate the potential value of 'systems theory' and 'shared value' as potential conceptual tools to investigate specific questions around youth unemployment pathways, business generation and advocacy. They also show how such research is important in addressing the lack of empirical research and theory around the potential role of construction social enterprises as a youth unemployment intervention. The findings from such research would have a wide range of employment and social procurement policy outcomes for government, construction industry stakeholders and social enterprises aspiring to operate in the sector. The potential reductions in youth unemployment would translate into many economic and social benefits for Australia associated with increased income, equality, health, innovation and self-confidence and reductions in physical and mental health impacts associated with youth unemployment such as cardiovascular disease, depression and anxiety and its associated impacts on social stability and isolation, drug and alcohol abuse and suicide.

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PROMOTING AN ECO-JUST HUMANITY: AN INTERFAITH EXPLORATION

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ABSTRACT

The environmental crisis threatens the very survival of humanity today. Its various interlocking manifestations- industrial pollution, resource depletion, the wide spread destruction of species, the unrelenting loss of habit, excessive consumption- are being increasingly felt across the globe. One of the greatest challenges to contemporary religious traditions is how to respond to the ecological crisis, which for some has been perpetuated by materialism and secularization while for others, (Lynn White, 1967) Judaism and Christianity with their emphasis on the transcendence of God above nature and dominion of humans over nature have contributed towards a devaluing of the earth and a subsequent exploitation of its resources. Some religious traditions have been accused of being traditionally concerned with the paths of personal salvation which frequently stressed other worldly goals to the detriment of caring for the present world. This paper consists of three sections. The first section attempts to describe the gravity of the ecological crisis today. The second section explores the great variety of insights embedded in the religious traditions in India and the final section spells out some dimensions of our eco-responsibility towards building a more just humanity.

Keywords: Consumption, contemporary, Eco-just humanity, Ecological crisis, Religious traditions

INTRODUCTION

Certainly religions have a distinctive role to play in the development of a more comprehensive worldview and ethics, by creating a common ground for dialogue and creative partnership in envisioning and implementing long term solutions to some of our most pressing environmental problems. The religions do have potential to become effective defenders of ecological values. Pope John Paul ll, in his World Peace Day Message titled, The Ecological Crisis: A common Responsibility (1990), invited people of all faiths and religions and even those who do not follow any religious tradition to share a common platform to express concern for the wounded planet. This is critical because the attitudes and values that form people's concepts of nature come primarily, if not exclusively, from religious world views and ethical practices." If ecological concerns are to be of great moment in a society's life, they must be recognized in the area where questions of ultimate concerns are raised and responded to. That is the area of religion where serious commitment is expected" (Errol D' Lima, 1998). Denis Edwards in his book (2006), Ecology at the heart of Faith, has shown a way to respond theologically to the ecological crisis not in terms of bypassing central affirmations of a given tradition but in terms of going more deeply into them and attempting to interpret them in the light of pressing contemporary ecological issues. This paper shares the assumption that religions have a significant role in forming values and in building concerns and commitments that will be crucial for the transformations required for creating indispensable modes of sustainable life in ecological age.

1. Ecological Crisis

Today more than ever before we face the devastating effects of air and water pollution, deforestation of natural resources, excessive consumerism, climate change, gradual destruction of the ozone layer, acid rain, poisoning of the earth, disappearance of plant and animal species, and the dangers caused by industrial and nuclear waste. Humans have egoistically placed themselves and all other life-forms in an ecological crisis. This section deals with some dimensions of the ecological crisis that we are facing today.

1.1 Water and air pollution

Illnesses related to water supply, waste disposal, and garbage kill 30,000people in the world everyday and constitute nearly 75 per cent of all the sickness that afflict humanity. In India due to rapid industrial and population growth 70% of the surface water is polluted. Out of 3100 towns, only 200 have sewage treatment facilities (many of them are properly maintained) .For instance, 900 million liters of sewage is dumped in the ganges, Out of about 132 big industries that pump wastage into the Ganges, hardly 12 of them do waste processing. But public drinking water should be free from coliform as per the standard set by the World Health Organization (Khoosho, 1998). The rivers which caused the emergence of great civilizations in the past are considered to be "arteries of life" have in reality become "the rivers of death" in the present times (Ipe M Ipe,1998).With the consumption of polluted water people suffer from diseases like fever, tuberculosis, pneumonia, lung problems and so on. The World health Organization (WHO) in 1993 reported, "Someone in the world is newly infected with tuberculosis literally with every tick of the clock- one person per second"(Siji,2007).

The united Nations Development Programme (UNDP) Report states that nearly 15 million people die every year due to lack of water. But the average water consumption of US citizen is 7200 litters a day, while that of an Indian is 25 litres. According to the World Bank assessment, in Mumbai around 600 million litres – nearly a fifth of the water –a day finds its way to the gutters even before it reaches the consumers, and about 800 million litres of water is wasted in Delhi alone by individuals in the long water pipe- line net work. On the other hand, one in three suffers from water scarcity in India. When there is lack of water, it is the poor women and children who have to suffer the maximum (Siji,2007).

The emission of motor vehicles, power generators, and waste incinerators pollute the atmosphere, and air pollution continues to be major global problem today. In Delhi alone transport vehicles deposit more than 200 million tonnes of pollutants everyday that result in health hazards especially children (Walter, 2006). According to a study by J.N. Pandey, Delhi's polluted air is responsible for 41 per cent increase in asthma cases and 39% rise in chronic bronchitis. Pollution and asthma are linked. Studies also show that the most vulnerable victims of asthma are the poor (Siji, 2007).

1.2 Deforestation

At the beginning of the 20th century, the total forest area of the planet was 5000 million hectares, and by the year 2000, it was reduced to 2900 million (Kamala, 1992). The forests of the world are disappearing at a rate of 20 million hectares every year. It is estimated that at every tick of the clock the space of a football field is added to the deforested area in the tropical forests and every year it is almost an area of the size of Australia. Deforestation not only destroys the natural habitat of wild animals but also turns the natural greenery into concrete jungles.

At the current rate of deforestation, the planet's rainforests will disappear within the next ninety years. A combination of forces- multinational companies seeking profits, and governments desperate to pay off international debts- eradicate tropical forests at an alarming rate. Forests are also called the wind brake and monsoon director. For instance, in Vidarbaha, the north eastern region of maharashrta, the ground water level has gone down drastically. People had to dig only 45 meters to get water in 1980s, 90 meters in 1990s and 460 meters in 2000s.

1.3 Extinction of Biodiversity

According to the living planet Index of 2002, from 1970 onwards there has been a 15% decrease in the planetary species, a 35% decrease in sea species and a 54% decrease in fresh water species. In the second half of the 20th century, the earth lost 300,000 species. Flora and fauna are lost at the rate of almost seventeen species every day. An estimate made by the UN cautioned that 25%of living species may disappear in the next 25 years (Stephen, 1999).

1.4 Climate Change and Global warming

The UN report of 2007 on the environment states that climate change is the biggest threat to humanity with extreme weather events, droughts and a rise in many diseases (Rachel, 1962& Jonathan, 1982). The latest UN report on the environment categorically states that the present global –warming is human made. A panel of scientists predicted a rise in temperature of 1.6 to 6.4 UC by the year 2100. The tragic fact is that the world's poorest countries face a dramatic rise in deaths from disease and malnutrition as a direct consequence of climatic changes caused by weather and more polluting countries.

Scientific data indicate that the increased levels of carbon dioxide primarily produced by the burning of fossil fuels and tropical rain forests, methane, nitrous oxide create a green house effect or global warming. Predictions suggest that CO_2 emissions from industrialized countries will reach levels of 50 to 70 per cent above 1990 levels in 2020. It is estimated that global warming could proceed even more quickly unless reversing current emission trends are enforced (Raymond, 2005). The temperature in India is rising at an average of 0.57 degree Celsius annually. The year 2002 was the second hottest since the time of record keeping, namely in the 1880s. With the unpredictable changes in the climate now Indian farmers are realizing that they can no longer depend on agriculture for their livelihood and they cannot plan their crops as they used to do in the past.

1.5 Unsustainable Population

Since 1950 urban centres have absorbed nearly two-thirds of the global population explosion. In this process of rampant urbanization, the world has become marked by the unruly growth of slums, characterized by overcrowding, poor or informal housing, inadequate access to safe drinking water and sanitation and a variety of environmental- related problems like waste disposal, diseases and epidemics. UN researches show that there were at least 921 million slum dwellers in 2001 and more than 1 billion in 2005, with slum population growing by a staggering 25 million a year. Moreover, the rapid growth in population adds incredible strain on the available natural resources and compels people to exploit nature indiscriminately (Siji, 2007). Since the Homo sapiens are the dominant species on the planet earth, it goes without saying that the increase in their numerical strength invariably affects other life- forms in many ways.

1.6 Unbridled Consumption

The World Wildlife Fund (WWF) reports that humanity today consumes nearly 20% more natural resources than the earth is able to generate. The same report also states that by 2050, this rate will be over 80%.To maintain the present rate of oil use the world must discover every ten years as much oil as there is in Saudi Arabia which holds 25% of the world's known reservoirs at present. Most experts predict little of the world's available oil to be left after 2059.In 1990 the industrial nations, with about one fifth of the world's population, consumed almost three-fourths of the world's energy. The United States alone, with only 6% of the world's population, consumed 30% of the world's energy accounting to a quarter of the total carbon emissions. The present generation does not have any monopoly of the earth and its resources. The future generations also have a claim on them and therefore the contemporary generation has a responsibility for the future generations.

1.7 Impact of Globalization on Ecology

The phenomenon of globalization that is sweeping the developing countries exploits nature and the poor to the maximum for its profit. It reduces nature and resources to a commodity to be used and abused for one's own selfish interests. The means of production fall into the hands of a few vested interests in a system that perpetuates and intensifies the destruction of ecological balance through domination as a perpetual structural practice. In the process, globalization escalates the environmental tragedies and victimizes and reduces the poor to a commodity (Swaminathen, 1995).

1.8 The poor: the most Vulnerable

Today for many people in the world the environmental crisis is already a matter of survival for themselves and for their children. Many of the conflicts in the world in the name of natural resources like water or any other issues victimize the poor who are the most vulnerable. The Chipko movement of women (1973) struggling for the protection of trees, which had its origin in the conflict about forest resources, is a classic case to illustrate the link between the forests and the marginalized. They warned the officials of the consequences of deforestation and declared, "The forest is our mother's home. If the forest is cut, the soil will be washed away. Landsides and soil erosion will bring floods which will destroy our fields and homes. Our water sources will dry up and all other benefits we get from the forest will be finished" (Trivedi, 1992). Thus the demands of the Chipko movement are of an ecological nature and points out the inter relatedness between the preservation of the forests and the preservation of the soil and water resources.

2. Insights from the Religious Traditions in India

The rich religious traditions in India offer inspiring insights, diverse theological and practical perspectives on ecological concerns. This section intends to explore humbly the resources in the religious traditions in India and glean the insights from them in the hope that they would raise our awareness and challenge our behaviour in all our relations with the earth, its creatures and with each other so that we may learn to live justly amongst the earth's abundance and rich diversity.

2.1 Ecological Insights from Hinduism

An underlying ecological sensitivity can be perceived within the Hindu tradition from the way the power and the value of the natural world is recognized various texts and rituals of the Vedic traditions of Hinduism praise the earth, atmosphere and the sky. The symbolic significance of the tree in the Hindu tradition can be an invitation to foster a greater care for nature. Rivers have been and continue to be an integral part of Hindu religious life and practice. A plurality of cosmological views find home in Hinduism. Consequently multiple ways of relating the humans with the natural world are noted within Hinduism (2006).

2.2 Ecological Insights from Islam

The earth is mentioned in the holy Qur an nearly 453 times where as the sky and the heavens are mentioned only about 320 times. Prophet Muhammad said, "The earth has been created for me as a mosque and as a means of purification". There is a good sense of the goodness and purity of earth hidden in the words of the prophet and his words acknowledge sacrality attributed to the earth which is considered a fit place for human to serve God in religious ceremonies or in daily life. With respect to humans' stewardship of the earth, the privilege entails a profound responsibility. For the Muslims green is the most blessed of all colours and it, "together with a great sense of the value of nature as God's perfect and most fruitful plan, provides a charter for a green movement that could become the greatest exertion yet known in Islamic history, a "green jihad" appropriate for addressing the global environmental crisis"(Denny,1995). As the literal meaning of the word jihad is: to exert/strive oneself for moral or religious perfection, "green jihad" could mean ecological perfection.

2.3 Ecological Insights from Christianity

The story of creation in the book of Genesis states that Yahweh first and foremost created space for living beings (Gen 1:1-26).It is a powerful proclamation that "every life needs its corresponding living space. Vital power and energy are not enough by themselves" (Juergen, 1994). Anyone who destroys the living spaces of others and other life forms destroys them by destroying their chances for living. In the New

Testament perspective we find Jesus in the pages of Gospels, is a child, friend and lover of nature. Nature was an open book that inspired and taught him. Jesus made use of the symbolism of food to explain the significance of his life and to be an expression of his continued presence with humanity. In fact, the Eucharistic celebration in the Christian community "unveils for the believer the God who always remains in relationship with the cosmos, the earth and communities of persons. To become aware of the presence of Christ in the Eucharist is to learn to discern the sacredness of matter".

One could observe two motifs in Western theological approach to nature. One motif is called as 'spiritual motif' and the other as an 'ecological motif'. The spiritual motif underlies an attitude that "the end of human existence is thought to lie either in a transcendence of nature or, in modern times, a humanization of nature" while the ecological motif perceives the end "to lie in community with nature, appreciative of nature's blessings and cognizant that nature has value apart from its usefulness to humans". The second Vatican Council opens a new window to the approach towards the environment and all the Popes continuing this orientation through their teachings. Bishops conferences in different parts of the world and the churches of different denominations continue to make efforts to bring greater awareness and sensitivity to urgent ecological concerns (Johnson,2004).

2.4 Indian Religious Experience

The culture and life style of the indigenous people in India bear testimony to a continuous life process that binds together human beings and nature, animals and gods. Their perception of nature, their relatedness to nature and to one another, their religio-social and cultural expressions reveal a symbiotic relationship with nature and a holistic vision of life. Indian religious experiences of nature synthesized in different faith traditions powerfully bring out the interrelatedness of humans with the whole of creation.

3. Basic Qualities for Building a More Eco-just Humanity

In the light of the ecological insights that our rich religious traditions offer us, some basic qualities are spelled out in this section towards building an eco-just humanity.

3.1 Journeying together with all creatures of the Earth

Ecological insights embedded in the religious traditions in India invite us to recognize the goodness of all of God's creation and to extend our respect and care for them. The awareness that we, all the life- forms of the mother earth, belong together challenges us not merely to look beyond the sky but to be sensitive to God's creation here and now. Indeed taking the first step locally gives us a sense of orientation and direction and fills us with a sense of belonging to all of God's creation universally. It is time to realize that we, humans, are on a journey with all creatures of the earth (Dieter, 1998).

3.2 Respecting the interconnectedness with and interdependency of all creatures

This is a simple truth and an elementary principle of ecology. Humans are not splendid isolationists, but part of God's creation. Humans are empowered with the ability to see the goodness of the Creator reflected in all creation and is bathed in an atmosphere of mutual respect for others, whether human or non-human. Humans exist in interconnectedness with all creatures and are interdependent. Losing sight of this inevitable dimension of human life can only lead to the very extinction of human life on planet earth.

3.3 Valuing the variety and richness of biodiversity

It may be difficult to explain the necessity of a single threatened species for the survival of the earth but the richness of ultimate well-being of the earth depends on the interaction of a greater diversity of beings...It is good that such creatures exist, and we find value in the rich diversity diminishes us as part of the family of all creation. Humans' failure to recognize and appreciate the value in the variety of life forms is in reality a failure to understand diversity as an enhancing quality and to experience the beauty, wholesomeness of the earth community and ultimately the fruits of the Spirit.

3.4 Accepting our profound responsibility for the earth

The vocation of humans is not merely to be stewards of God's creation but is to be stewards of life's continuity. This understanding of our vocation challenges us to respect the evolutionary wisdom and divine authority embodied in the natural world; be accountable to the common good and to future generations; foster a communal and less resource-consumptive vision of good life. In fact, humans' call to be stewards of life's continuity implies that we need to nourish and cherish the dynamic relationship that exists in the planet earth and consequently the great task of humans is to support a new pattern of human presence on the planet based on relationality and justice toward all, humility and esteem for every life- form and a praxis of frugality and simplicity of life- style.

3.5 Responding to the double-edged challenge of eco-justice

Respect and care for earth seeks justice for biodiverse- kind as well as human kind. Eco-justice has been the thrust of several recent publications. These publications point out that eco-justice provides a dynamic framework for reflection and action that fosters ecological integrity with socioeconomic justice through appropriate and constructive human response towards environmental prosperity and social equity. One of the features of an eco-just society is the consciousness of its responsibility towards the future generations (Hessel, 1998). Environment is not the monopoly of the present generation but it is the common heritage of humanity. Therefore the present generation has responsibility towards the future generations.

Joining hands with everyone we should search together for ways and means to preserve what is threatened, to heal what is wounded and to make efforts to build a more just society that cares for the earth as well as the poor and powerless in the society. In the quest for life abundant, that is in harmony with the earth, the basic qualities mentioned in this section and other ones that our multi-religious context inspires us would reawaken and orient us to act justly, love tenderly and walk humbely with the Spirit of life.

Conclusion

"Care for the environment represents a challenge for all of humanity. It is a matter of a common and universal duty" (Paul, 1996). In the context of the environmental crisis that confronts us, religions have an important role in helping us rethink or reorient our attitudes towards nature and the poor. Our Indian context with its plurality of religions, ethnicities and cultures, has the rich potential to make our dialogue-interreligious and ecumenical –on the issues of ecology very enterprising and rewarding. Our commitment to work against all life- denying tendencies that tend to dominate the planet would also fill us with a sense of fulfilment that we are striving towards building a more just humanity. Concern for the well-being of the planet is the one concern that hopefully brings the nations (all the religions) of the world into an inter-nation (and inter-religious) community.

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PERCEPTIONS OF RETIREMENT VILLAGE DEVELOPERS ON SUSTAINABILITY IN AUSTRALIA

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ABSTRACT

Population ageing is an established trend in Australia, which has placed a huge pressure on housing for older people. Retirement villages have been regarded as a viable living arrangement for older Australians, and village developers need to provide a sustainable living environment where residents' social, economic and environmental requirements are well satisfied. For village developers in Australia, providing a retirement village with sustainable features is becoming increasingly popular. Nevertheless, to date, no study has explored the perceptions of village developers on sustainability in Australia. This study aims to address this research gap through a qualitative content analysis of official websites of 15 representative Australian village developers. Overall, 41 sustainability features of retirement villages perceived by these developers have been identified, with the "independent living" and "basic healthcare services provision" being mostly mentioned. From these findings it appears that village developers generally focus more on social-friendly environment, ignoring the financial and environmental aspects of sustainability. Additionally, compared with not-for-profit village developers, private village developers promise more on sustainability. Findings of this study will guide the development and operation of a sustainable retirement village in the future.

Keywords: Retirement village, Sustainability, Perception, Retirement village developer, Australia

INTRODUCTION

The ageing of the population is an established trend in Australia. During 1994-2014, the proportion aged 65 years and over increased from 11.8% to 14.7%, and it is predicted that this proportion will increase to 19.4% in 2031 (Australian Bureau of Statistics, 2013, 2014). Although the majority of older Australians prefer ageing-in-place, there have been an increase number of older adults moving to retirement villages in their later life. Currently, approximately 5.7% of the over 65 population live in retirement villages, and it is predicted that the penetration rate will reach 7.5% in 2025 (Property Council of Australia, 2014).

A retirement village is a senior-oriented living environment where diverse accommodation, services and facilities are provided to residents to meet their needs. Retirement village living can benefit residents in diverse ways, such as promoting social connections and participation, and improving health conditions (Gardner et al., 2005). Nevertheless, some retirement villages have failed to meet residents' requirements in terms of affordability, life-style and environmental friendliness (Xia et al., 2015).

Sustainability aims to meet the needs of people without compromising the requirements of future generations. A sustainable housing offers residents a comfortable standard of living, reducing environmental impacts and achieving affordability (Malience and Malys, 2009; Plaut et al., 2011). Therefore, it is suggested that the delivery of a sustainable retirement village is a promising approach for village developers to meet residents' needs on affordability, life-style and environmental friendliness (Xia et al., 2015). Generally, a sustainable retirement village is a well-designed environment where village residents' social, economic and environmental requirements are well satisfied (Hu et al., 2015a).

The development of sustainable retirement villages is becoming increasingly popular in Australia, and village developers are one of the most important contributors. As village developers' perceptions on sustainability impact their sustainable behaviours directly, understanding their perceptions is important and meaningful. Nevertheless, to date, no study has explored this issue in the Australian context. Therefore, the aim of this study is to explore village developers' perceptions on sustainable retirement villages relating to environmental, social and financial aspects. It is expected that this study will benefit the development and operation of sustainable retirement villages in Australia.

SUSTAINABLE RETIREMENT VILLAGES IN AUSTRALIA: A LITERATURE REVIEW

Despite the ample research on "sustainable development" and "retirement villages" respectively, studies exploring "sustainable retirement villages" are limited. Results of Barker et al. (2012) and Xia et al. (2014) indicate that village residents from both not-for-profit and private villages are concerned about the consumption of unsustainable resources, and would like to make their village become more sustainable. Nevertheless, residents from not-for-profit villages are also concerned about the extra cost related to sustainable features in retirement villages (Barker et al., 2012). Xia et al. (2014) investigated residents' perceptions on sustainability in a private retirement village, and found that the majority of this private village's residents would like to pay a higher price of living in a sustainable retirement village. Hu et al. (2015a) proposed a framework of a sustainable retirement village based on the ecological theory of ageing and the triple bottom line of sustainability. Four interrelated domains of a sustainable retirement village are suggested in this framework, including senior-oriented basic settings, financial affordability, age-friendly social environment, and environmental sustainability. In general, a sustainable retirement village should meet the unique housing requirements of residents in terms of affordability, life-style, and environmental friendliness.

As the main contributors to the development of sustainable retirement villages, some not-for-profit and private village developers have taken actions to make their villages more sustainable in Australia. For instance, Zuo et al. (2014) investigated the crucial issues to be considered by a not-for-profit developer in the development of its sustainable retirement village in South Australia. Research findings suggested that not-for-profit village developers are concerned about the high initial investment involved in various sustainable features. This study also identified diverse green practices used in the planning, design, and construction of the sustainable retirement village. A case study of a resident-funded village by Xia et al. (2015) also identified diverse practices to make a sustainable living environment for residents, such as the green design for the site and floor plan, and the provision of diverse services and facilities to residents. Despite these efforts, developments of sustainable retirement villages are still limited in Australia.

RESEARCH METHOD

The method of qualitative content analysis was adopted in this study. Qualitative content analysis focuses on the characteristics of language as communication with attention to the content or contextual meaning of the text (Hsieh and Shannon, 2005).

In this study, the qualitative content analysis started with the identification of materials to be used. These materials were village developers' descriptions regarding their "retirement village business", and were retrieved from their official websites. The online database of the Retirement Living Council (www.retirementliving.org.au) was adopted to identify representative village developers. The Retirement Living Council recommends a number of leading village developers to potential residents. These recommended village developers are also members of Property Council of Australia. In the present study, 15 large village developers were used. They were selected because that among the recommend village developers, only these 15 village developers manage and operate villages nationally. These village developers are well represented in the Australian retirement village industry. The official websites of these village developers were then searched and their descriptions of "retirement village business" were retrieved and recorded.

This was followed by the analysis of identified materials. More specifically, identified materials were reviewed, and developers' sustainability features were recorded, coded and categorised. These identified sustainability features can reflect village developers' perceptions on sustainability. Then, to explore the relative importance of identified sustainability features, the frequency of each was calculated. Based on this process, the study aim can be achieved.

SAMPLE CHARACTERISTICS

Figure 1 shows the number of village developers managing and operating villages in different states/territories. In addition, among these 15 village developers, nine of them are private ones and other six are from the not-for-profit sector.

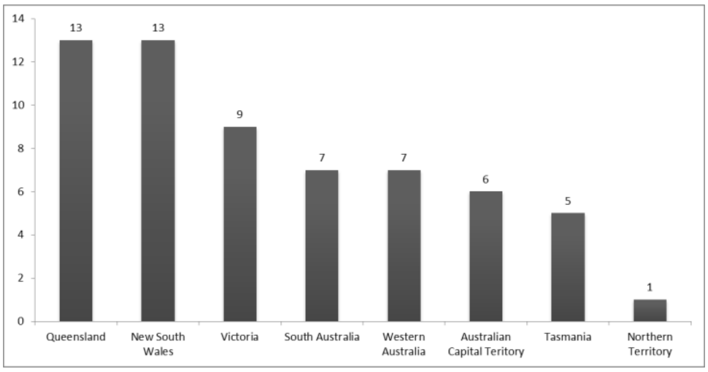

Figure 1 The Number of Retirement Village Developers Managing and Operating Villages in Different States/Territories

RESULTS

The result of the qualitative content analysis is shown in Table 1. Overall, 41 features of a sustainable retirement village perceived by those developers have been identified. It can be seen that all village developers value the independent living of residents, and provide basic healthcare services to residents. Other mostly mentioned sustainability features include "security", "support and service provision and accessibility", "social connection", "social engagement", "flexible accommodation options” “affordable village living” and “less responsibilities”. In addition, some features are mentioned less by village developers, such as “habitat and wildlife protection” and “waste management”.

Table 1 Sustainability Features of Retirement Villages Perceived by Village Developers

Code	Sustainability features	Frequency
1	Independent living	15
2	Basic healthcare services provision	15
3	Security	14
4	Support and service provision and accessibility	14
5	Social connection	13
6	Social engagement	13
7	Flexible accommodation options	13
8	Affordable village living	11
9	Less responsibilities	11
10	Age-friendly village management and operation	10
11	Privacy	9
12	Freedom	9
13	Facilities provision and accessibility	8
14	Respect	7
15	Continue improvement of villages	7
16	Residents’ development in later life	6
17	Senior-oriented home design	6
18	Suitable village location	6
19	Life quality improvement programs	5
20	Information sharing	4
21	Senior-oriented village planning and design	4
22	Dignity	4
23	Familiar living environment	4
24	Interests sharing	3
25	Civil engagement	3

26	Fairness	3
27	Attractive natural environment	3
28	Capital gains sharing	2
29	The sense of belonging	2
30	Child-friendly village environment	1
31	Fulfilment	1
32	Friendly residents	1
33	Trust	1
34	Recyclable and renewable materials	1
35	Energy efficient products	1
36	Recycled water	1
37	Solar electricity generation	1
38	The selection of sustainable soft furnishings	1
39	Energy generation and efficiency	1
40	Habitat and wildlife protection	1
41	Waste management	1

These identified features can be further classified into different categories. According to Hu et al. (2015a), a sustainable retirement village is comprised of four interrelated domains, including senior-oriented basic settings, financial affordability, age-friendly social environment and environmental sustainability. The four categories are shown in Table 2.

Table 2 The Categories of Sustainability Features Perceived by Village Developers

Categories	Sustainability features	Frequency
Age-friendly social environment	Independent Living; Security; Support and service provision and accessibility; Social connection; Social engagement; Flexible accommodation options; Less responsibilities; Privacy; Freedom; Facilities provision and accessibility; Respect; Continue improvement of villages; Residents' development in later life; Life quality improvement programs; Information sharing; Dignity; Familiar living environment; Interests sharing; Civil engagement; Fairness; The sense of belonging; Attractive natural environment; Child-friendly village environment; Fulfilment; Friendly residents; Trust;	26
Environmental sustainability	Recyclable and renewable materials; Energy efficient products; Recycled water; Solar electricity generation; The selection of sustainable soft furnishings; Energy generation and efficiency; Habitat and wildlife protection; Waste management;	8
Senior-oriented basic settings	Senior-oriented home design; Suitable village location; Senior-oriented village planning and design; Basic healthcare services provision; Age-friendly village management and operation;	5
Financial affordability	Affordable village living; Capital gains sharing;	2

As shown in Table 2, most sustainability features (26 in total) relate to the development of an "Age-friendly social environment". This is followed by the two categories of "Environmental sustainability" and "Senior-oriented basic settings", with 8 and 5 features respectively. The category of the "Financial affordability" was only mentioned twice, including "affordable village living" and "capital gains sharing".

A further examination of these sustainability features reveals that all private village developers value "independent living", "basic healthcare services provision", "security", "social connection", "social engagement", and "flexible accommodation options". All not-for-profit village developers emphasise on "independent living", "basic healthcare services provision", and "support and service provision". In addition, the average number of sustainability features mentioned by a private village developer is 16.8 whereas this figure is 11.5 for a not-for-profit village developer.

DISCUSSION

The result of the qualitative content analysis reveals that village developers focus more on the development of a social-friendly village, and the financial and environmental sustainability of retirement villages are less mentioned. The top seven sustainability features are related to age-friendly social environment. The social sustainability of a village environment is of great importance for residents as it can benefit residents in diverse ways such as improving social connection and engagement, and ensuring an independent and secure environment (Hu et al., 2015a). In addition, given that all sustainability features in the "Environmental sustainability" category are mentioned only once, it gives the implication that village developers have not paid much attention to the provision of an environmentally-friendly environment.

Although an age-friendly social environment is crucial to the wellbeing of residents, they also expect their village environment to be green and affordable (Gardner et al., 2005; Barker et al., 2012; Hu et al., 2015b). The expectation of residents on an environmentally-friendly lifestyle is partly due to their recognition of the importance of environment protection (Xia et al., 2014). Meanwhile, as village residents' income is declining in their later life, an affordable living arrangement is also expected (Hu et al., 2015b). Although most village developers value the "affordable village living" of their village residents, residents may also face difficulties especially when they seek for the next living accommodation (e.g., nursing home) if they do not have enough money while leaving the village. For a sustainable retirement village, village developers should consider the affordability issue of village residents' future living arrangement (Hu et al., 2015a).

Compared with not-for-profit village developers, private village developers promise more on sustainability. As aforementioned, the average number of sustainability features mentioned by a private village developer is 16.8 whereas this figure is only 11.5 for a not-for-profit village developer. Private villages are resident-funded for the purpose of making money. To attract the relocation of potential residents, private village developers deliver a more sustainable village environment by ways such as providing more support and services. For not-for-profit village developers, they normally do not have such strong financial capacity compared with private village developers, which may be an important reason that results in relatively less commitments on sustainability.

In addition, sustainability perceptions of private village developers differ from that of not-for-profit village developers. Private village developers focus more on the delivery of an age-friendly social environment (e.g., independent living, security, social connection and engagement) and the provision of basic healthcare services to residents. For not-for-profit village developers, though they also stress the provision for residents with an age-friendly social environment and healthcare services, they also value the affordable living of their residents. This is in line with Petersen and Warburton (2012)'s view that village developers from the not-for-profit sector provide rental and affordable housing for residents. However, it should be noted that "not-for-profit" does not mean that they do not create surpluses. Not-for-profit village developers also need to make profits. Nevertheless, they redirect their profits to their residents to improve their living environment (Zuo et al., 2014). For private village developers, they are more profit driven, and thus often design a retirement village project that is marketable and saleable to make money (Petersen and Warburton, 2012).

CONCLUSIONS

Retirement village living is a viable living arrangement for older adults. To meet residents' requirements in terms of affordability, life-style and environmental friendliness, the need of delivering a sustainable retirement village is becoming increasingly pressing. As village developers are one of the most important stakeholders delivering sustainable retirement villages, this study aims to understand their sustainability perceptions through a qualitative content analysis of their online descriptions of retirement village business.

Overall, 41 features of sustainable retirement villages were identified. Village developers value the independent living of residents, and provide basic healthcare services to residents. In addition, village developers also expect to provide a security, supportive, and a socially connected and engaged village environment. However, it should be noted that village developers focus more on the development of a social-friendly village, and largely ignore the financial and environmental sustainability. In addition, compared with not-for-profit village developers, private village developers promise more on sustainability though both private and not-for-profit village developers stress the provision of the age-friendly social environment and healthcare services provision to residents.

One limitation of this study is that only 15 village developers were analysed. Nevertheless, these 15 village developers were representative ones that develop and operate villages nationally. The present study guides the development and operation of sustainable retirement villages in the future.

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MANAGING MULTICULTURAL TEAMS: THE MULTIPLE INTELLIGENCES OF A PROJECT MANAGER

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ABSTRACT

The prevalence of multicultural teams has increased as we move towards a global economy. This presents a challenge for project managers who must manage across borders, time zones, languages, and cultures. Peak project management bodies of knowledge and key educational texts are critical sources which educators draw on to prepare students to be effective project managers in trans-national business activities. Analytical intelligence, emotional intelligence, and cultural intelligence have been identified as key components of successfully managing a multicultural team, and the research aimed to identify to what extent these components are represented in key educative sources. Document analysis was applied to (i) peak project management bodies of knowledge, (ii) peak project management institute websites, and (iii) textbooks utilised within a project management undergraduate degree. Results revealed that all sources acknowledged the importance of analytical intelligence, and to a lesser extent emotional intelligence and cultural intelligence. However few sources considered intelligence types in the context of managing multicultural teams. It is recommended that educators incorporate strategies into the curriculum which enable project management students to develop a holistic capacity to manage in a multicultural environment. Incorporating awareness and ability to work with multicultural teams into the curriculum supports the work readiness of students as they transition from university into a globalised workplace.

Keywords: analytical intelligence, cultural intelligence, emotional intelligence, multicultural teams, project management education

INTRODUCTION

Project management

It is recognized that project management is a key tool for achieving an organization's strategy, as well as improving organisational performance

(Longman & Mullins 2004; Project Management Institute 2013a; Williams & Samset 2010). Reported expenditure on projects is extensive. For example, the cost of existing and potential major capital projects in Australia, including resource, infrastructure, and major commercial projects, was estimated to be $921 billion at 2012 (Business Council of Australia 2013). However, the Project Management Institute (2014) found that poor project management performance resulted in organisations losing $109 million for every $1 billion invested in projects and programs. Given the magnitude of project expenditure and the strong link to organisational strategy and performance, project professionals are positioned as critical in the successful delivery of projects. According to the Project Management Institute (2013b), 15.7 million new project management roles will be created globally from 2010 to 2020. It is imperative that project professionals' education and professional development equip them with the competencies they require to be successful practitioners.

As globalisation continues to encourage transnational business operations, the prevalence of multicultural teams within projects has increased (Schneider 1995; The Economist Intelligence Unit 2015). Transnational teams, as defined by Iles and Hayers (1997, p.95), is any multicultural team that 'successfully transcends the cultural, geographic and managerial barriers to team effectiveness'. Managing projects is known to be high paced, time pressured and can induce high stress levels (Sommerville & Langford 1994). The nature of multicultural project teams generates additional pressures and presents complex situations that may not arise in typical project teams, such as conflict (Brett, Behfar & Kern 2006), communication barriers and discrimination (Miller et al. 2000).

Multiple intelligences

It is vital that project managers develop the competencies required to work effectively in a global economy. Alon and Higgins (2005) contend that to successfully transcend cultural barriers and encourage members to work to their optimal potential, leaders must demonstrate three types of intelligence; (1) analytical intelligence, (2) emotional intelligence, and (3) cultural intelligence. Analytical intelligence is referred to as the 'rational and logical based verbal and quantitative intelligence,' (Alon & Higgins 2005, p. 503). Emotional and cultural intelligence are emerging to become critical facets of intelligence, with the increase of global collaboration. Emotional intelligence is described as the ability to 'be aware of one's own emotions and be able to manage them, just as one must also be aware of the emotions of others and be able to manage any interaction' (Alon & Higgins 2005, p.504). Cultural intelligence is defined as 'a person's capability for successful adaptation to new cultural settings, that is, for unfamiliar settings attributable to cultural context' (Earley & Ang 2003, p.9). When managing projects in a multicultural environment, emotional intelligence must be implemented into this culturally diverse context, and this calls for the convergence of both emotional and cultural intelligence (Alon & Higgins 2005). In order to overcome the barriers which may arise in a multicultural project team, it is fundamental that project managers develop and utilise all intelligence types to ensure that their team members are not only performing optimally, but that their wellbeing is ensured.

AIM

In order to be work ready, project management graduates must be equipped to work in a culturally diverse workforce and have the competencies required to work effectively in a multicultural project team. This research aims to investigate the extent to which key sources informing university curriculum make reference to the three intelligence types and consider these in the context of managing multicultural teams. Two research questions guided the exploratory study: (1) To what extent are the intelligence types acknowledged within project management sources?; and (2) How do these sources address the management of multicultural project teams?

METHOD

Sample

The sample was guided by key educative sources used to inform the curriculum design and content of the RMIT project management degree. Three categories of data were utilised in the study. The following sources were selected for each category:

i) Peak project management bodies of knowledge

1. Project Management Institute 2013, A Guide to the Project Management Body Of Knowledge (PMBOK guide), 5th edn, Project Management Institute, Newtown Square, PA.
2. Great Britain Office of Government Commerce 2005, Managing Successful Projects with Prince2, 4th edn, TSO (The Stationary Office), UK.

ii) Peak project management institutes

3. Australian Institute of Project Management 2015, About us, Australian Institute of Project Management, viewed 29 August 2015, <https://www.aipm.com.au/about-us>.
4. Project Management Institute 2015, About us, Project Management Institute, viewed 29 August 2015, <http://www.pmi.org/About-Us.aspx>.

5. International Project Management Association 2015, About IPMA, International Project Management Association, viewed 29 August 2015, <http://ipma.ch/about/>.

iii) Textbooks utilised within the RMIT University Project Management Degree

6. Larson, EW & Gray, CF 2011, Project Management: The Managerial Process, 5th edn, McGraw Hill, New York, NY.
7. Zein, O 2015, Culture and Project Management: Managing Diversity in Multicultural Projects, Gower Publishing, Surrey, UK.
8. Laufer, A 2012, Mastering the Leadership Role in Project Management, FT Press, Upper Saddle River, NJ.
9. Kerzner, H 2006, Project Management Best Practices: Achieving Global Excellence, John Wiley & Sons, Hoboken, NJ.
10. Taylor, P 2014, Real Project Management: The Skills and Capabilities You Will Need For Successful Project Delivery, Kogan Page, London, UK.

Analysis

In the first stage of analysis, a key word search was conducted on the ten data sources to ascertain the prevalence of the three intelligence types (analytical, emotional, cultural) and of the terms 'multicultural' and 'teams'. The following terms were used in the key word search:

- Analytical intelligence: hard skills, technical, analytical technique.
- Emotional intelligence: soft skills, emotional maturity, behavioural.
- Cultural intelligence: cultural awareness, sociocultural.
- Multicultural: diversity, globalisation.
- Teams: project teams, network, team work.

In the second stage of analysis, data obtained from the first stage were examined using method of agreement. Method of agreement is a form of analytic comparison (Ragin 1987). Analytic comparison is a qualitative data analysis technique that uses method of agreement to discover causal factors that affect an outcome among a set of cases (Neuman 2014). Data is organized for the set of cases (often three to ten) and involves comparing characteristics or features that are similar across instances that share the same outcome (Neuman 2014). The ten cases used in this exploratory research seek to inform the wider project management population about best practice and hence share a similar outcome or purpose. Cases (sources) were analysed using five features (analytical, emotional, cultural, multi-culturalism, team) to draw a conclusion regarding the importance of multiple intelligences in managing multicultural teams and whether they were addressed in sources to ascertain the prevalence of the intelligences in the context of multicultural teams. The information arising from method of agreement is frequently organised as a chart (for an example, refer to Neuman 2014, p.494). Explanation in analytical comparison tends to be interpretative rather than nomothetic (Neuman 2014).

RESULTS

The results of the method of agreement analysis are summarised in Table 1. Case 1, the PMBOK guide (Project Management Institute 2013a), referred to all components and acknowledged cultural sensitivities when managing diverse project teams. The PMBOK guide states that 'in light of globalisation, understanding the impact of cultural influences is critical in projects involving diverse organisations and locations around the world. Culture becomes a critical factor in defining project success and multicultural competence becomes critical for the project manager' (Project Management Institute 2013a, p. 21). In contrast to case 1, case 2, the Prince2 model (Great Britain Office of Government Commerce 2005), is solely focused on the analytical competencies implemented within a team. The cultural awareness competency was not described and emotional competencies seldom acknowledged.

The acknowledgment of ethical consideration within the Australian Institute of Project Management (case 3) identified the requirement of project managers to become emotionally aware when dealing with 'members of project team, the client, associated project stakeholders and the public' (Australian Institute of Project Management 2015, Code of ethics section). Case 4, the Project Management Institute website, acknowledged all components, highlighting the period of growth and change within the industry towards a culturally diverse project management community. Cultural intelligence was demonstrated through the recognition of the Institute's global demographic and their dedication to delivering value 'through global advocacy, collaboration, education and research' (Project Management Institute 2015, About us section). The brief statements made within the 'about us' pages of the International Project Management Association (case 5) clearly establish the acknowledgement of a 'global network' to 'facilitate co-creation and lever the diversity of our global network into benefits for the profession, economy, society and environment' (International Project Management Association 2015, About section). Although the cultural awareness of the Association is evident, there is a lack of acknowledgement towards implementing this awareness within project teams.

In case 6, Larson and Gray (2011) effectively integrate all components within a multicultural team context, particularly through the use of a bi-faceted model combining technical skills and sociocultural awareness (Larson & Gray 2011). In case 7, Zein (2015) continues with an integrated approach, through the implementation of analytical techniques within a range of culturally diverse situations, addressing the emotional and cultural aspects of multicultural teams. In case 8, Laufer (2012) also provides a unique insight into the importance of people skills in overall project success and states that using an analytical approach solely is impractical. Similarly, in case 9 Kerzner (2006) demonstrates a detailed understanding of all three intelligence forms within the context of multicultural teams. The premise of this text is to present case studies from global organisations and industry leaders, as justification and evidence to support Kerzner's (2006) assertions. On the contrary in case 10, Taylor (2014) utilises only analytical and emotional intelligence to describe best project management capability.

Table 1: Results of the method of agreement analysis

Case	*Components*					*Outcome*
	Analytical	*Emotional*	*Cultural*	*Multi-culturalism*	*Team*	*Address the importance of multiple intelligences in managing multicultural teams*
1	✓	✓	✓	✓	✓	*Yes*
2	✓	*x*	*x*	*x*	✓	*No*
3	✓	✓	✓	✓	✓	*Yes*
4	✓	✓	✓	✓	✓	*Yes*
5	✓	*x*	✓	✓	*x*	*No*
6	✓	✓	✓	✓	✓	*Yes*
7	✓	✓	✓	✓	✓	*Yes*
8	✓	✓	*x*	*x*	*Y*	*No*
9	✓	✓	✓	✓	✓	*Yes*
10	✓	✓	*x*	*x*	*x*	*No*

In summary, six of the ten sources addressed multiple intelligences in a multicultural context, based on the method of agreement. However, there continues to be a lack of interconnectedness between managing multicultural project teams and utilising all three intelligence forms as the intelligence forms were often addressed exclusively from a culturally diverse context rather than a team context.

DISCUSSION

Two research questions guided the exploratory study. The first question explored to what extent the intelligence types are acknowledged within project management sources. Results indicated that emotional and cultural intelligence were inconsistently acknowledged, while analytical intelligence was highlighted in all sources. Project management education has been criticized for focusing on the technical (hard) skills, and largely ignoring the interpersonal (soft) skills (Gillard 2009; Ramazani & Jergeas 2015). This is consistent with Pant and Baroudi (2008, p.126) who contend that "the focus of most project management training, in the context of universities, has been on the technical skills deemed essential to achieve project success, that being primarily the iron triangle of time, cost and quality". Findings suggest that sources informing project management curriculum may fall short in preparing students to operate in a globalised work force, and student preparedness for successfully transitioning into a culturally complex environment may be underdeveloped. This highlights the requirement for a multi-faceted approach to education which balances development of the hard and soft skills to enable graduates to be work ready.

The second research question explored how project management sources addressed the management of multicultural project teams. Results indicated that multicultural teams were addressed indirectly, typically describing the relevance of cultural understanding but not consistently within a team context. The project team was often discussed, however the additional complexity of culturally diverse team members was often lacking and articulated within other contexts, such as virtual project teams. Previous research has revealed the benefits of a multi-ethnic project team (Iles & Hayers 1997; Miller et al. 2000). It is imperative that project management programs consist of material which considers multicultural teams, and provides a platform from which students can work towards developing this competency. For example, case studies, problem-based activities, field visits, international exchange programs and study tours, mentoring, and guest speakers are all strategies which can be implemented by educators to raise students' awareness of diversity and cultural differences as they relate to working in teams. Strategies such as these can provide a context in which students can develop their multiple intelligences in the context of diversity and how this relates to project teams. It is also imperative that assessment tasks build in the multiple intelligences, as assessment defines the core of the curriculum (Ramsden 1992) which includes defining what students regard as important and how they come to see themselves as both learner and graduate. Taking a deliberate and planned approach to learning and skill development will equip the new generation of project managers with the ability to function in complex and diverse multi-cultural environments.

Arguably, the Project Management Institute plays a critical role in the context of project management curriculum, especially in instances where the academic program has accreditation from the Project Management Institute (Crawford et al 2006). This is particularly the case as the PMBOK Guide (Project Management Institute 2013a) forms the basis from which accreditation is assessed. While it does address the importance of multiple intelligences in managing multicultural teams, the PMBOK Guide (Project Management Institute 2013a) falls short in explicitly stating how project professionals can develop the competencies required to support multi-cultural teams. In this context, the Project Management Institute plays an integral role in supporting educators to equip the new generation of project managers to succeed in a globalised workforce.

CONCLUSION

Findings of the study indicate that six of ten project management sources addressed the utilisation of multiple intelligences in managing multicultural teams. The findings reveal the need for emphasis on not only the technical skills and knowledge related to analytical intelligence, but on the emotional and cultural competencies required to execute the technical aspects of projects. To support the readiness of students transitioning from tertiary education to a globalised workforce, curriculum should include a range of strategies that are specifically targeted at developing the cultural intelligence of students. Further research is required to explore how the cultural intelligence of students is developed, and which strategies are effective in building student's competency. It is also possible that improved capacity to manage multicultural teams will lead to a higher degree of project success. It is recommended that further research explore how cultural intelligence of project managers impacts on the project success in terms of time, cost, quality and benefits realisation.

A limitation of this research is the data used. Ten sources were used in the sample and this is not representative of all of the sources used within RMIT project management degree. Furthermore, results cannot be generalised to other project management programs or other universities. Finally, as this study focussed on an undergraduate program, results cannot be generalised to postgraduate project management programs. While the findings are limited, they provide a basis from which further research can occur in the understudied area of the multiple intelligences required of project managers.

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INFORMATION REQUIREMENTS FOR RESOURCE PLANNING IN RESIDENTIAL CONSTRUCTION PROJECTS – A BIM PERSPECTIVE

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ABSTRACT

The advent of digital engineering environments and Building Information Models (BIM) was envisioned to enhance our ability to plan on-site construction operations. However, the reliance on full-fledged architectural BIMs is at times impractical, especially for the relatively small projects in the residential housing domain, due to the effort required to develop these models. Simpler and more abstract BIMs can still provide value to the automation of site and resource planning approaches. To advance the use of BIM in the Australian residential housing construction, the herein presented research aims to identify the type of information and semantic knowledge requirements needed for on-site resource planning, with a long-term goal of developing abstract BIMs better tailored for managing on-site construction operations. The study adopts both a desk research of the existing literature and semi-structured interviews with domain experts. This paper reports on the outcomes of stage 1, which is desk research and discusses how the identified required information can be mapped onto data structures in IFC-based building information models.

Keywords: building information model (BIM), building projects, resource management, residential construction, site operations

INTRODUCTION

Building Information Modelling (BIM) has transformed from a buzzword in its early days to an enabling and transformative technology that has been steadily gaining popularity in countries such as USA and UK. Supporters of Building Information Modelling argue that BIM has a potential to improve productivity (Malalgoda et al. 2011) and streamline processes throughout a project's entire lifecycle (Kraatz, 2014). In comparison, the level of BIM uptake in Australia has not been the same. A recent study by Aibinu and Venkatesh (2014) of certain construction professionals in Australia, such as quantity surveyors and cost consultants, confirmed that

BIM was not widely used in industry practice. According to that study, the lack of uptake amongst these construction professionals could be attributed to the uncertainty about the integrity of 3D models issued by designers, incompleteness of information in models, lack of demand by clients, and last but not least, the cost and time needed to implement BIM features. They also cited many instances where cost consultants were not issued the 3D BIM developed by designers and they primarily depended on 2D drawings for quantity take-off and cost estimation.

Smaller size contractors, especially those working in the residential sector, may find it even more difficult to access or utilise complex BIM technology. Barston (2014) found that using BIM to run construction projects may be daunting; however, these digital models can still help contractors improve their productivity. The question is how to overcome some or all of the obstacles construction professionals face when attempting to use BIM. In light of the earlier study by Aibinu and Venkatesh (2014), full-fledged BIM developed by designers can be too for the specific needs of construction professionals: They consume time and money to develop and/or manipulate, which make them less attractive to contractors. Moreover, construction professionals require a specific set of information more relevant to the construction process. Interestingly, despite the large amount of information available in a typical BIM, some of the information needed by these construction professionals may not typically be part of the full-fledged BIM delivered by designers/architects.

The current research attempts to better understand the type of information and semantic knowledge requirements needed by construction professionals, particularly to support the on-site resource planning of residential housing projects in Australia. The study adopts both a desk research of the existing literature and semi-structured interviews with domain experts in Australia. This paper addresses the first stage, i.e. desk research, and discusses how the identified required information can be mapped onto data structures in the BIM representation standard IFC (Industry Foundation Classes).

OVERVIEW OF BUILDING CONSTRUCTION PLANNING AND BIM UTILIZATION

Thorough construction planning and efficient site utilisation are of substantial importance to building construction (Wang et al. 2004). Research has been conducted since the 1970s with attempts to improve the ability to plan and schedule construction works. However, a relatively recent study by Chen et al. (2012) argued that to date few construction planning methods or models in the literature had considerably helped project managers decide on the better distributions of manpower, material, equipment and space taking into consideration project objectives and bounding constraints. Chen et al. (2012) mention that the traditional scheduling methods or models often result in a "seat-of-the-pants" style of management, rather than decision making based on analysing a rather complete reflection of actual on-site data. Importance of proper resource planning and construction scheduling cannot be overlooked. In the Australian context, Doloi et al. (2011) demonstrated through their structural equation model that technical planning and control expertise is a top contributor to project success for medium sized Australian construction contractors.

Researchers saw the advent of digital engineering environments and Building Information Models (BIM) as an opportunity to migrate from intuition-based construction resource planning to an information- and knowledge-based process. Many researchers have developed approaches for improving site planning leveraging BIM data. For example, Moon et al. (2013) have developed a "BIM-Based Construction Scheduling Method", Choi et al. (2014) demonstrated the use of BIM in construction work-space planning, while Zhang et al. (2015) proposed to leverage BIM data for automated safety planning for job hazard analysis on site.

All of these studies rely on the availability of an architectural BIM that can be leveraged for site related planning. However, as cited by a group of surveyed AEC firms in Queensland, Australia, BIM is "expensive to operate and maintain" (Alabdulqader et al. 2013), which is understandable as an architectural BIM requires a lot of detail. As a result, it is more likely for projects of higher values to involve the use of BIM (Alabdulqader et al. 2013), despite the fact that some standard CAD tools used in the design stages support the development of a BIM. Alabdulqader et al. (2013) show that even experienced companies do not always develop BIM models for projects but may consider doing so at project values of about $50 million or higher.

For these reasons, it cannot be expected that architectural BIMs will be developed or simply utilised for the relatively small projects in the residential housing domain. However, it has to be understood that even simple BIMs can provide value to the automation of site planning approaches. Often, the proposed approaches utilising BIM data for site planning support only rely on a subset of the data typically available in a BIM. Wang and Boukamp (2011) showed that mere knowledge about the existence of components and their material can help improve the job safety analysis for a project. Thus, a detailed architectural BIM is not required as a basis for supporting and improving the planning and management of on-site construction resources.

Even the full-fledged architectural BIM may still lack certain important information that is useful for construction planning. Kim and Cho (2015) argue that the current building models still lack construction-specific information, e.g. spatial information of bounded spaces and exterior construction site perimeter, which is essential to developing detailed construction plans. It can be concluded that a more abstract yet better tailored BIM, which incorporates necessary construction-specific information, can help with the uptake of BIM in construction and resource planning. The following sections will discuss the factors deemed necessary to efficiently perform construction site and resource planning followed by an attempt to contextualise them within a BIM environment.

CONSTRUCTION SITE PLANNING AND RESOURCE MANAGEMENT: AN OVERVIEW

There is a large body of knowledge on construction site planning and resource management. In the first stage of the herein presented study, the authors undertook a comprehensive review of the existing literature to better understand the context and process of construction site/resource planning and the factors that may need to be accounted for. This section reports on the findings of this stage of research.

The optimal distribution of construction resources, including manpower, material, equipment and space, plays a critical role in project’s success (Sutt et al., 2013). Various techniques have been proposed by researchers over the years in an attempt to plan construction resources and site operations efficiently (Chen et al., 2012). Studies however differed in the context being addressed. Some have focused on specific types of projects (Aram et al., 2013; Gu & London 2010; Mitropoulos and Memarian, 2012) whereas others focused at a more generic level (Doloi et al., 2011; Navon and Goldschmidt 2003; Sacks et al., 2005; Thomas and Završki 1999).

There are different factors that might be critical to construction resource and site management, especially for the targeted project type, i.e. residential housing projects. The thorough reviewing of the salient literature led to the identification of two classes of resource- and site-related factors. They are: (1) general construction knowledge and enterprise/organization factors, and (2) project- and task-specific factors.

General construction knowledge and enterprise/organization factors

This class of factors pertains to the general industry knowledge and norms, construction standards and codes, in addition to the experiences, capacities and capabilities of a construction organisation (Figure 1).

In his study of construction performance, Koskela (2000) revealed that one of the main sources of disruptions in the construction phase is related to equipment, tool and material issues. The impact of material availability on on-site resource planning is also highlighted by Sutt et al. (2013). Other researchers with economic and sociological perspectives highlight the criticality of an organization’s human, knowledge and social capital.

Sacks et al. (2010), for instance, emphasise the significance of communication channels and feedback decision on the resource planning success. Koskela (2000) also argue that the social conditions of the work group can create additional psychological stress. According to Mitropoulos and Memarian (2012), the knowledge existing within the organization and the industry plays a key role in the effective execution and management of construction tasks.

One key dimension is associated with health and safety requirements. Mitropoulos and Memarian (2012) contend that the safety requirements are additional work constraints that need to be constantly monitored and evaluated. Sutt et al. (2013) support and develop this view by elaborating on the factors critical to health and safety. Studies conducted by Thomas and Završki (1999), Lipman (2004), Partouche (2009), Sacks et al. (2010), and Sutt et al. (2013) also investigate administrative factors, e.g. those related to the methods for monitoring, controlling and reporting construction progress. The prevalent rules and regulations are paramount for on-site resource planning. Among others, Doloi et al. (2011) and Sutt et al. (2013) emphasised the importance of these factors.

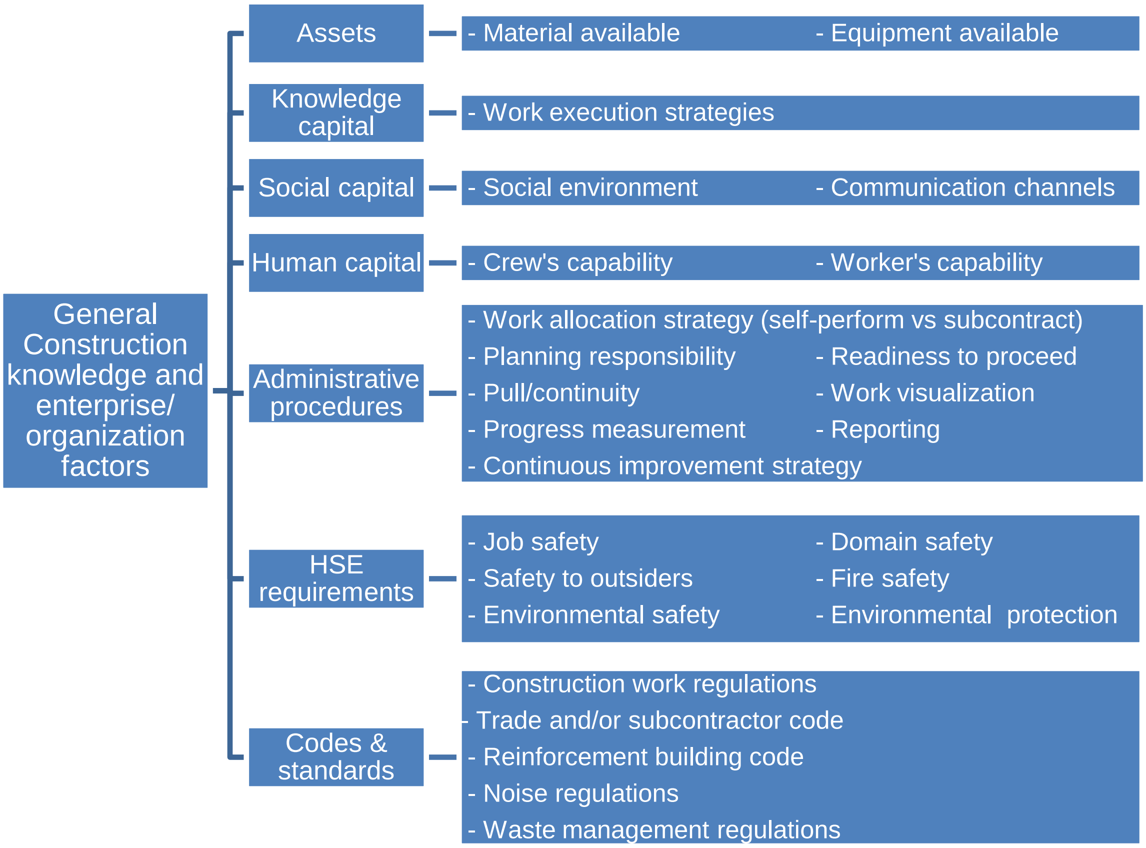

Figure 1. General Construction Knowledge and Organization Factors

Project- and task-specific factors

Project- and task-related factors (see Figure 2) typically address aspects pertinent to cost, time, quality, site characteristics, and productive resources of a particular project or task. These factors are typically identified and documented for each project on an individual basis.

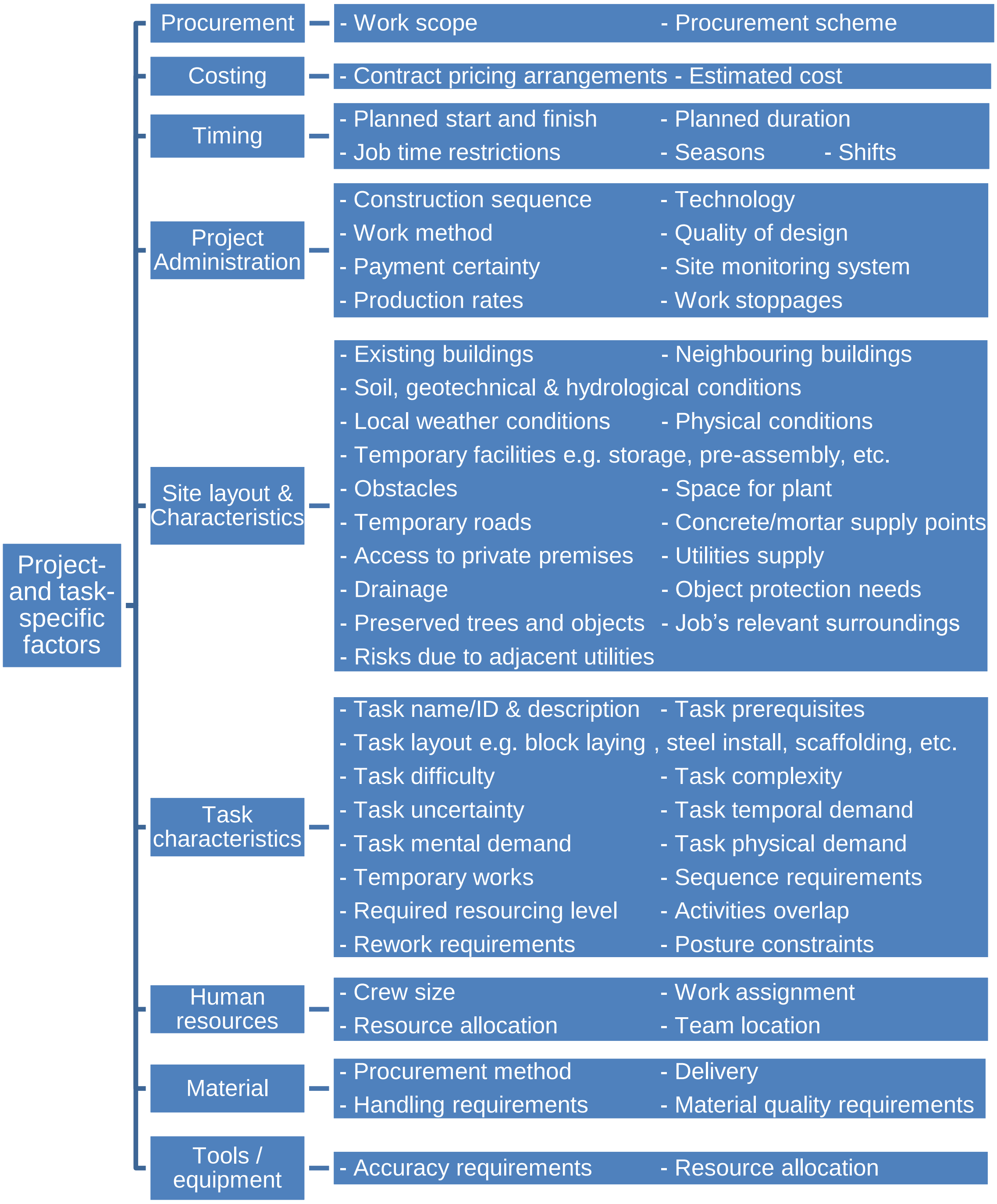

Figure 2. Project- and Task-Specific Factors

The category "Site layout & Characteristics" is perceived as fundamental to on-site resource planning by many studies (Sacks et al., 2010; Sutt et al., 2013). Similarly, task characteristics are realised as important parameters that influence the on-site construction performance (Koskela, 2000; Partouche, 2009; Sacks et al., 2010). Other factors identified in the literature include procurement, timing, costing (Sutt et al., 2013), project administration (Bosche and Haas, 2007; Navon and Goldschmidt, 2003; Sacks et al., 2005; Sacks et al., 2010), human resources, material, tools and equipment (Koskela, 2000; Sutt et al., 2013).

IFC CLASSES FOR ABSTRACT CONSTRUCTION-ORIENTED BIM

To support the adoption of BIM in residential housing projects, it seems important to change the focus from an architectural BIM to a production oriented BIM, to provide more value to the contractor. The above identified factors were evaluated for their representability in a BIM using the international BIM data exchange standard IFC v4-Addendum 1.

As BIMs are project specific, project specific factors can be relatively easily modelled in BIM. Other more general factors can at times be modelled, but their representation is associated with difficulties and/or limitations. Some factors simply cannot be represented or have very limited value when represented in a project specific BIM.

The literature review highlights that site layout, project- and task related factors are perceived as fundamental to on-site resource planning. To support the site layout planning, basic geometry of elements on the site needs to be represented in a BIM. However, it may be sufficient to use simpler shapes rather than detailed architectural representations of the objects on site. While the shape of a building component facilitates its visualisation and can be used to determine material quantities required, a simpler visualisation (e.g. a box or similarly simple shape) may suffice for the rough identification of an object. Quantity information would then be stored directly in the model. Thus, the associated *IfcProduct* representing the building component can have a simplified *IfcProductRepresentation* that provides the general outlines of the component sufficient for rough representation and site planning. Combined with a representation of the spaces (using the *IfcSpace* class), a basic geometrical representation of site conditions is possible that enables site planning without requiring the architectural detail typically invested in a BIM.

Project specific information is easily represented in IFC, as long as clear definitions for how the information is to be interpreted are available. For instance, construction management information, such as scheduling information, can be associated with the project and each product represented in the BIM through the *IfcConstructionMgmtDomain* schema. For example, this domain schema allows for representation of cost, time, resource, task and productivity information, and provides clear definitions for the information representation in an IFC model and its interpretation.

Not every aspect is clearly described in IFC though, but requires additional interpretation agreements. Information at times also should not be defined on the project level, but – for example – on the organisational level, which requires additional data sources other than the project's IFC model to be used for information storage and definition. For example, specific work methods would usually be defined outside a BIM, as a BIM is project specific. The BIM then contains instances of the applied knowledge in the form of *IfcTask* elements that carry a text label named “Work Method” in which the name of a defined work method can be stated. This allows identifying the relevant work method and then consulting other sources for the definition of the actual work method.

Other even more abstract factors could be represented in a BIM at the *IfcProject* level, e.g. as textual descriptions included as either *IfcPropertySets* or attached as additional documents through *IfcDocument* associations, but may have limited value when stored in a BIM. These factors, including social capital factors, such as the social conditions of work groups, often are related to soft skills affect the planning and management but have to be evaluated on an as needed basis. Storing descriptors of these factors in a BIM may provide limited value as the descriptors could be misinterpreted, depending on the presentation approach, and could be outdated by the time the information is needed. These factors are usually knowledge embedded in the organisation and may change frequently. BIM is not necessarily a good medium for this information to be stored and managed.

Additionally, some of the administrative procedure factors relevant to on-site resource management can be represented in IFC-based BIM. For instance, responsibilities can be allocated by assigning *IfcActor* elements to different parts of the BIM, such as tasks or building elements.

Abstract aspects that require analysis and interpretation, such as “safety” can only be represented to a limited extent, e.g. through property sets describing the concepts or through links to external documents. Additional knowledge, such as the rules to be used for the actual analysis, would need to be represented in other external systems.

CONCLUDING REMARKS

The objective of this research is to identify approaches that allow to set up BIM for sharing and leveraging semantically rich site resource management related information without requiring a lot of architectural detail. It can be seen, based on the reviewed literature, that most of the planning relevant information is not tied to detailed geometry that would require a detailed architectural BIM. Whilst the shape of a building component facilitates the visualisation of the component and can be used to determine material quantities required, a simpler visualisation (e.g. a bounding box representation or a similarly simple shape) may suffice for the rough identification of an object for site planning, while the detailed quantity information can be stored directly in the model. Similarly, semantically rich information about tasks, responsibilities and other resource planning relevant information can be tied to the products and the project in an IFC base BIM which may not even require geometrical representations at all, depending on the planning approach used. Many researchers have shown the value of this semantically rich data for different construction management domains, such as safety (e.g. Moon et al. 2015, Zhang et al. 2015), yet the lack of adoption of BIM hinders the realisation of any of these benefits in the residential housing industry. Rethinking the approach to the development of a BIM and the tools available to the industry may help overcome this hurdle. A geometrically abstract BIM developed by the contractor and shared with suppliers and client can still provide value, as it still can contain information useful to the construction and facility management phase of the project (such as component and supplier information).

The completed stage of research depended primarily upon the existing literature. However, it is equally if not more important to capture the knowledge of subject matter experts on the same. The research is planned to proceed with conducting semi-structured interviews with domain experts on aspects such as procedures adopted for site planning and resource management, factors and types of information typically accounted for, existing and/or required level of automation needed to perform these functions, how BIM can contribute to the success of construction and site planning and management, and the obstacles to such aim. Findings of stage 2 of the research will be reported in another future publication by the authors.

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AN EXPLORATION OF THE CHALLENGES FACED BY CONTRACTORS ENGAGING IN POST DISASTER RECONSTRUCTION PROJECTS

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ABSTRACT

Natural disasters are becoming more frequent due to climate change. With the increasing population density, handling and managing the post disaster period is critical. Natural disasters typically require recovery and rebuild projects whose magnitude depends on the scale of the disaster itself. There is an expansive body of knowledge on the effects of natural disasters on the environment and individuals. However, little research is available on the difficulties post disaster contactors face while undertaking this kind of work. A research was conducted by the authors to explore this domain. The study adopts a qualitative approach and uses semi-structured interviews to investigate the research inquiry. Interviewees were all involved in post disaster reconstruction activities including houses, roads, infrastructure etc. Through a thematic analysis of the interview content, the significant challenges contractors had faced were identified. While contractors agreed there were many challenges, the overall view was to continue being involved in such activities due to the potential for financial gains and also the overall rewarding experience.

Keywords: Construction business, disaster management, natural disasters, reconstruction activities

INTRODUCTION

In recent years, and as a result of climate change, the frequency and severity of natural disasters have increased worldwide (IPCC, 2012; Garnaut, 2008; Middlemann, 2007). The same has been observed in Australia. The Department of Transport and Regional Services (2002) declared that:

> "*Since 1980, the average number of disasters of that magnitude [$10 million or more] has been tending to increase*".

The construction industry has a role, and also a duty, to bring life back to normal in these badly affected areas. Following a natural disaster, damaged infrastructure and properties are either repaired or demolished and reconstructed. This comes with massive investments in residential and commercial property along with partial/complete rebuild of roads, rail networks, bridges and sewerage infrastructure. Natural disasters have the potential to generate sizable business, and hence revenue, for construction companies involved in the rebuild effort. Despite the positive impact on the industry, the inherent uncertainty and challenges of post disaster reconstruction may outweigh potential benefits.

This research set out to "explore" the challenges faced by contractors who were involved in post disaster reconstruction projects in Australia. The research particularly emphasizes reconstruction activities that follow bushfires and flooding. Australia has experienced some of the worst of these natural disasters e.g. the 2009 Black Saturday Bushfire, the major flooding in Victoria and Queensland during the years 2010-2012, and others. Working in such an environment can be challenging since work conditions are more difficult than usual. Research primarily focuses on contractors who have had active and knowing involvement in post disaster construction rebuild efforts, whether residential, commercial or infrastructure construction. Contractors who acted due to the necessity of reconstructing works that they had invested in prior to the instance of the natural disaster are not part of the research scope.

LITERATURE REVIEW

Australia is vulnerable to the effects of climate change and extreme weather events such as floods, tropical cyclones and bushfires (Garnut, 2008; Middlemann 2007). This vulnerability is further exacerbated by the increase in population and housing density (Middlemann 2008). Surprisingly, climatic disasters were found to be associated with long-run economic growth (Skidmore and Toya, 2002). Loayza et al. (2012) also found moderate disasters, such as floods, to have positive economic effects in some industry sectors whereas severe disasters do not. In addition to "building-back", reconstruction after a natural disaster generates opportunities to "build-back-better" (IPCC, 2012; CERA, 2012; QRA, 2011; Bosher et al., 2007).

However, reconstruction following natural disasters has its own problems and hardships. IPCC (2012) warned against the rush to rebuild houses, reconstruct infrastructure, and rehabilitate livelihoods in a way that could recreate or even increase existing vulnerabilities and further preclude efforts for enhancing resilience and sustainable development.

The nature of natural disasters also prevents determining the requirements of a project before it is needed (Hayles, 2010). After a natural disaster strikes, appropriate plans for all reconstruction projects need to be developed. Chang-Richards et al. (2013) argued that, in a post disaster situation, standard construction management processes may not effectively tackle the challenges a large scale disaster recovery scenario would present. Meanwhile, there is a pressing need for quick and decisive actions in order to restore the affected area’s way of life. However the effectiveness of a post disaster construction project is hampered by issues such as availability of resources. Lack of resources was found to have a detrimental effect on the effectiveness of a post disaster reconstruction projects in the case of the 2004 Indian Ocean Tsunami and the 2005 Hurricane Katrina disasters (Zao et al., 2009; McGee, 2008).

Another major hurdle to the success of post disaster reconstruction projects is the time constraints placed on the project managers (Hayles, 2010). These time constraints may prevent the appropriate risk mitigation practices from being implemented, among other aspects. Organizational and management issues were also identified by Hayles (2010) as critical factors to the success or failure of reconstruction projects post disaster. A review of the 2010-2012 floods in Victoria revealed lack of clarity around responsibilities and ownership of infrastructure assets, which left councils repeatedly taking on responsibilities that are beyond their capacity, expertise, and resources (Spence, 2012). Furthermore, all stakeholders involved in a post disaster reconstruction project have to, in one way or another, deal with grieving communities. Survivors of community-wide disasters are likely to encounter significant on-going stressors that can act to amplify the original trauma (Caruana, 2010). Contractors working on these reconstruction projects are working with people who have experienced huge trauma and loss. At the end, it is safe to say that contractors involved in post disaster reconstruction projects face a wide array of issues atypical to their regular business.

RESEARCH DESIGN

In constructivism, humans derive knowledge and meaning from experiences (Walliman, 2011; Hammond and Wellington, 2013). With a constructivist view, this research attempted to draw on the ideas and experiences of construction industry professionals to create an understanding of the post disaster reconstruction context and its challenges. A qualitative approach that employs in-depth semi-structured interviews was chosen. The interviews had a number of open-ended questions intended to elicit the views and opinions of the participants (Creswell, 2003). Questions inquired about the type of post disaster reconstruction projects interviewees were involved in, the differences between conventional and post disaster reconstruction projects, challenges with undertaking post disaster reconstruction projects, status/quality of completed work after reconstruction ends, clients' behaviour, issues with other contractors in the same work zone, issues with local councils/communities, resource management and employee turnover, need for plant upgrade, impacts on the company and its future direction, and the overall impression of the post disaster reconstruction project experience.

For the interviews, professionals who have actively and knowingly been involved in post disaster reconstruction projects were sought. For this exploratory stage, 7 interviews were conducted. Interviewees included one company director, one special projects manager, two project managers, one construction manager, one works manager at a local council performing in-house recovery works, one contractor's principal consultant. Interviewees worked on a variety of post disaster reconstruction projects, such as, vegetation, residential construction, commercial construction, civil infrastructure, etc. The selection also allowed for a wide variety between small, medium and large companies.

The research/interviews focused on recent natural disasters in Australia and the subsequent reconstruction works, i.e. those within 5 years prior to research commencement. This included the 2009 Black Saturday bushfires and the 2010-11 Queensland floods, among others. This was necessary to ensure the results were not adversely skewed by factors such as disparity in population size, technological advances, management methods, climate change considerations, and so forth.

FINDINGS

Questions were structured to investigate each interviewee's own beliefs and experiences on the challenges of working on post disaster reconstruction projects in Australia. Nine major challenges were detectable from the analysis, as presented in the following sub-sections.

Poor scope definition

The first major challenge of working on post disaster reconstruction projects is the considerable up-front effort put by contractors to assess the situation and understand the scope of work. One interviewee who worked for a large contractor summed this up by saying:

> "*The first thing about disaster projects is that they need a huge amount of initial effort to understand the scope and then get sufficient people early enough, quick enough with sufficient skills to man it*".

This same view was also shared by several other interviewees citing that the urgency to rectify immediate issues meant that some jobs needed to be undertaken immediately without having any plans or specifications to work off. Usually, solutions to how to best tackle the job need to be dealt with on site. There is not much choice though. Right after the disaster, the extent of the damage is yet to be realized and thoroughly understood which makes it very hard, from a planning perspective, to efficiently scope out and plan the recovery works. As one of the interviewees said:

> "*We probably didn't do it [planning] in the timeline that was really in retrospect desirable. But yeah that was more really an understanding that no one knew the extent of it*".

The nature of natural disasters means that there is no way to fully judge the requirements of a project before it is needed (Hayles, 2010). Unfortunately, a poorly defined scope can create a lack of clarity around strategic objectives and accountabilities of the rebuild work, which leads to other hardships in project delivery.

Difficulties with fund allocation

Government funding allocated to reinstate lost infrastructure after a natural disaster is required to be spent within a specific period of time e.g. two years. This creates a push from local councils to ensure that the funding is spent in time, in some cases resulting in jobs being rushed or not able to be completed as originally planned. An interviewee stated:

> *"They just start shutting stuff down, and you get half-finished jobs. They'll say 'Alright, don't worry about the trees now we'll just worry about culverts, just get everything operational, so that we can open up to the public' ".*

A difficulty some contractors faced was that infrastructure funding was only to reinstate to previous conditions. Natural disasters give opportunity to build better (IPCC, 2012; CERA, 2012; QRA, 2011; Bosher et al., 2007); yet, the tactic adopted was mostly to rectify rather than improve. Changes in conditions, such as road alignment, called for improvement, and which if not undertaken could affect the integrity of the job and compromise the reputation of the contractor. An interviewee mentioned:

> *"There was that fine line there as to, doing a job properly and making sure that next time it's not going to fail, and then doing it as an improvement".*

A strict auditing process was put in place to determine what was rectification and what was improvement. If improvements outside scope were made, they needed to be justified and documented by the contractor. Contractors were therefore hesitant to take the risk of not getting approval for an improvement unless there was prior permission.

Uncertainty/conflict over responsibilities and authority

Several interviewees cited a lack of clarity around responsibilities i.e. what work needed to be undertaken. Also, in line with Spence (2012), there was sometimes a lack of certainty around the ownership of State infrastructure. Interviewees mentioned instances where there was uncertainty about authority, particularly between local and state government organisations, and who the contractors needed to liaise with for permissions.

Moreover, due to the large number of companies working closely together in the disaster-affected areas, conflicts could arise. An interviewee stated:

> *"We were working over the top of each other. So we might be clearing the roads and they are clearing the power lines in the same area. So that was pretty frustrating sometimes".*

A different view was given by one interviewee who questioned whether work could be managed and run internally by the local council or whether they had to contract out the works to external contractors.

> *"Our CEO was very keen that our workforce be as involved as it could be in the delivery of the restoration program, so that led to some fairly lengthy debate with the federal government".*

Local councils having difficulty coping with disaster situation

The post disaster situation can overwhelm some local councils and thwart their ability to fulfill their role as a client. They may repeatedly take on responsibilities that are beyond their capacity, expertise and resources (Spence, 2012). Several interviewees cited the challenges when dealing with local councils. One interviewee stated:

> *"Really a lack of understanding just how big an issue it was. So they were telling me I'd only work there for a few weeks and [it] ended up being two and a bit years".*

Challenges from the local communities

Disasters create highly emotional environments. With such large numbers of contractors in one area, clashes may arise between community members and the contractors working in that area. Interviewees mentioned cases where community members were not happy with the work being undertaken particularly from arborists post the bushfires. With chances of certain actions to backfire, an interviewee stated:

> *"We had security guards on our sites overnight because we were having people coming and vandalising equipment and people threatening violence".*

Multiple interviewees also mentioned that community members see all contractors as the same and that they were blamed for someone else's poor quality work, which posed a significant risk to the company's reputation. An interviewee stated:

> *"Community members look at contractors and they don't recognise that they are from different companies, even though we are obviously a completely separate entity".*

Yet, one interviewee spoke to the importance of being aware of people's emotional state and employing the right people who communicate appropriately. The interviewee stated:

> *"People who didn't fit in were allocated to different tasks. So there were people who had good empathy and [were] good listeners".*

But, this can also place a large emotional strain on the construction workers themselves. Mentally preparing people to work in a disaster situation is critical. It is essential to ensure workers are able to mentally cope with confronting issues and keep their morale high. An interviewee stated:

> *"Prepping people to get into a disaster situation. It is a lot about their mental capacity to cope with the issues that you confront, and a lot of it is to do with people's mental health".*

Challenges with resources

Studies, e.g. Chang et al. (2012) and Chang-Richards et al. (2013), have iterated how securing resources creates a broad range of challenges for those working on post disaster reconstruction projects. Interviewees also highlighted several problems relating to the availability and supply of resources. For instance, due to the urgency of the work, mobilising resources poses a great challenge. One interviewee stated:

> *"Because everything is off the cuff, a lot of the time you've got the wrong resource in the wrong spot"*.

Second, due to the high demand for certain resources, supply shortages were not uncommon. Some contractors were not willing to travel for work and there were shortage of supervisors to monitor the work.

> *"It was massive. At our peak we had 4 staff full time in the office and we were still looking for staff. Not so much the office side, but out in the field supervision. You know it would be not uncommon to find one of our crews ducking down the road to do a private job or something. You really had to keep on top of them. So obviously the more people the more supervision and also the more planning".*

Another challenge emerged of the need to provide accommodation for such a large influx of contractors. An interviewee said:

> *"That was the drama. There was no accommodation up there so we had them staying everywhere. Some bought their caravans".*

Hazards and safety concerns

Disaster situations create some very serious safety and hazard issues. Implementing safety measures e.g. clean up, transport of hazardous materials, disposal of hazardous waste along with managing the public's perception of risk proved to be a major challenge. One bushfire posed serious hazard and safety issues with regards to clearing and transporting the bushfire waste. There were significant issues with asbestos as well. An interviewee mentioned:

> *"Bushfires generate mini cyclones that cause houses to explode, and they explode outwards. Asbestos sheets come into pieces about maybe 2/3 inches squared, and we had people picking this up by hand".*

Concerning the management of community members' perception of hazards, another interviewee mentioned:

> *"Country and farming people have got everything stored in the shed, it could be anything. One of the people [had] unexploded ordinates. They had to shut the whole town down after the fire had gone through and the army disposal team had to come up and find it".*

Legal issues

In post disaster reconstruction projects, there could be uncertainties over rules and consent to undertake work on private property. Contractors were weary of liabilities. An example is cited by an interviewee:

> *"As time went on we couldn't afford to do that [removing trees on private property] because we would have [been] sued. So then we had to say 'how do we define a boundary when the fences are all gone?' ".*

A comparable situation was discussed by another interviewee. They have put together a consent form and had residents of 4000 houses, which they became responsible for their post disaster clean-up, to sign that consent form. The interviewee stated:

> *"That [consent form] had to be developed with the government, in order to allow [us to go into private property], because of the way the law is written you cannot go in onto anyone's property without their expressed permission".*

Uncertainty over building codes and standards

A couple of contractors mentioned a lack of clarity over which standards should be used. After the 2009 Black Saturday bushfires, the government made changes to the bushfire attack levels. One interviewee stated:

> *"They brought in the bush fire attack levels, which everyone sort of didn't know exactly what was required. Everyone was in a bit of a grey area whether our windows would withstand in a bushfire attack level of 40, so companies were testing products to make sure they comply".*

Post disaster situations also created uncertainty over what was deemed a suitable rectification of the works, with questions of whether durability needed to be scaled up. For example an interviewee who was undertaking a series of road resurfacing jobs post floods commented:

"We have a condition score for our gravel roads, and there were other shires putting on a lot more material, which we think is a bit excessive".

CONCLUDING REMARKS

Large natural disasters can cause massive damage to the built environment thus creating the need for reconstruction projects. There are economic benefits to contractors to be involved in these efforts, and this paper is not intended to undermine those benefits. However this is not business as usual. There are challenges and understanding these challenges can help contractors better prepare for this type of work.

There were three key challenges that the majority of the interviewed contractors cited. First is the lack of adequately defined scope. Due to the urgency of these projects, there is a lack of understanding of requirements and expectations. Second is the difficulty of managing resources. The availability and proper management of resources, whether building materials, workers, or plant, can often be a determining factor in project success or failure. Third is the challenge of dealing with local councils and communities, which can often result in disputes and conflicts to resolve. Despite these challenges, those interviewed still indicated that the benefits they experienced on these projects would motivate them to get involved in post disaster recovery and reconstruction activities again in the future. This paper has not elaborated on the benefits; however they will be reported in another publication by the authors.

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TERTIARY ARCHITECTURE AND CONSTRUCTION MANAGEMENT STUDENTS' ACADEMIC PERFORMANCE: ROLE OF DEMOGRAPHIC VARIABLES

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ABSTRACT

This study presents an account of how different demographic variables affect students' academic performance. The studied sample comprises a cohort of 133 Architecture and Construction Management (ACM) students in a third-year unit allocated to construction methodology and structural knowledge required for high-rise construction. Data is collected for these students studying at the School of Architecture and Built Environment at Deakin University (A+B). Outcomes of group and individual task (exam) are analysed deploying statistical methods. The findings show no significant difference between students coming to university from Year-12-to-and those that come from the vocational education sector. Furthermore, the findings indicate significant discrepancy in terms of performance amongst the students enrolled in construction management course with double-degree and architecture students. Additionally, the study reveals that female students outperform male students in individual tasks. The findings could be applicable to redesigning assessments as well as planning of prerequisite units in the studied curricula.

Keywords: Academic performance, demographic variables, students, architecture and construction management, Deakin University

INTRODUCTION

Evidence shows that demographic variables could act as significant predictors of university academic performance for students. These variables include gender (Smith & Naylor, 2001) and impacts of transferring from one tertiary institution to another (Tickell & Smyrnios, 2005). This is particularly important within the Australian higher education system in which students can transfer from Technical and Further Education (TAFE) to a university (Tickell &

Smyrnios, 2005). Performance in particular subjects could also be manipulated by established priorities and the curriculum of different university courses from which students commence their studies (Becerik-Gerber, Gerber, & Ku, 2011; Tickell & Smyrnios, 2005). Yet, despite the salience of the matter, findings of studies on impacts of demographic variables on tertiary-level students' academic performance have remained inconclusive and inconsistent (Tickell & Smyrnios, 2005). Moreover, any knowledge associated with students' academic performance should be situated in the context of local experiences based on expectations and conditions of particular academic subjects (Bloxham & Boyd, 2007). Against this background, a review of literature reveals a paucity of research into the influence of demographic variables of academic performance for Architecture and Construction Management (ACM) students. In view of this, the primary objective of this paper is to identify whether factors known as demographic variables affect the academic performance of students in a particular unit SRT351–construction and Structures 3. SRT351 is the third in a series of 3 core units allocated to construction methodology and structural knowledge for Architecture and Construction Management (ACM) curricula at A+B. The reason for focusing on this unit comes from the fact that units allocated to structural concepts are unique in view of their challenging nature for ACM students (Nawari, 2015). Besides, due to the high rate of failure of students, SRT351 is regarded as the unit with the highest failure rate amongst the units of the abovementioned curricula. Where the outcome of an assessment is not acceptable for stakeholders, reviewing the potential factors leading to such outcome becomes necessary (Baartman, Prins, Kirschner, & van der Vleuten, 2007; Banta & Palomba, 2015). This has been the raison d'être for conducting the present study.

BACKGROUND

Studying structural analysis concepts is necessary for ACM students. That is because architects and construction managers have to exhibit an understanding of how engineering considerations affect design and management of construction projects (Dabby & Bedi, 2012). Teaching structural engineering concepts needs students to think in ways that are not common to their discipline. Thus, units allocated to structural engineering concepts stand out as the most challenging and are delineated from other units in ACM curricula (Nawari, 2015). By the same token, SRT351 has been always a challenging unit for students at A+B in terms of high rate of fails and discontent with results of the assessments.

According to Sadler (2005) assessment represents the process of forming a judgment of the level of students' academic performance.

The main aim of assessments is to evaluate the ability of students to perform professional tasks and assessing their theoretical knowledge. This is to safeguarded students' professional and generic competencies (Gulikers, Baartman, & Biemans, 2010). Such judgment occurs on account of grading the task(s) completed by a student. This entails classification of the quality of a student's performance for a single piece of work, which a student submits in response to a specific task. A wide range of tasks could be utilised as elements of assessment including various combinations of assignments and examinations (Sadler, 2005). The grade received by students for these tasks could be regarded as indicators of students' performance, which is an acceptable approach in the literature (Tickell & Smyrnios, 2005). However, regardless of the nature of the assessment tasks, previous studies have warned against the impacts of demographic variables on the way students perform in assessments.

As asserted by Bloxham and Boyd (2007, p. 49) "Students' perception of what assessment task require can vary significantly and are influenced by their prior experience and preferences.". Students in Construction Management, Architecture and those seeking a double-degree have to pass the studied unit. Discrepancies in terms of background knowledge of these three groups on structural analyses concepts have yet to be investigated. Nevertheless, Becerik-Gerber et al. (2011) established that priorities and the contents of each of these courses are glaringly different.

At A+B, the majority of offers are made through VTAC (Victorian Tertiary Admissions Centre). This applies for Year 12 entrants as well as mature age applicants such as those who are articulating from TAFE. For the latter, there are a number of criteria for acceptance, one of which is the successful completion of a Diploma or Advanced Diploma in a cognate field. Nearly every applicant to the Bachelor of Construction Management (Honours) has completed the Diploma of Building and Construction with those applying for the Bachelor of Design (Architecture) having completed the Advanced Diploma of Building Design (Architecture). The Advanced Diploma is also the usual qualification for those seeking entry to the combined Bachelor of Design (Architecture) / Bachelor of Construction Management (Honours). There is agreed Credit for Prior Learning in place for students who have completed these qualifications at a TAFE. There is disagreement amongst Australian-based researchers with regard to performance of students coming through the TAFE and those admitted through the Year-12-to-university pathway. Where Bowden, Abhayawansa, and Bahtsevanoglou (2015) believes that there is significant discrepancy between the performance of the former and latter cohorts, the findings by Tickell and Smyrnios (2005) show no difference by final years of university study.

The impact of gender on performance of students is also still a matter of controversy. In this regard, Smith and Naylor (2001) showed that performance of students shows different results based on the course under question where female students are worse in architecture. On the contrary McNabb, Pal, and Sloane (2002) asserted that female students perform generally better regardless of the type of subject. Furthermore, observations amongst ACM students by Fonseca, Martí, Redondo, Navarro, and Sánchez (2014) manifested no discrepancy among female and male students. As a result, the impact of gender on ACM students' performance has remained to be studied (Maghiar, Sturges, Maurer, & Jackson, 2015).

RESEARCH METHODS

Assessments should be treated as highly context-specific phenomena (Bloxham & Boyd, 2007; Gulikers et al., 2010). As a result, the "case study" approach was deemed most appropriate in being capable of providing the best correlation with the natural context and the highest level of detail (Flyvbjerg, 2006). Conforming to the definition proposed by Flyvbjerg (2006) the essence of the case study in this paper encompassed exploring an entity (assessment results for a unit) for a certain period of time. This was to illuminate what the results of interactions of a number of factors would be.

Data for this study was sourced from unidentifiable academic student results in in 2015. This included results of students in group tasks (50%) and an examination (50%) as the individual parts of the assessment for the studied unit. Further, students were separated based on their mode of entry (Education), enrolled course (Course) and their gender (Gender).

These three variables were conceptualised as independent variables potentially affecting students' performance in assessment of the studied unit. Data analyses entailed use of parametric data analyses tests in view of the nature of variables in the data. That was because, marks (numbers) were regarded as dependent variables, which manifest performance. Hence, parametric methods were used due to their higher analytical power (Cronk, 2014).

FINDINGS OF THE STUDY

Sample diversity

As illustrated in Figure 1, the studied unit was dominated by male students with above 75% of students enrolled in the unit were male (see Figure 1). Likewise, around 65% of students enrolled in the unit were coming from TAFE where only 35% of students were accepted as Year 12 students. Students were enrolled in four different courses with Architecture students in majority, comprising above 44% of all students in the unit. Construction management and double-degree students accounted accordingly for around 26% and 25% of students in the sample while architecture technology students represented only 4.5% of the sample.

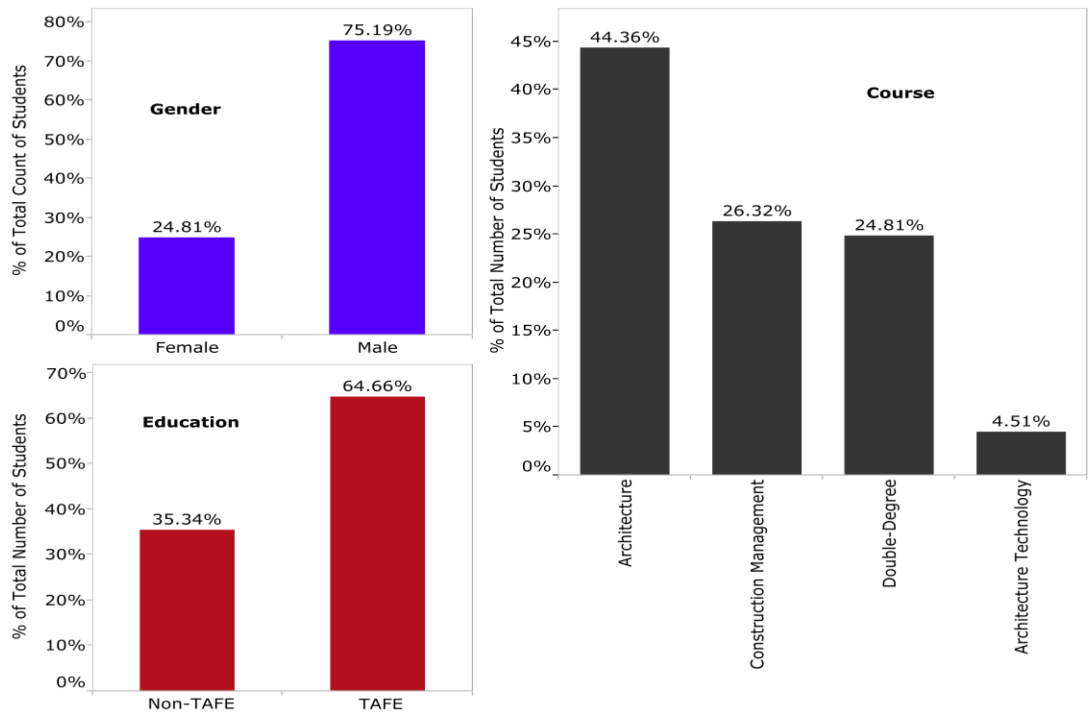

Figure 1 Diversity of students in the sample

Impact of Students' Backgrounds

Gender

Table 1 illustrated the mean scores of students' results for group and individual tasks for each value of Gender as the independent variable. As inferred from Table 1, female students outperformed male students in individual assessment tasks as well as group tasks. To investigate whether the observed discrepancy is statistically significant, an *independent-sample t test* comparing the mean scores of male and female students in both types of tasks was performed. The test found a significant difference between the mean to two groups for the individual task ($t(131) = -2.474, p < .05$).

Table 1 Performance of male and female students in the studied unit

Assessment	Gender	N	Mean (*M*)	Std. Deviation (*sd*)
Individual	Male	100	29.57	6.68
	Female	33	33.04	7.80
Group	Male	100	36.92	5.05
	Female	33	37.93	4.04

Hence, the mean score of results for female students ($M = 33.04, sd = 7.80$) was significantly higher than the same scores for male students ($M = 29.57, sd = 6.68$). Interestingly, the group task scores did not show any meaningful discrepancy in terms of gender. That is, no significant difference was found ($t(131) = -1.042, p > .05$). Thus, the mean score of group tasks for female students ($M = 37.93, sd = 4.04$) was not significantly different from that of male students ($M = 36.92, sd = 5.05$).

Education

Considering the educational background as the independent variable, mean scores of students' results are illustrated in Table 2. As inferred from Table 2, Non-TAFE students had a higher performance based on the higher scores received in individual task as well as the group task of the studied unit. Nevertheless, none of the tasks scores showed any meaningful discrepancy in terms of educational background of students. That is, no significant difference was found for individual tasks ($t(131) = -1.769,\ p > .05$) as well as group task ($t(131) = .561,\ p > .05$). Thus, the mean score of group tasks for students coming from TAFE was not significantly different from that of students accepted as Year 12 students (see Table 2).

Table 2 Performance of students based on their educational background

Assessment	Gender	N	Mean (*M*)	Std. Deviation (*sd*)
Individual	TAFE	86	29.65	6.49
	Non-TAFE	47	31.90	7.98
Group	TAFE	86	37.34	4.62
	Non-TAFE	47	36.85	5.21

Course

As shown in Figure 1, students in the sample were enrolled in four different courses. To investigate if the results are significantly different across these four groups, a one-way ANOVA test was conducted. Use of one-way ANOVA was considered as using *independent-sample t* pair-wise comparison of two groups ends up in an inflated Type I error and increases the risk of drawing incorrect conclusions (Cronk, 2014). Post-hoc test are necessary where one-way ANOVA is utilised to predict the event of a significant ANOVA. That is because. Where results show a significant ANOVA, post-hoc tests enable researchers to identify which groups are different from which other groups. A wide range of post-hoc tests is available for one-way ANOVA. The mostly used one is Tukey's HSD as the method deployed in the present study in line with the recommendations put forward by Cronk (2014). Descriptive statistics for the four groups in the sample are illustrated in Table 3.

Table 3 Performance of students based on their enrolled course

Assessment	Gender	N	Mean (M)	Std. Deviation (sd)
Individual	Architecture	59	30.54	6.88
	Architectural Technology	6	35.00	9.01
	Construction Management	35	27.33	6.22
	Double-Degree	33	32.70	6.99
Group	Architecture	59	37.75	4.09
	Architectural Technology	6	37.68	3.63
	Construction Management	35	34.32	5.90
	Double-Degree	33	39.07	3.65

Results of descriptive analysis of scores showed that construction management students were the group with the lowest scores both in the individual tasks (exam) and group task. Double-degree students received the highest scores in group tasks where Architecture-technology students received the highest scores in their individual task (exam).

Table 4 illustrates the results of one-way ANOVA test across these four groups. As inferred from Table 4, performance of students in individual task (exam) was different across the four courses ($F(3, 129) = 4.50, p < .05$). Likewise, performance in group task was found to be significantly different among students enrolled in the four courses ($F(3, 129) = 6.90, p <. 05$). The nature of spotted difference was revealed in view of the results provided by Tukey's HSD test. That is, the analysis showed that students enrolled in construction management performed at a significantly lower level in the individual task ($M = 27.33, sd = 6.22$) compared to their peers enrolled as double-degree students ($M = 32.70, sd = 6.99$). Students enrolled in other courses were not significantly different in terms of their performance in the individual task (exam).

Table 4 ANOVA results to test the significance of difference in performance across the four courses

Assessment		Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Individual	Between Groups	633.32	3	211.11	4.50	.005
	Within Groups	6043.74	129	46.85		
Group	Between Groups	425.75	3	141.91	6.90	.000
	Within Groups	2652.54	129	20.56		

As for the group task, students enrolled in construction management received scores $(M = 34.32, sd = 5.90)$ significantly lower than the scores received by students in architecture $(M = 37.75, sd = 4.90)$ and double-degree students $(M = 39.07, sd = 3.65)$.

DISCUSSIONS

The findings of the study support the idea with regard to context-specific differences between male and female students. That was because, the findings show discrepancy between male and female students, which contradict the observations by Fonseca et al. (2014) who indicated that there is no meaningful difference between male and female students. Nevertheless, the findings resonate with the insight put forward by McNabb et al. (2002), who asserted that irrespective of subject, female students outperform male students. The findings also contradict the findings of the study by Bowden et al. (2015), who stated that students articulating from the TAFE sector underperformed academically compared to Non-TAFE students. That is, students from TAFE performed at the same level with other students. To explain this contradiction, Tickell and Smyrnios (2005) maintained that students from TAFE might perform at lower levels in early years of university study. However, by final years, TAFE students performed at the same level with the Year-12-to-univerity cohort. Yet, at A+B students from TAFE complete SRT351 as their first university study. Therefore, the findings establish that there is no discrepancy between TAFE and Non-TAFE students regardless of the year of university study. The findings of the study with regard to the impacts of enrolled course are in line with the observations by Tickell and Smyrnios (2005). According to Tickell and Smyrnios (2005), only demographic variables associated with the background discipline act as determinant of students' performance.

Nevertheless, the findings being evidence of underperformance of construction management students in comparison to architecture and doubled degree students should be treated as a source of concern. As well as revisiting the nature of the assessment tasks, the root causes of such underperformance should be thoroughly investigated and dealt with.

CONCLUSION

This is the first study in its kind, which focuses on investigating the impacts of demographic variables on performance of students within the ACM curricula. This is particularly important in view of the fact that the findings of the study put to test previous observations in other fields within the natural context of ACM curricula. The findings reveal a number of discrepancies among students enrolled in different courses within the curricula, which warrant further research to discover the root causes of such discrepancies. As another contribution, the present study provides a sample for similar units and a fertile ground for identify and discover the root causes of existing discrepancies. However, the findings of the study should be considered in light of a number of limitations. That is, the findings are based on considering the performance in one unit. Hence, the findings might be affected by the particular condition in assessment and teaching of the considered unit. Broader inquiries including a wider range of units might address this limitation as another potential area for further investigation.

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BARRIERS TO BIM ADOPTION: PERCEPTIONS FROM AUSTRALIAN SMALL AND MEDIUM-SIZED ENTERPRISES (SMES)

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ABSTRACT

This study draws upon a questionnaire survey distributed amongst SMEs in Australia to offer an insight into the main barriers to BIM adoption within Australian SMEs. Based on analyses of 78 completed questionnaires from non-adopters, the main barriers making SMEs shy away from BIM adoption are discussed. The findings show that currently around 42% of Australian SMEs are engaged with BIM. It comes to light that lack of knowledge and resources within SMEs is not a major barrier for Australian SMEs. In essence, the main barriers stem from lack of interests of clients and subcontractors working for SMEs alongside the risks associated with an uncertain return on investment (ROI) for BIM as perceived by key players in SMEs. The study contributes to the field by providing an updated insight into the status quo of BIM in Australian SMEs and spots the main barriers to target for promoting BIM adoption across Australian SMEs.

Keywords: Building information modelling (BIM), Barriers, Adoption, SMEs, Construction industry, Australia

INTRODUCTION

Despite the great advantages associated with use of BIM on construction projects, a large number of construction projects are still sitting on the sidelines of BIM implementation (Cao et al., 2016). Particularly, this has been identified as a serious issue in small businesses (Forsythe, 2014). In order to leverage the potential of BIM and to reshape the laggard fractions of the construction industry, therefore, it is essential to develop a robust understanding of the factors that cause project participants shy away from BIM adoption on their projects (Cao et al., 2016). However, available studies have for the most part focused on large-sized companies, which deliver ambitious projects (Rodgers et al., 2015, Pretti and Vieira, 2016). Therefore, BIM adoption within SMEs has remained underrepresented in the existing literature (Poirier et al., 2015a). Despite such scant attention devoted to BIM in SMEs, this area is of outmost importance for the construction industry in view of the fact that "…smaller firms will continue to dominate the construction industry landscape far into the future." (Shelton et al., 2016, p. 180). Besides, it is estimated that around 98% of the construction industry in developed economies is made up of small to medium-sized businesses (Poirier et al., 2015a).

This study is intended to address these things. To this end, this study aims to identify the barriers, which cause project practitioners in Australian SMEs retreat from adoption of BIM on their projects.

Review of Literature

In Australia, according to the definition for SMEs proposed by SME Association of Australia (SMEAA, 2011) a micro business is defined as having less than 4 employees and a small business has between 5 and 20 employees. A medium-sized company is specified via its range of employees between 20 up to 200 people. In line with this definition, SMEs in Australia represent around 98% of the construction sector, with similar percentages applicable to other countries e.g. the US, the UK, Asia (Forsythe, 2014). It is widely believed in construction literature that SMEs are typically lagging behind large-sized firms in embracing innovation and technological advancement. Therefore, it is imperative to evaluate the barriers obstructing SMEs from harnessing the advantages of innovative methodologies (Shelton et al., 2016) such as BIM.

Barriers to BIM in SMEs

BIM is treated as a remedial solution for a wide range of deficiencies affecting the construction industry (Poirier et al., 2015b). Major benefits include coordinating the project process, reducing the number of errors and clashes, preventing reworks, improving logistics and supply chain systems and delivering precise project information (McGraw Hill, 2014, Gledson and Wardleworth, 2016). Considering the small size of projects handled by SMEs, implementing BIM in SMEs could be highly advantageous resulting in noticeable productivity gains (Poirier et al., 2015a, Poirier et al., 2015b, Rodgers et al., 2015). That is because, smaller groups of project participants and shorter project duration offer vast opportunities for reaping the benefits of BIM, its adoption in higher levels (Engineers Australia, 2014) and possible swift organisational changes (Arayici et al., 2011).

Despite the potential advantages of BIM, its implementation rate is slow and its uptake in the construction industry within SMEs in particular is sluggish (Newton and Chileshe, 2012, Forsythe, 2014, McGraw Hill, 2014, Poirier et al., 2015b). Such lack of interest in adoption has been traced to the barriers inherent to SMEs. In essence, in view of limited resources available for SMEs, implementing BIM justified by anecdotal evidence represents considerable risk (Poirier et al., 2015b). Wood et al. (2011) revealed that different organisational structures of SMEs require different skills, training and equipment for BIM implementation. It was further identified that the cost of BIM implementation in SMEs are higher than that of in large counterparts due to the demerits of software acquisitions. By the same token, the report of McGraw Hill (2014) on business benefits of BIM in Australia shows that SMEs are "relatively new to the use of BIM". The report also indicates that BIM implementation rate for SMEs in Australia is lower than large-size enterprises, without providing clear reasons to justify such observation. However, the study by Rodgers et al. (2015) in South Australia has considered a number of major barriers such as software requirements, equipment and skills for implementing BIM in SMEs.

RESEARCH METHOD

The questionnaire for the present study was based on the questionnaire deployed for South Australian SMEs by Rodgers et al. (2015). An exhaustive review of literature on barriers to BIM adoption was also conducted to complement the questionnaire. The preliminary questionnaire was presented to seven SMEs directors each with more than 12 years of experience on construction projects in Australia. The project managers approved the questionnaire, with their suggestions incorporated in designing the final version of the questionnaire. Subsequently, a number of terms were revised, 3 questions were merged and 2 questions, which were deemed confusing or leading, were removed. Key terms such as BIM and BIM adoption were explained and defined using professional expressions rather than academic terms. The first section of the questionnaire included the overarching aims of the research study and covered questions to identify the demographic attributes of respondents, whereas the second section included statements describing 13 barriers, which might make construction practitioners shy away from BIM adoption within SMEs. In line with the recommendation by Holt

(2014) for identifying the relative importance of a set of variables, respondents were asked to rate their level of agreement with regard to the influence of each of described barriers in form of a five-point Likert-scale where (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree).

Data analysis

Parametric statistical methods and statistical methods with assumptions about normality of distribution are only valid as long as variables in dataset meet the requirements about the normal shape of the distribution. Collecting data through Likert-type scales results in ordinal variables (Mueller and Hancock, 2006) for which use of non-parametric tests is deemed appropriate. The test of internal consistency of the survey was conducted using reliability analysis for the identified barriers. The Cronbach alpha was found to be 0.79 for the pool of variables, which was greater than 0.70, thus indicating an acceptable level of reliability.

FINDINGS OF THE STUDY

Construction related companies (contractors, architecture and design companies) active within the Australian context were targeted as the population of interest for the survey. Data collection through targeting clusters of population of interest or "cluster sampling" as termed by Neuman (2006) is appropriate for administration of questionnaires where the population is in a wide geographic area such as a country. As such, a list of architects, design firms and contractors was prepared arbitrarily (downloaded from available websites and collated from yellow pages). A total of 1365 (712 architects and 653 contractors) questionnaires were sent by post as well as email to directors of these companies from which 149 duly completed questionnaires returned. Data collection started in October 2015 and finalised in February 2016.

Respondents' profile

The findings showed that out of 149 collected responses 10 (6.7%) came from large-sized companies. These questionnaires were omitted from the dataset. Besides, 4 questionaries came from companies active as suppliers of building materials, which were not deemed relevant to BIM adoption. These were not included in the analyses of findings. Therefore, the final sample comprised of 135 SMEs. Upon further investigation of the received responses, 78 (57%) had no engagement with BIM, thus were identified as non-adopters of BIM. The data belonging to these SMEs were separated and provided the information for identifying the barriers for non-adopters. Table 1 illustrates the profile of non-adopters.

Table 1. Profile of SMEs identified as non-adopters of BIM

Number of Employees	Contractor/Builder	Designer	Total
0-4 employees (*micro*)	16	31	47
5-19 employees (*small*)	16	11	27
20-199 employees (*medium-sized*)	3	1	4
Total	35	43	78

The findings in Table 1 revealed that as far as size is concerned, around 94% of respondents were from micro and small businesses where medium sized companies made up below 6% of SMEs. Above 45% of SMEs in the sample were contractors and builders where 55% were design companies. Around 92% of companies had a history of service of more than 11 years in the industry while around 88% of the respondents were directors and project managers of companies. Thus, respondents were key decision makers in SMEs with direct awareness of policies of companies with regard to adoption of BIM.

Barriers to BIM adoption and implementation

Use of relative importance index (RII) for assessing the relative importance of a variables in a pool of similar items is an acceptable and widespread technique within construction research (Holt, 2014). Besides, this method is not based on mean and standard deviation of variables, which were deemed not fitting the variables in the dataset with non-normal distributions. Calculations for defining RII for each barrier were performed according to Equation 1.

$$\mathrm{RII} = \frac{1\mathrm{n}_1+2\mathrm{n}_2+3\mathrm{n}_3+4\mathrm{n}_4+5\mathrm{n}_5}{\mathrm{A}\times\mathrm{N}} \qquad \text{Equation 1}$$

Where: $\mathrm{n}_1, \mathrm{n}_2, \mathrm{n}_3, \mathrm{n}_4, \mathrm{n}_5$ were corresponding number of respondents, which scored each of the items on the scale (from 1 to 5). N was the total number of respondents for each variable and A is the largest integer on the scale range (5 for the present study). Table 2 summarises the results of ranking the barriers as perceived by the respondents.

Table 2. Ranking of the barriers to BIM adoption in Australian SMEs

No	ID	Description	N	RII	Rank
1	Ad_Barr01	Sub-Contractors do not have enough knowledge and expertise in BIM	78	0.833	1
2	Ad_Barr02	Our clients do not have sufficient knowledge about BIM and its benefits	78	0.818	2
3	Ad_Barr03	There is a significant BIM implementation cost to our firm	78	0.777	3
4	Ad_Barr04	Sub-Contractors are not interested in using BIM	78	0.762	4
5	Ad_Barr05	The cost of BIM training is significant to our firm	78	0.759	5
6	Ad_Barr06	Our clients are not interested in using BIM on their building projects	78	0.741	6
7	Ad_Barr07	There are no official standards for adopting and using BIM on building projects	78	0.721	7
8	Ad_Barr08	Our firm believes that it takes too much organisational efforts to adopt BIM	78	0.687	8
9	Ad_Barr09	There is no or low benefits in adopting BIM on our building projects	78	0.682	9
10	Ad_Barr10	Our firm does not have the skills and expertise for BIM adoption	78	0.664	10
11	Ad_Barr11	The current technologies we are using are enough, so we don’t need BIM	78	0.656	11

12	Ad_Barr12	Our firm is reluctant to adopt BIM because we don't know how to adopt BIM	78	0.656	12
13	Ad_Barr13	BIM is not suitable for our building projects	78	0.626	13

As inferred from Table 2, the most influential barriers were Ad_Barr01 and Ad_Barr02, which were associated with lack of knowledge of sub-contractors and clients within the supply chain of the construction industry. This 3rd and the 5th barriers indicated major costs of BIM adoption for SMEs. The 4th and the 6th most influential barriers referred to the lack of interest from sub-contractors and clients working with SMEs.

As illustrated in Table 2, barriers ranked as the 7th, 8th and 12th barriers in terms of their level of influence as perceived by construction practitioners were all related to the lack of ability within SMEs to meet the requirements of BIM adoption. These were related to the required effort, resources alongside instructions and intra-organisation knowledge for BIM adoption. The barriers ranked as 9th, 11th and 13th were all indicative of the perceptions of SMEs with regard to lack of alignment between the advantages of BIM and the nature of their projects. As illustrated in Table 2, barriers falling within this category were the group with the lowest level of influence as perceived by Australian SMEs.

DISCUSSION

This could be inferred from the findings that around 57% of Australian SMEs still have not had any engagement with BIM on their projects. The level of BIM engagement within SMEs in the present study (42%) is close to the recent estimation by Rodgers et al. (2015) in South Australia who claimed that around 45% of SMEs have been involved in BIM. Yet, the findings show a different feature compared against the studies conducted around 2010 within the Australian context. That is, while the findings show that around 42% of SMEs have been engaged in BIM, the study by Gerrard et al. (2010) estimated an overall engagement of 25% within the construction industry, which is much lower than the figures revealed by the present study. Such gap observed between adoption figures during around 5 years indicates how fast-moving BIM is within the Australian construction industry and reveals the successful attempts of SMEs to keep up with this trend as pointed out by Rodgers et al. (2015).

The findings on barriers also corroborate such inference about the growth of BIM amongst SMEs. That is, the findings clearly indicate that lack of knowledge and interest of subcontractors (i.e. trades working for SMEs) and clients are the causal roots of shying away from BIM adoption for SMEs. In essence, parties in the construction supply chain (as key stakeholders) rather than organisational factors make SMEs withdraw from adopting BIM. This is in contradiction with the findings of previous studies pointing to lack of knowledge and expertise on BIM as a major barrier towards higher level of BIM adoption within the UK construction industry (Khosrowshahi and Arayici, 2012) as well as the Australian context (Gerrard et al., 2010, Rodgers et al., 2015). This similarly challenges the common belief with regard to the typical failure of SMEs in managing knowledge on BIM where they are interested in its adoption (Poirier et al., 2015a).

Other influential barriers identified were stemmed from the perceptions about the large amount of effort and expenses to be allocated for adoption of BIM within SMEs. From this perspective, the lack of interest of SMEs to accept the risks associated with the return on investment (ROI) of BIM is still an influential barrier for Australian SMEs. This is fathomable as the level of BIM engagement is directly associated by the perception of decision makers in the company with regard to the ROI they receive on their investments and allocated resources (McGraw Hill, 2014). For SMEs struggling to survive in the market, taking such risks is beyond their acceptable level. In essence, SMEs inherently have a tendency to adopt reliable methods with guaranteed ROI and previously-verified elsewhere (Poirier et al., 2015a).

CONCLUSION

As the first quantitative study focused on SMEs within the national Australian context, the findings of the present study provide a new insight into the status of BIM within SMEs in Australia in several ways. First, it becomes clear that the rate of BIM adoption in SMEs is fast and acknowledges the success of SMEs in adopting BIM judging from the comparison of the adoption percentage as discussed in the present study with the findings of studies conducted around 5 years ago. Second, the study brought to light that low rate of BIM adoption is no more stemmed from the inherent idiosyncrasies of SMEs such as lack of resources and knowledge. In fact, the main barriers are all stemmed from lack of interest from parties in the construction supply chain exacerbated by lack of evidence showing the advantages of BIM for small-sized project. This makes BIM adoption too risky and unrealistic in view of the limited resources available for small businesses.

Despite the contributions, the findings of the study should be applied in view of a number of limitations. That is, the findings are reflective of Australian SMEs perceptions with a majority of respondents being micro companies. Therefore, direct use of the findings for other countries and for medium-sized companies should be treated with caution. Nevertheless, this provides a number of fertile grounds for research. These include validating the findings in other contexts and countries with larger samples and larger companies.

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IDENTIFICATION OF BIM-COMPATIBLE VARIABLES FOR ENERGY OPTIMIZATION OF BUILDINGS – A DELPHI STUDY

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ABSTRACT

It is believed that drawing an applicable, relevant and coherent batch of variables is a fundamental tenet in the success of having an integrated BIM-based energy optimisation but in order to achieve a high level of usefulness, these variables need to be refined and prioritised. Thus, this paper is to investigate BIM compatible variables which are of top priorities for energy optimisation of residential buildings in the design stage. A sequential exploratory research was conducted to find out the most relevant and significant variables that have a high impact on the energy consumption of residential buildings. A pool including more than 30 variables was established and refined through running Delphi approach with energy and BIM experts to reach the final list of prioritized variables. Conducting a three-round Delphi enabled authors to obtain more meticulous results via a consensus agreement among the respondents on the top 13 variables through lenses of BIM compatibility, applicability to optimization and design stage.

Keywords: BIM, Delphi, Design Stage, Energy Optimisation, Residential Building

INTRODUCTION

During the last decade, a plethora of researches have been carried out commercially or academically with respect to tackling sustainability issues in construction ranging from green building process implementation to renewable energy initiatives (Kibert, 2012). However, these efforts are yet to meet their fullest potential in managing sustainability of high-performance buildings. According to 2013-2014 annual report of Sustainable Building and Climate Initiative of United Nation Environment Program (UNEP), the performance of buildings is 'far below current efficiency potentials' (UNEP, 2014, p. 15). They still are the most contributors to GHG emission and consumer of the world's produced energy. Using Building Information Modelling (BIM) can expedite this process and provide the opportunity of designing and constructing more energy efficient buildings if the capability of testing and assessing different alternatives and materials' impacts on the building can be introduced. A BIM Model represents the building as an integrated database of coordinated information but beyond graphically depicting the design, much of the data needed for supporting energy efficient design can be captured naturally as design of the project proceeds (Cerovsek, 2011). The current BIM does not support an in-built decision making procedure and cannot provide design variable alternatives that need to be optimized. Nevertheless, BIM, because of being parametric and object-oriented, could be enhanced effectively to endorse intelligent decision making platforms based on a confirmed matrix of variables with their relative importance.

At the building level, when it is to design with the purpose of energy performance optimization, large number of factors and variables can be considered but some constraints may convince the researchers to narrow down the variables into a manageable number. The quest for optimum energy consumption requires a coherent implementation of the factors that together optimise the performance of the whole building system(Radhi, 2008). As a holistic view on the previous works (Bucking, Zmeureanu, & Athienitis, 2014; Yu, Haghighat, Fung, Morofsky, & Yoshino, 2011), it can be inferred that the problem of lacking a reliable list of parameters applicable to optimization and design stage and compatible with BIM authoring tools have been remained unsolved. Thus, to proactively rectify building performance issues, the aim of this paper is to identify the significant variables that play key roles in the energy consumption of residential buildings through the lenses of BIM applicability, optimization applicability and design stage applicability by means of Delphi method.

RESEARCH METHODOLOGY

The methodology adopted for this research is the mixed method; *QUAL→quan* (Creswell, 2013) according to the 'sequential exploratory approach' in which, a literature based exploratory research and a qualitative Delphi study were applied to discover the building energy parameters and a minor quantitative approach was then adopted for prioritisation of the variables within the Delphi method. The Delphi study is mainly "a qualitative method used to combine expert knowledge and opinion to arrive at an informed group consensus on a complex problem" (Donohoe and Needham, 2009, p. 2). This method is not designed to collect random surveys of respondents but it is an iterative discussion method to obtain a consensus opinion from a relatively small sample of experts. The basics of this facilitated method for complicated issues are similar such as possibility for respondents to convey their viewpoints on the topic, follow-up of feedbacks, compiling the responses and analysing the group judgement and an opportunity of consolidated agreement anonymously. The problem targeted to this project is to identify and prioritise the variables that play key roles in energy consumption of residential buildings with respect to BIM. To do this, first, the parameters used for energy analysis and optimisation from the relevant literature were screened to establish a basis for the Delphi study. Second, the Delphi method was applied because the problem is a relatively subjective and new for research. Therefore, it was broken down into a series of smaller inquiries addressing in three rounds:

- Perceptions toward the applicability of the variables with regard to the optimization, BIM authoring tools and design stage

- Brainstorming with regard to the main variables contributing to the energy consumption of residential buildings

- Prioritisation of the identified key variables

The knowledge areas required for this Delphi inquiry involve with BIM, architecture, building science and services and mechanical engineering. For this reason, criteria of a minimum of bachelor degree and 3 years relevant work experience in the above-mentioned areas were set to establish a survey sample and among 50 people invited, 30 people including 10 BIM people, 16 energy and buildings experts and 4 mechanical and sustainability engineers accepted the invitation. In terms of work experience, 21 experts have up to five years and the rest are experienced for more than 5 years (Figure 1). This study comprised of three-round Delphi to cover three main aspects of brainstorming, prioritizing and confirming sessions distributed through the Google Form platform.

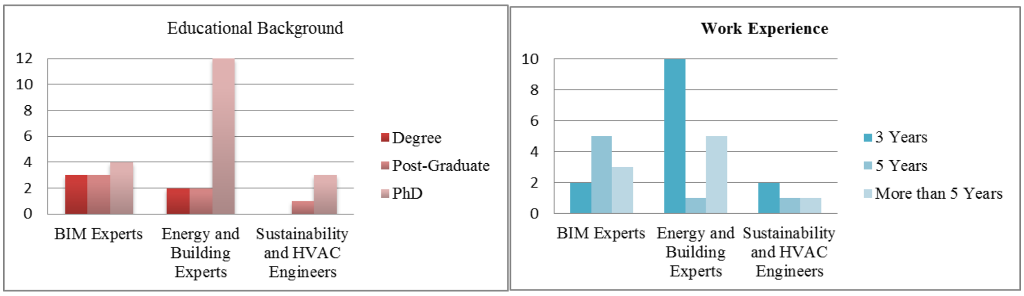

Figure 1. Delphi Respondents Profile

ANALYSIS AND DISCUSSION

Round 1

The Round 1 was commenced on the 1st of October; 2015, designed to provide a brainstorming session and the respondents were invited to provide opinions on the following open-ended questions:

- What are the main variables contributing to the energy consumption of residential buildings in the design stage?
- What are their implications toward the applicability of these variables to BIM, optimization and design stage?

From the identified 30 people, 23 responses were accordingly collected. This sample size could be regarded sufficient as participants for a typical Delphi study generally range from 3 to 15 (Rowe and Wright, 1999, Yeung et al., 2009). Thirty-five variables were extracted from the qualitative responses by counting the frequency of the parameters and it was observed that material and climatic variables with 10 times of referring and water fitting, water heating, structural design and shape with only one time of mentioning are the most and least frequent variables. Applying normative assessment method; the comparison of each variable within its peers, only variables selected by 50 percent of experts or above were chosen to be analysed and included in Round 2 of the study (Chan et al., 2001). They were, then, ordered from a range of 10 to 3 most frequent ones resulting to the initial 18 variables. Around half of the parameters did not meet the 50% cut-off criterion and were not chosen for further study. In addition to the cut-off rule, the derived initial 18 variables were checked as to the variables selection criteria; compatibility with BIM, applicability to optimization and design stage complied from the literature and respondents opinions.

In terms of BIM compatibility, very generic variables cannot be considered since their semantic values are not associated with the topological relationship within the BIM model. For instance, building envelop was divided into material types of internal wall, external wall and roof falling to the predefined ranges of BIM families (Kim and Anderson, 2012). In addition, the variables with twofold effects need to be also omitted because BIM has not been yet equipped with intelligent fuzzy rules to identify the root causes of two-fold parameters. For example, cross ventilation effect hugely depends on the climatic condition. In a cold climate, it causes a demand for heating load however, in temperate weathers, it reduces the cooling load. Checking the subjectivity and objectivity of the variables is also another important task and a too subjective variable like Morphology was omitted due to not being still parameterised in BIM.

Over the buildings projects lifecycle, design stage is the most promising phase in terms of energy efficient design as decisions affect 60-70% of the lifecycle costs of the construction and operation (Stumpf et al., 2009, Kim et al., 2011) but some variables seem to be more associated with the construction and operation phases and their values cannot be identified in this stage. For example, occupant behaviour category of variables refers to the people and their occupancy profile over the operation phase (Yu et al., 2011a). In the design stage, designers are provided with some general descriptions of the client outlines and they cannot acquire any detailed data regarding the number of people residing in the building units, their occupancy rate and their schedules. From the optimization perspective, the basic principle is to identify the best choice for given alternatives and for doing so, the whole possible choices should be tested and the authenticity of the optimum should be validated (Sun and Yuan, 2006). In consonance with this principle, the selected types of variables should be feasible for optimisation purposes. In fact, nature-related variables such as climatic parameters including temperature, wind speed or humidity are the elements set and mandated by natural rules and their optimisation does not make sense. Likewise, the variables which have predefined values like the type of building unit and its total number of rooms are not applicable for optimisation as they are established by project clients in the design briefs. Considering the literature, the initial 18 parameters and variables selection criteria, Figure 2 illustrates the schematic view on the 19 ultimate variables to be analysed in the next round.

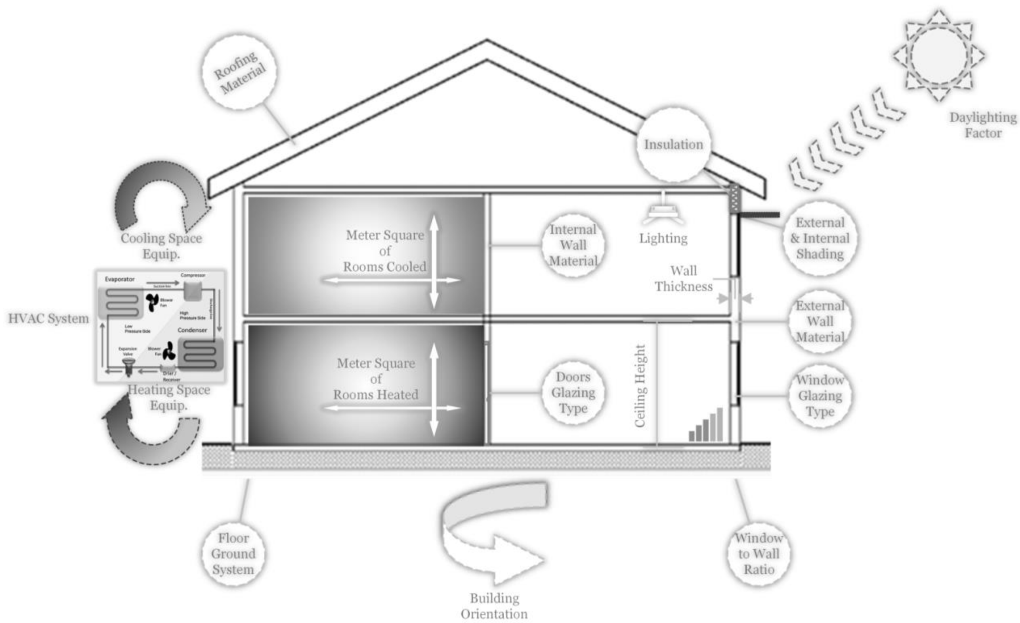

Figure 2. Variables Resulted from the First Round

Round 2

The second round of this Delphi study was started on the 1st of November; 2015 with a focus on the prioritizing of 19 variables derived from the first round. A five point Likert scale questionnaire form was developed ranging from 1=least important to 5=most important and 18 responses, in total, were collected successfully within 20 days indicating a response rate of 60%. A preliminary series of weighted variables was developed based on the mean ratings using the following equation (Chan, Yung, Lam, Tam, & Cheung, 2001):

$$L_{vi} = \frac{\sum_{i=1}^{n} P_{vi}}{n} \quad (1)$$

Where L_{vi} stands for the Likert mean of each variable, P_{vi} is the point received for each variable (from 1 to 5) and n is the number of responses for each variable. In addition, corresponding weighting of each variable was computed according to the below (Chan et al., 2001):

$$C_{vi} = \frac{L_{vi}}{\sum_{i=1}^{n} L_{vi}} \quad (2)$$

In which C_{vi} refers to the corresponding weighting of each variable, L_{vi} is the associated Likert average obtained from the equation 1 and n is the number of parameters. As a result of this round, the variables which received the L_{vi} equal to 3 or above (Perera, Rameezdeen, Chileshe, & Hosseini, 2014) were identified to be further analysed for the next round. Table 1 shows the ranking of all variables, illustrates the selected variables highlighted in blue and reveals that external shading, wall thickness, doors glazing, daylighting, internal wall material and internal shading are the least important ones which will be ignored from additional considerations.

Table 1. Results of Round 2 Questionnaires

Variables	Likert Points Mean (L_{vi})	Corresponding Weighting (C_{vi})	Rank
Insulation	4.29	0.0617	1
Roofing Material	4.17	0.0600	2
External Wall Material	4.11	0.0591	3
Windows Glazing	4.00	0.0575	4
Window to Wall Ratio	3.94	0.0567	5
Ceiling Height	3.82	0.0549	6
Lighting	3.58	0.0515	7
Meter Square of Rooms Heated	3.58	0.0515	7
Building Orientation	3.52	0.0506	8
Meter Square of Rooms Cooled	3.52	0.0506	8
Type of Main Space Heating	3.47	0.0499	9
Type of Main Space Cooling	3.47	0.0499	9
Floor Ground System	3.41	0.0490	10
External Shading	2.90	0.0482	11
Wall Thickness	2.90	0.0473	11
Doors Glazing	2.90	0.0439	11
Daylighting	2.50	0.0439	12
Internal Wall Material	2.29	0.0359	13
Internal Shading	2.29	0.0329	13
Number of Variables			13
Number of Respondents			18
Kendall's Coefficient of Concordance (W)			0.149

The findings so far indicate that respondents emphasized on the role of building envelop in the energy consumption of residential buildings. The top three parameters of this ranking; insulation, roofing material and external wall material receiving the average Likert points of +4 belong to the building envelop category of variables. It is widely accepted that building envelop because of the direct exposure to the external environment is responsible for more than half of the total heat gain in buildings (Koo, Park, Hong, & Park, 2014). In addition, these variables are benefited from a full support given by BIM families to cover a wide range of classifications. Merely, the already identified variables cover a wide range of parameters involved with those categories consideration in simulation and optimisation; building envelop, building layout and HVAC, respectively. All in all, through the journey from the brainstorming stage in the Round 1 to the significant variables identification stage in the Round 2, more than half of the items were only selected by less than one third of the experts implying that they were perceived not substantial as compared to the research aim. For the sake of providing a measure of consistency, a statistical analysis was performed to compute the Kendall's coefficient of concordance (*W*) (Kendall & Smith, 1939), for the responses provided by the 18 experts and on the selected 13 variables. Kendall's *W* is a non-parametric test, running for the normalisation of Friedman statistic test, that can be used for assessing an agreement among participants. If the Kendall concordance coefficient equals to 1, all the survey scorers have been unanimous and they rate the variables identical. On the contrary, if the test results in 0, it means that there is no overall trend of unanimity among the assessors and they rank completely different (Corder & Foreman, 2009). In this case, the Kendall's *W* test produced a score of 0.149 at 10% significance level for the ultimate 13 variables that suggests rejecting this null hypothesis that the participants rated the variables randomly and unrelated to each other. Therefore, these 13 variables were confirmed to be significant and consistent.

Round 3

In the third round, the panel was provided with the results of the previous one; those 13 significant variables along with their respected weightings on the first of December; 2015. The experts were tasked with reconsidering their judgements in light of the ratings received from their peers reaching to 15 completed questionnaires in the end of this round.

Table 2. Results of Round 3 Questionnaires

The Variables	Likert Points Mean (L_{vi})	Corresponding Weighting (C_{vi})	Rank
External Wall Material	4.46	0.081	1
Insulation	4.38	0.079	2
Roofing Material	4.15	0.075	3
Windows Glazing	4.00	0.072	4
Building Orientation	3.84	0.069	5
Window to Wall Ratio	3.76	0.068	6
Ceiling Height	3.61	0.065	7
Type of Main Space Heating	3.53	0.064	8
Type of Main Space Cooling	3.53	0.064	8
Meter Square of Rooms Heated	3.53	0.064	8
Meter Square of Rooms Cooled	3.30	0.060	9
Lighting	3.30	0.060	9
Floor Ground System	3.23	0.058	10
Number of Variables			13
Number of Respondents			15
Kendall's Coefficient of Concordance (*W*)			0.267

Using equations (1) and (2), Table 2 shows that the majority of the experts had re-evaluated their rankings in which external wall material was raised from the third to the top level while insulation and roofing material were lowered to the second and third rates, respectively. This implies that the building envelop has still caught the first consideration and likewise the respondents have directed their particular attention to the external wall material because of its recognised effect on the heat transfer of building fabric. Furthermore, lighting was dropped from 7th to 9th and on the other hand, type of main space heating was raised by 4 rankings. Interestingly, twin variables of meter square of rooms heated and cooled became convergent taking the places of 8th and 9th. Moreover, the Likert Point Mean (L_{vi}) of all variables kept the score above three confirming an appropriate congruence among the results. The consistency of the survey was again calculated via Kendall's coefficient of concordance (W) using equations (3) and (4). It was revealed that the consistency was remarkably enhanced where it attained a number of 0.267 at 10% significance level pointing out a 180% improvement as compared to the second round.

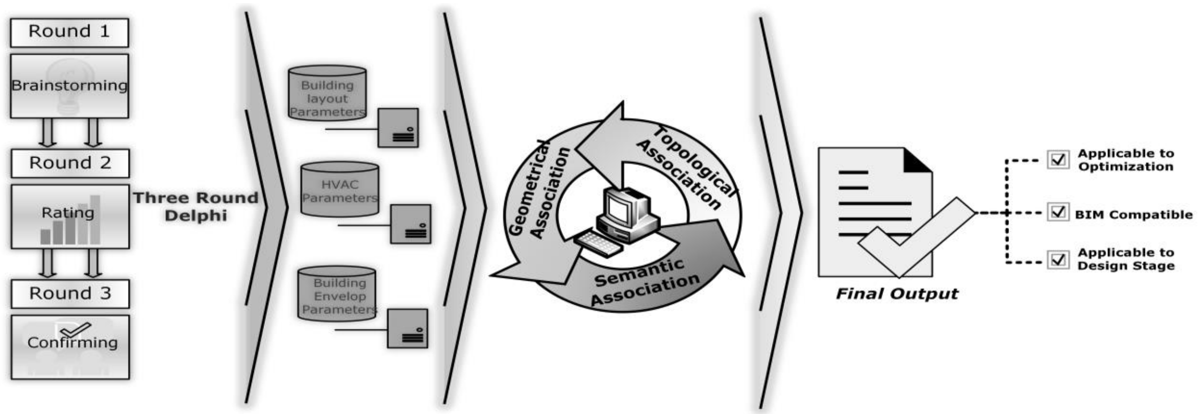

Figure 3. The Graphical Diagram of the Steps Leading to the Output

Discussion

The three round Delphi process was ended up with the identification of the most important variables of energy in buildings that comprise major categories including building envelop, building layout and HVAC. These variables could be the key asset for energy optimisation of buildings in the design stage if they are encapsulated through a unified approach in the BIM design process. To this end, the parametric definition inherited in the BIM technology should be focused. It was previously elucidated that the identified variables were checked with the BIM compatibility criterion to secure their semantic association with the geometrical and topological enrichment of data in BIM model. These variables are then required to be parametrised via the BIM development underlying approaches; artificial intelligence such as machine learning and data transformation algorithms in order to be approachable in the BIM environment. Integrated and parametric platform of BIM allows for the implementation of 'what if scenarios' so that the optimisation techniques and algorithms are run on these variables to find the most optimum values and minimise the energy consumption of buildings in the design stage (Banihashemi, Ding, & Wang, 2015). The steps taken in this research procedure is depicted in Figure 3.

CONCLUSION

The current BIM does not support decision making procedure to indicate a roadmap of energy optimization of the significant variables of the design through the perspectives of BIM compatible variables. Therefore, this paper was intended to identify the key parameters of energy efficient design; applicable to BIM authoring tools, the optimization and the design stage. The sequential exploratory research method combined with three round Delphi was conducted and the final matrix of significant parameters along with the associated weightings, fulfilling a reliable concordance analysis, was developed. This matrix could be effectively employed in BIM through AI algorithms in order to pave the way of developing intelligent decision makings for BIM platforms in the future studies. This paper also sheds light on a new emerging field; when it is intended to integrate a design and construction process with BIM, the elements and factors which are necessitated to be parameterised or simulated in BIM should be also investigated in view of their compatibility with three BIM-based data enrichment criteria including topological, geometrical and semantic associations. The results of this research should be treated with caution if other project lifecycles; construction and operation stages delve into discussion. Besides, the findings are more fitted with the residential buildings context and other types such as high-rise, office and industrial buildings set different agenda.

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STUDENT PARTICIPATION IN PROFESSIONAL ORGANISATIONS: THE NEED FOR INNOVATION

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ABSTRACT

Professional organisations in construction management and built environment list many benefits of membership, including professional development and engagement with fellow professionals. However, despite free membership for students, their membership and retention is generally low and it is important for the future of professional organisations to determine reasons for this disinterest. Do current students understand the benefits of professional organisations and place any value on membership? This paper presents the findings of a research project to better understand why recruitment of students and their active participation in professional organisations is low. A questionnaire survey was conducted across the students of the degrees of construction management in Deakin University to obtain the evaluations of the membership, while interviews were undertaken with representatives of professional organisations to determine the alignment between the parties. Student expectations of membership were shown to be a mismatch with the stated benefits offered by the professional organisations, or at least with how these benefits are communicated. Possible improvements are suggested to ensure that, in this era of instant communications and access to information, professional organisations innovate to remain relevant to the future leaders of their industry.

Keywords: Construction Management, Construction Management Students, Graduate Outcomes, Membership, Professional Organisation

INTRODUCTION

Universities that offer construction management degrees place high value on obtaining accreditation by these national and international professional organisations as this provides evidence that graduates will have current industry skills and knowledge, including interpersonal skills demanded by industry. Membership of a professional organisation conveys authority and recognition of ethical and proficient practice in construction management fields. To practice as a quantity surveyor, architect or builder in the Victorian construction industry it is legally required to gain registration as a building practitioner. Registration is possible without being a member of the corresponding professional organisations – the Australian Institute of Quantity Surveying (AIQS), the Australian Institute of Architects (AIA) or the Australian Institute of Building (AIB). As membership of professional organisations is completely optional the value of such membership is not always evident and it is generally agreed that member numbers and the active participation of existing members are decreasing. Students are a ready pool of potential members but research by Warren and Wilkinson (2008) shows that while students can see the importance of professional organisations, they do not actually intend to become a member or remain a member upon graduation. All professional organisations have a similar purpose and aim to ensure ethical behaviour of members, disseminate best practice and encourage excellence. They support research and represent their profession to legislators, the industry and the community. They have a commitment to the education of future industry professionals that is shown through their accreditation of university programmes. Student membership of RICS in the two years to 2010 fell by nearly 9% and the level of conversion did not improve (Wilkinson and Reed, 2010).

Research supported by the Royal Institute of Chartered Surveyors (RICS) Oceania (Warren and Wilkinson, 2008) raised a number of issues relating to student membership. Students were unaware of the differences in built environment professional organisations but nevertheless they linked professional membership with employment opportunities points. They also felt that full membership took too long to achieve.

Membership of a professional organisation offers both symbolic benefits and tangible benefits (Markova et al., 2013). Symbolic benefits are largely focused on the opportunity to define one's position and to identify with like-minded people in a chosen field while tangible benefits include access to publications and job opportunities. The value of these benefits to members is crucial in recruiting and retaining members.

The future of the construction industry rests in the hands of today's students. Students gain knowledge and skills through education and work experience but they gain leadership skills through life experiences (Toor and Ofori, 2006) that can include travel, sporting activities and participation in other extra-curricular activities. Membership of and engagement with professional organisations is one means of improving the leadership potential of current students.

It is important that the membership position of professional organisations with respect to these future leaders is investigated. In particular, the reasons why students do not join or, upon membership, do not participate in professional investigations requires further understanding. It poses the question whether student awareness and understanding is deficient, or whether the professional bodies are not meeting the needs of the student.

RESEARCH METHOD

The primary aim of this research is to explore the key factors that influence student membership and engagement in professional organisations within the construction and built environment industry. This research was carried out using the students from construction management degrees at Deakin University and the Australian Institute of Building (AIB) as a case study. Research method included survey questionnaire for students while semi-structured interviews were undertaken with committee members of the professional organisation. Approval for this study was granted by the Deakin University Human Research Ethics Committee.

The survey questions comprised multiple choice, ranking and short answer questions and were available online through the Deakin student portal to all students enrolled in construction management units. The survey was designed to gain insight of the students' perceptions of the purpose of professional bodies and what students want from the AIB. The survey was completely anonymous and there were no survey questions that gave the researchers any identifiable student information. The student surveys were complemented by interviews with representatives of the Australian Institute of Building (AIB) and Young Builders Alliance (YBA) which is a student specific arm of the AIB. The main objective of the committee interviews was to determine what the AIB believed it offered the student member and how that aligned with student expectations. General questions regarding student membership were also addressed.

RESULTS OF STUDENT PERCEPTIONS

Student Demographics

A total of 42 questionnaires were returned from both undergraduate and postgraduate students. The majority of student respondents (38%) were in Year 3 of their studies, closely followed by 29% in Year 4. Fewer early year students responded – Year 1 and Year 2 students comprised 9.5% and 12% respectively. There were also 12% of respondents who were enrolled in postgraduate studies. The majority of students (57%) saw their future career in project management, with 19% and 9.5% as quantity surveyors and site managers respectively. Nearly 10% of the students confirm that they have no clear idea about their future career. Moreover, over 60% students indicate that they may work overseas for a short or long period, or permanently.

Student Membership of Professional Organisations

The AIB is the most known of the four professional bodies named in the questionnaire at 75%. The AIQS at 57%was followed closely by RICS (53%), with the COIB the least known at 17%. There were also 17% of students that had never heard of these professional organisations. Despite this high awareness, membership is extremely low as more than half (58%) are not members of any professional body. It is not unexpected that the AIB is the professional organisation with the greatest number of students at Deakin with membership at 26% as the AIB is active at Deakin and the university could be deemed to be AIB friendly. The COIB came second at 10%, the AIQS at 5%. RICS had no student members from the 42 questioned. A summary of the distributions of the awareness and membership of professional body are illustrated in Figure 1.

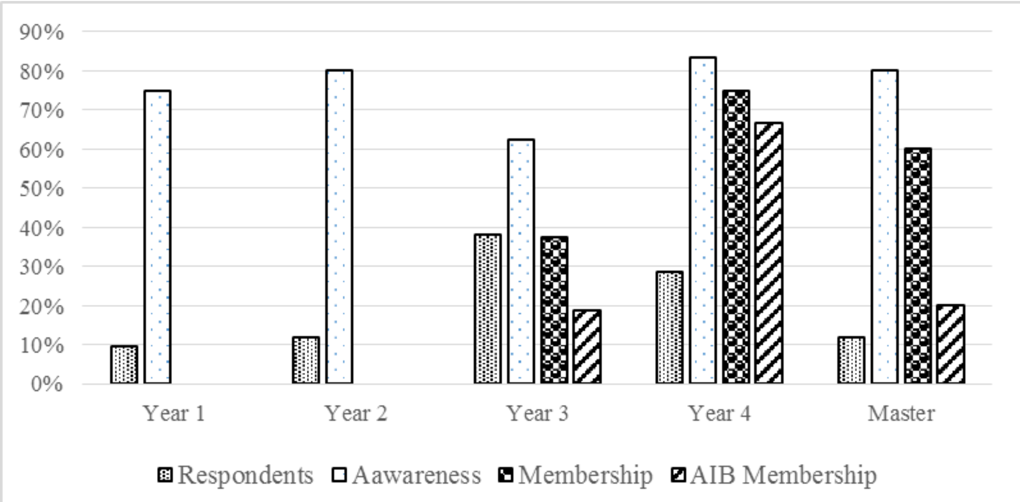

Figure 1: Distribution of respondent, awareness and members

The results show that the awareness of the professional bodies vary slightly across the years of study from 63% in Year 3 students to 83% in Year 4 students. On the other hand no students in the first two years of their study are members and membership of Year 3, Year 4 and Master students stand at 38%, 75% and 60% respectively. This indicates that students are more likely to join professional bodies as they near graduation. The research also shows that the AIB membership proportion is 19% for Year 3 students, increasing to 67% for Year 4 students. The percentage of AIB members in postgraduate courses is only 20%.

Students had various reasons for joining a professional body as illustrated in Figure 2.

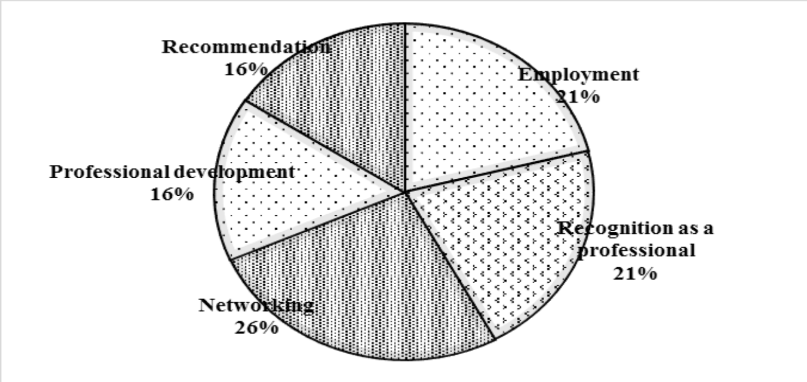

Figure 2: Reasons why students joined a professional body

The main reason for joining a professional body was for networking at 26%. To be recognised as a professional and to assist with employment both received 21%. Professional development and word of mouth (the recommendation that membership was a good idea) both received 16%.

Benefits of Professional Membership

Students overwhelming felt that being a member of a professional organisation would assist them in finding work upon graduation. This applied to both national and international employment. Students were less certain (60%) that employers actually expected or placed much value on membership. The purpose of accreditation was understood by 60% of students, with 28% and 13% either not knowing or not caring about accreditation. It is apparent from Figure 3 that students with membership had stronger confidence in the benefits of the professional bodies than the students without membership.

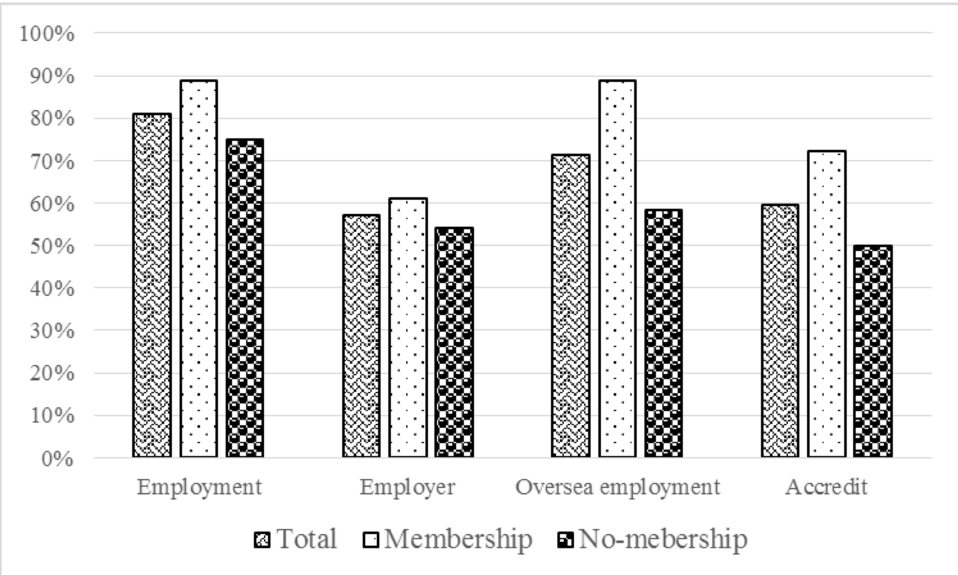

Figure 3: Employment and accreditation benefits of membership

Furthermore, the online questionnaire listed 10 options for the benefits of professional membership. The student was able to tick all of the proposed benefits in this question with possible responses being 'strongly agree', 'agree', 'neither disagree nor agree', 'disagree', and 'strongly disagree'. The majority of responses were either 'strongly agree' or 'agree' and therefore 'strongly agree' was used as the ranking criteria. The students' ranking of services and benefits is shown in Table 1.

Table 1: Students' rank of professional membership benefits

Rank	**Strongly Agreed**
1	Networking with the industry
2	Access to industry mentors
3	Career planning
4	Site Visits
5	CV/Interview workshop
6	Seminars designed for student development
7	Seminars designed for professional development
8	Study support
9	Social events
10	Attending award nights

The most popular benefit was networking with the industry where 25 strongly agreed (and a further 15 agreed). Access to industry mentors (23 strongly agreed) and career planning (22) were the next highest rated benefits. Site visits followed with 19 strongly agreeing and there was minimal difference between CV-interview workshops (15) and student development seminars (14). Professional development seminars (12) was closely followed by study support with 11 strongly agreed. Interestingly attending BBQ or social events was one of the lowest scoring benefits, especially given that networking was the highest, with only 8 strongly agreed. The benefit that scored the lowest amount of strongly agrees at 4 was attending the AIB annual awards night, which also received the highest amount of disagrees at 6. There was no difference in the ranking between students with memberships and those without.

RESULTS OF COMMITTEE PERCEPTIONS

All four representatives interviewed agreed that student membership is the future of the AIB. Specifically, it is important that the AIB uses its industry network to keep student members up-to-date with changing trends within the industry. This open network would also aid students as they enter the professional community with more clarity on the professional expectations of the industry. The AIB suggested that the involvement of student members would help develop the AIB as a professional body as a whole, and as students make the transition from student to young professional there would be a fresh opinion offered to the AIB. The AIB's main strategy in recruiting new members is directly though tertiary institutions. They promote events such as site visits and seminars to students and encourage current members to attend and network with student members.

FINDINGS: COMPARISON OF STUDENTS AND COMMITTEE

The committee members were asked to rank the same benefits as were the students. The comparison of these findings are presented in Table 2.

Table 2: Comparison of Perceived Benefits - Students and Committee

Rank	**Students**	**AIB Committee Representatives**
1	Networking with the industry	Networking with the industry
2	Access to industry mentors	CV/Interview workshop
3	Career planning	Site Visits
4	Site Visits	Access to industry mentors
5	CV/Interview workshop	Seminars designed for professional development
6	Seminars designed for student development	Attending award nights
7	Seminars designed for professional development	Social events
8	Study support	Seminars designed for student development
9	Social events	Career planning
10	Attending award nights	Study support

The student and the AIB agreed that networking with the industry was the most beneficial aspect in joining the AIB. The next student ranking was access to industry mentors which was ranked at number 4 by the AIB. The AIB suggested that CV/ interview workshops and site visits would be of more benefit than industry mentors, as a student could consult with members directly about job hunting strategies in the CV workshops and the site visits would offer the student practical experience to complement the theory learnt in the class room. The AIB rated access to industry mentors and seminars for professional development next as the student would gain good insight on the industry they are entering before they begin work. The professional development seminars are ranked lower by the students.

Surprisingly, students put career planning at number three of benefits even though this is not on offer at all from the AIB, suggesting that students are misinterpreting the service the AIB offers. Students also rated seminars designed for student development and study support at ranks 6-7 and, again, the AIB does not actually offer these services.

Social nights rated low with both the committee and the students however, the AIB rated the Awards Night quite highly, suggesting that this gives the student direct access to industry professionals and directors from large construction companies in Victoria. Despite this, a high number of students felt that attending award nights would be of no value to them.

The gap between student rankings and those of the AIB may be, in some part, nothing more than students finding it difficult to "join the dots". Students perceive a site visit as an opportunity to obtain construction information rather than an opportunity to network or make contact with those who could be perceived as industry mentors. The AIB should consider ensuring that current members are available at site visits, more so than just as guides, and specifically promoting the opportunity to meet with industry at a site visit.

Similarly, while the AIB ranked Awards Nights and social events highly this may well be because it is much easier to network once you are an established industry professional than when you are a less confident student in an unfamiliar environment amongst people you have not met previously. In this same vein, the committee members in their interviews stressed the 'word of mouth' benefits from attendance at any event. They viewed attendance as an opportunity where students could gain information about possible career paths, projects about to commence or any of the other informal information discussed when professionals from the same industry gather.

One interesting aspect of the student rankings was that they placed a high value on benefits that are not offered by the AIB, specifically career planning and seminars for student development. This may be one area where professional organisations need to refocus on student requirements and look at how they can offer these services within the mission and vision of their organisation.

This research has a number of limitations. The first is the small sample size with only 42 responses which represents less than 10% of the possible respondents. Further, the respondents were all Deakin University students and it might be that students from non-regional centres could view membership differently. The use of the AIB as the case study for interviews is another limitation. Despite the shared goals of all professional organisations, it could well be that the CIOB, RICS and the AIQS have different opinions on student membership. Further research has been conducted at Deakin to determine student engagement with, as distinct to membership of, professional organisations. This research again is limited to Deakin students but canvasses the opinions of both the AIB and the CIOB. This will shed further light on how professional organisations can address student expectations.

CONCLUSION

The findings show that the Australian Institute of Building is doing an excellent job at gaining awareness among the students, however it is less clear to students what the AIB does or what benefits accompany membership. The mismatch between the AIB perceptions and those of the students seems to be largely a failure in communication.

The professional organisations themselves must be responsible for ensuring that the networking so desired by students does, in reality, occur. That is, the onus needs to be on current members to instigate conversations that provide clear benefit to those students that attend. Once the link between attendance and 'networking' is established, this information will be passed through the student community and lead to improved attendance and, eventually, increased member numbers of the professional organisation.

Drawing upon the findings of the surveys and interviews, a number of recommendations can be considered. Site visits can be restructured to include more time for general industry discussion as well as attendance by industry members. As well, current members can be tasked with ensuring student members are made welcome at social events. Professional organisations can look at how they can contribute to the education of students and improve their value to employers through more than just accrediting their university of choice. More broadly, the AIB and professional organisations generally can consider the 'how' of networking, mentoring and career development desired by students.

Professional organisations need a strong and vibrant membership in order to thrive and succeed in their goals of encouraging excellence in the industry. There is no apparent innovation in how they operate, the events they hold or their communications with current and future members. There must be a willingness to consult with student members on their needs and expectations. The findings of this research opens up the possibility of improving professional bodies, to not only be a more useful resource for students, but also to improve the outcomes and interest for all members and the organisation itself.

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EMPLOYER ENGAGEMENT WITH HIGHER EDUCATION INSTITUTIONS: A LOOK INTO THE ROLES/FUNCTIONS

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ABSTRACT

The importance of industry linkages to academia is well recognised in the recent literature. There are different schemes that can be applied in higher education institutions (HEIs) to unleash the full potential of this collaborative relationship. Examples include work integrated learning, student placement, joint research programs, graduate student sponsorship, knowledge transfer partnerships, among others. Many of these schemes are viewed as critical to preparing students for both life and work. In addition, industry benefits from acquiring valuable knowledge to help improve competitiveness. This paper attempts to better understand the roles and functions of both HEIs and employers in such a collaborative relationship. Desk research is performed to investigate the existing literature and help establish a foundational basis of how HEI and employer engagement can be improved and optimised. The paper consolidates the findings and captures how the different elements of HEI and employer engagement can be integrated.

Keywords: collaboration, employability, higher education institutions, industry and employer engagement, pedagogy

INTRODUCTION

Higher Education Institutions (HEIs) are recognised as primary vehicles for delivering work-ready professionals to the different economic sectors of society. Leitch (2006), in a White Paper on the state and future of higher education (HE) in the UK, stated that in order to improve national competitiveness, links need to be strengthened between universities and businesses. As such, the duty of universities is to "work with business to develop the skills of the workforce and technical and professional levels" (Clarke, 2003, cited in Drake et al., 2009, p.24). Employers also have a stake and strategic interest in developing the potential employability of graduates (Romenti et al., 2012). Leitch (2006) went as far as to say that for universities and employers to work together is not an optional extra, but rather an economic necessity.

There are different facets to employer engagement in HE. Bolden et al. (2009) analysed 27 case studies of HE-employer engagement initiatives, which revealed the great diversity of existing schemes. They reported that many employers were looking to HE for a long-term relationship that goes beyond regarding HE as simply another training provider. Many HEIs also were seeking to establish similar strategic relationships with employers.

The last decade has witnessed further changes in the HE landscape; most importantly the government intention/movement in different countries to give more economic autonomy to HEIs (Bolden et al., 2009; Romenti et al., 2012). This makes HE-employer engagement critical to HEIs' long-term sustainability. As a contribution to the greater body of knowledge in this area, this paper attempts to better define the functions/roles of both HEIs and employers in such a collaborative environment. Bolden et al. (2009) ended their report by emphasising the need to have an integrated approach that collectively encompasses the different aspects of HE-employer engagement in order to be able to capture the ultimate benefit of employer engagement. In this paper, the model developed by Bolden et al. (2009) will form the basis for identifying and exploring the functions/roles in the HEI-employer collaborative environment.

OVERVIEW OF INDUSTRY/EMPLOYER ENGAGEMENT IN HIGHER EDUCATION

Definition of employer engagement

Employer engagement is a relatively new term which gained wide currency in the first decade of the 21st Century through the British government's initiatives to enhance innovation, knowledge transfer and national skills development. Blackwell and Higson (2014, p.241) describe employer engagement as a "portmanteau term that covers a wide range of complex interactions between higher education and employers".

Fundamentally, employer engagement involves a mutually beneficial partnership between a university/ies and an employer/s, built on reciprocal trust and communication, with each partner contributing different unique resources to facilitate knowledge transfer to build business and university capacity and to prosper the economy and society at large. Employer engagement can take the form of multiple collaborative interactions between HEIs and businesses in order to enhance student employability, to develop skills in the existing workforce and to provide industry with ready access to specialist knowledge and research expertise to facilitate innovation (Quality Assurance Agency (QAA), 2014). Employer engagement schemes involve a broad and diverse set of "knowledge transfer activities including student placements, graduate recruitment, applied research, outreach and the dissemination of research-based knowledge" (Bolden et al., 2009, p.31).

Previous Research

The academic literature on employer engagement tends to be fragmented into two separate streams, each focussing on different facets of the university-business collaboration. The first and earliest stream of employer engagement research is situated in the innovation literature and explores traditional research-business engagement relating to knowledge production and transfer through collaborative research partnerships (e.g. Pertuzé et al., 2010; Petruzzelli, 2011). The second, more recent stream of employer engagement research resides mainly in the education and careers literatures, focussing on teaching-business engagement to develop graduate employability skills and build capability in workers (e.g. Kettle, 2013). In the non-academic literature, publicly funded reports tend to adopt a broader, more holistic perspective which brings together the multi-faceted dimensions of employer engagement (e.g. Bolden et al., 2009); however this approach is rare in the academic literature. To address this gap, the remaining sections of the paper will present a more integrated overview of the various strands of employer engagement and the rich and diverse tableau of activities which they encompass.

STRANDS OF EMPLOYER ENGAGEMENT WITH HIGHER EDUCATION INSTITUTIONS

Teaching and research have been the traditional missions of HEIs with a third mission, i.e. business engagement, coming to light only recently (Bolden et al., 2009; Howlett, 2010). Business/employer engagement paves the way for moving from the traditional supply-led provision of HE to a demand-led one (Saunders, 2011). But there is no size that fits all. There are many schemes to enable businesses and employers to engage with HEIs. This HE-employer engagement should then become an activity that ripples throughout the entire fabric of the HEI (Bolden et al., 2009). It is not sufficient for this activity to be a third mission/stream, but rather a mainstream element that complements and enhances the traditional activities of teaching and research.

Bolden et al. (2009) recommended a more connected model for HE-employer engagement that links the three missions together (see Figure 1). This integrated model can be viewed as a cyclic process that continues to improve on all missions and activities of HEIs. Yet, this model needs to be unpacked to better understand the functions and roles of the two primary stakeholders, HEIs and employers. In each theme in Figure 1, e.g. curriculum development, collaborative R&D, etc., each stakeholder exhibits different functions/roles. These functions/roles complement each other within and across themes. With a clear definition of functions/roles, both parties will be able to identify how each side can contribute to a successful HE-employer engagement.

To unpack the model, three *strands* will be addressed; they are: (1) teaching–business engagement, which includes, curriculum development, CPDs, and taught masters programs; (2) employment–business engagement, which includes student placement, career advice & support, academic placement and secondments, and consultancy; and (3) research–business engagement, which includes knowledge transfer partnerships (KTPs), collaborative R&D, PhD studentships, and access to specialist facilities. Details follow in the following subsections.

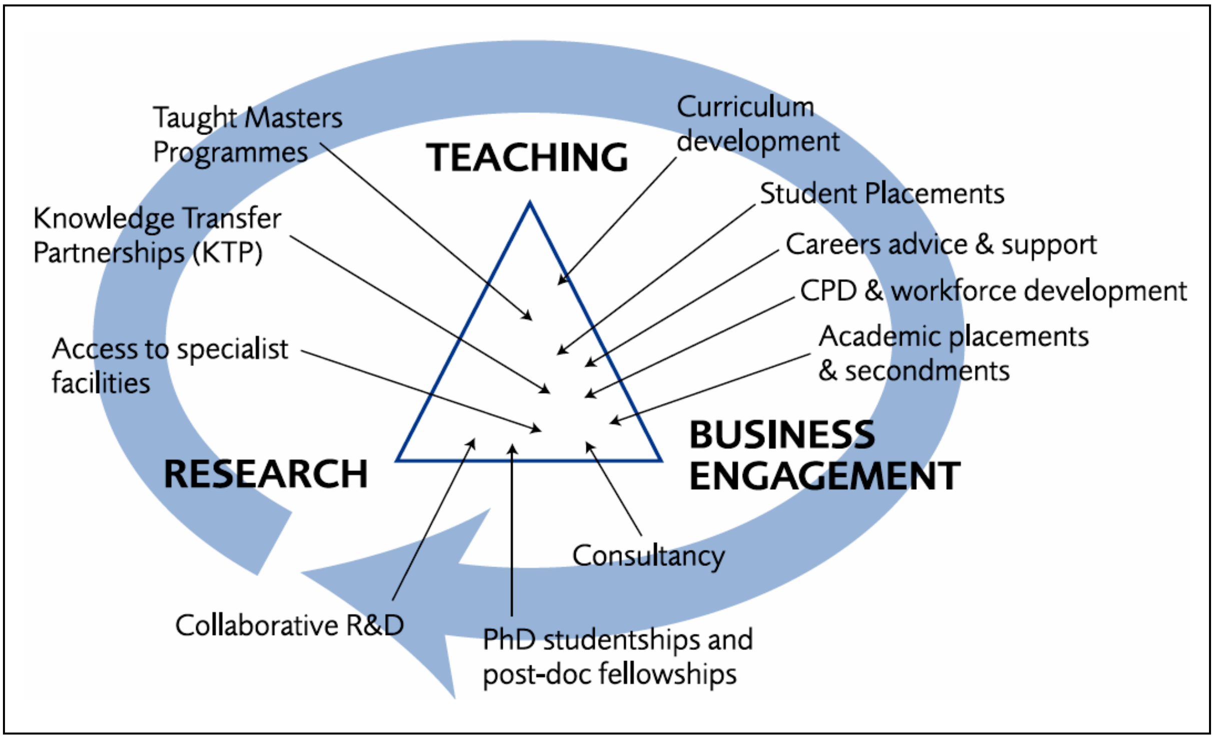

Figure 1 Integrated Employer Engagement Model
(Source: Bolden et al., 2009)

Teaching – business engagement strand

Effective business engagement for learning is the foundation of effective pedagogy (Mann et al., 2014). Employer/professional body input into curriculum design and delivery ensures that HEI programs deliver current knowledge and expertise relevant to employers'/professions' needs, while enhancing the student learning experience and developing their employability skills (QAA, 2014). Examples of activities which strengthen teaching-business engagement are professional accreditation of degrees; industry advisory boards; industry guest speakers; industry teaching fellows; and embedding practical, work-based skills and industry-based projects in the curriculum. The challenge for HEIs is to balance the vocational demands of a market-driven economy while still being responsive to students' individual needs for personal enquiry, self-reflection and the development of lifelong learning skills (Kettle, 2013).

Workplaces are also sites of learning; thus, taught masters programs can benefit from a flexible delivery mode by both academics and practitioners so that students are provided with an authentic learning experience reflective of the business environment while maintaining academic rigour (Keleher et al., 2011). Skills development at the postgraduate level can be enhanced by the addition of visiting industry speakers (Keleher et al., 2011) and industry-academia partnerships for designing and delivering bespoke postgraduate programs (Thomas et al., 2011). Additionally, employers and HEIs can collaboratively tailor shorter in-company training programs to upskill/reskill an employer's workforce, co-delivered either at the worksite or on campus (Wilson, 2012).

Employment – business engagement strand

Increasingly, HEIs, employers and students all recognise the value of work-based learning (WBL) experiences, such as short-term placements, longer-term internships, sandwich years, for developing realistic student expectations and building work-readiness skills (QAA, 2014). Students with WBL experience are more likely to obtain employment and to gain a higher starting salary (Mann et al., 2014). Other forms of work-based employer engagement are site visits, career fairs and advice, networking events, business mentoring, and student membership of professional associations. Employers can also increase HEIs' awareness of their workforce needs through offering WBL placements to academic teaching staff to maintain the currency and relevance of their subject matter expertise (QAA, 2014).

Another form of employment-business engagement involves HEIs undertaking to carry out, on a paid basis, research and development, product design, or investigation of some industrial problem, etc., for clients that do not possess the knowledge to undertake that work themselves (Howlett, 2010). Consultancy to business by academic staff encompasses the transfer of academic knowledge to a business and its employees while creating opportunities for those academic staff to maintain currency in their industry knowledge and experiences (Thomas et al., 2015). It is worth noting that the on-going consultancy assignments can be an influential element of an effectual pedagogy as they inform the design and development of curricula to include current and practical business issues.

Research – business engagement strand

Collaborative doctoral programs –supported by business engagement and funding/sponsorship– are characterised by students conducting research with an industry partner under the co-supervision of an academic and industry team (Borrell-Damian et al., 2010). Such collaborations benefit all parties through co-creating knowledge for business innovation, producing industry-relevant research outputs for academics and enhancing the skills development and human/social capital of all collaborators (Kitagawa, 2014). Through this process of knowledge exchange and translation with an industry partner, PhD students and their academic supervisors develop valuable knowledge and skills to bridge the academic-industry cultural divide (Butcher and Jeffrey, 2007). In many countries, a significant proportion of doctoral graduates go on to secure a career in industry, enhancing boundary spanning knowledge networks which benefit both academia and industry.

Furthermore, research learning and practice can occur outside the HEI due to a particular environment, facility, or data only available elsewhere (Siu, 2011). Specialist facilities and/or experts may not be present in-house requiring an expansive R&D collaboration with industry. Benefits of these collaborative arrangements for postgraduate research are many, including, gaining invaluable research experience, bringing new insights to both industry and HEIs, and establishing broader research networks (Jackson and Schuler, 2000, cited in Siu, 2011).

There are other means of transferring good ideas, research results and skills amongst universities, research organisations, businesses, government, and the wider community (BIS, 2009 cited in Howlett, 2010). Knowledge transfer partnerships (KTPs), for instance, have been recognised as one of the most effective mechanisms for knowledge transfer, dissemination and exchange in the UK (Howlett, 2010). The classic three-way collaborative KTP model involves: (1) a university or research centre with special knowledge and skills, (2) a company or community organisation that has a demanding business issue upon which a research project is founded, and (3) a KTP associate, who is typically a graduate who works in the company/organisation on the research project while being mentored by an academic from the university or research centre (Howlett, 2010). Also, there are derivative and much broader forms of KTPs such as knowledge networks/hubs, knowledge clusters, and innovation networks (Johnston et al., 2010). These networks are organised around universities, research institutions and firms to help drive innovations and create new industries (Evers, 2008 cited in Johnston et al., 2010).

ROLES AND RESPONSIBILITIES OF HIGHER EDUCATION INSTITUTIONS AND EMPLOYERS IN ENGAGEMENT

To extend Bolden et al.'s (2009) model, relevant literature was reviewed to delineate the specific roles and responsibilities of HEIs and employers in relation to each of the identified engagement themes (see Table 1).

In exercising their primary role as teaching and learning bodies, HEIs have a duty to establish academic and professional degrees with

Table 1. HEI and Employer roles and responsibilities in engagement

Theme	Functions/roles	
	HEI	**Employer**
Curriculum development	• Accredit degrees with professional bodies • Form industry advisory boards	• Staff membership of professional bodies • Provide staff for industry advisory boards
CPD	• Develop and deliver professional degrees • Develop and deliver bespoke WBL programs	• Fund employee tuition costs/study time • Fund bespoke onsite programs during work hours
Masters Programs	• Applied and bespoke masters programs • Recruit lecturer-practitioners	• Partake in applied & bespoke masters programs • Provide practical industry knowledge
Student placements	• Encourage student part-time/holiday work • Provide structured work experience and credit	• Provide part-time/full-time/holiday work • Provide short-term work-placements/internships
Careers advice	• Network with industry/professional bodies • Provide careers counselling and career fairs	• Participate in career fairs • Maintain a careers page on company website
Academic placements	• Recruit industry speakers/ casual teaching • Release staff for industry placements	• Provide guest speakers; casual teaching staff • Provide placement opportunities
Consultancy	• Design and develop consultancy schemes • Release staff for industry consultancy	• Create consultancy opportunities • Engage academics as consultants
Collaborative R&D	• Establish relationships with industry partners • Co-generate and resource research initiatives	• Research investment • Long-term research partnerships
PhD studentship	• Design and develop PhD fellowship schemes • Involve industry members in supervision	• Fund/support PhD fellowships and Post Docs • Provide placements, staff mobility, supervision
KTP	• Systematize research assignments in industry • Create and facilitate knowledge clusters	• Identify industry problems; KTPs with HEIs • Membership in knowledge networks/clusters
Specialist facilities	• Collaborative research with industry • Use industry research capacity	• Facilitate use of owned research facilities • Knowledge transfer with HEI researchers

openness to alternative and contemporary schemes, e.g. bespoke WBL, and innovative delivery methods that involve and benefit of industry practitioners. With their solid academic establishment, HEIs have the capacity to accredit academic degrees and endorse professional programs as well. However, the teaching and learning capacity can only emerge with the industry's provision and diffusion of practical knowledge into the HEI curriculum and teaching content. Industry has a responsibility for partaking in industry advisory boards; and collaboratively designing, funding and supporting the delivery of applied and bespoke programs.

While industry has strong interest in up-skilling prospective and current employees, HEIs need to reach out to industry to help create work opportunities for up-skilling both their students and staff. The purpose of which is to facilitate students' transition into the workforce via short-term work assignments before graduation and help HE staff to acquire knowledge necessary for enhancing their teaching, research and administrative skills. Employers should react by embracing outreach activities that allow them to reach out for prospective future employees, e.g. participating in career fairs, providing placements and consultancy opportunities, among others.

As for research activities, HEIs need to break down academic silos and collaborate with industry in the co-delivery of "applied" research. This outreach can reshape the research direction for some HEIs and provide academics with opportunities not possible otherwise e.g. undertaking research in specialist facilities owned and run by large industry corporations. Furthermore, employers and businesses can provide significant funding for applied research to the mutual benefits of all involved. Employers can better identify their current and pressing research needs, fund and further facilitate the delivery of this research. Also as a matter of social contribution, employers can fund research fellowships that not only benefit the industry, but the society at large.

CONCLUDING REMARKS

Industry engagement with HEIs can significantly enhance the teaching and research capacity in HE and allow a two-way transfer of knowledge that is beneficial to both sides. This paper sheds light on the functions/roles of the primary stakeholders in such collaborative environment i.e. HEIs and employers. A review of the literature clearly revealed that less research has been undertaken in Australia compared to the UK and USA. It has been a decade since Leitch's (2006) White Paper was released, which was followed by many actions on the ground in HEIs in the UK. Progress is lagging in Australian HEIs. It is critical that Australian HEIs embark on this collaborative opportunity to enhance their teaching and research strategies.

Employers are the other prime stakeholder in this collaborative relationship. Despite having a strategic interest in developing the employability of university graduates (Romenti et al., 2012); some employers are still not persuaded to engage with HEIs due to their internal emphasis on profit maximisation and satisfaction of organisational aims (Edmond et al., 2007). In other words, they are driven by short-term gains rather than long-term benefits. This poses a challenge to both the government and academic community to state the message loud and clear. Australia needs to take further steps to create an environment where there is a true understanding of the importance and criticality of employer engagement with HEIs for the long-term prosperity and economic gains of the entire community.

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IMPACT OF SUPERVISORY LEADERSHIP STYLE ON WORKER'S SAFETY CONSCIOUSNESS IN CONSTRUCTION ENVIRONMENT

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ABSTRACT

In an industry that employs 9% of Australia's total workforce, safety is paramount. Authoritarian, Democratic and Lassiez-Faire are the three leadership styles used by leaders to manage their team. This study aims to investigate the impact of different leadership styles of construction supervisors on workers' safety consciousness within the construction environment. Data were collected using questionnaire survey. Two separate data collection tools were developed: (1) a safety leadership styles survey for construction supervisors; and (2) a safety consciousness survey for construction workers. The survey was administered through different work groups of a construction contractor in Sydney, Australia. In total, 94 workers and 32 supervisors from 32 work groups responded to the survey. Of the 32 supervisors surveyed to find their particular leadership style, 23 were found to possess the Democratic leadership style, five were found to possess the Lassiez-Faire leadership style and four were found to possess the Authoritarian leadership style. The results show that construction workers' safety consciousness is positively related to the Democratic leadership style, whilst negatively related to the Lassiez-Faire leadership style. The findings suggest that the development of democratic leadership style for supervisors of construction work groups would contribute to improve their workers' safety consciousness.

Keywords: Construction, Leadership, Safety, Safety consciousness

INTRODUCTION

The Australian construction industry employs around 1.033 million people (Australian Bureau of Statistics, 2012) and makes up around nine per cent of the total Australian Workforce (Safe Work Australia 2012). Bentil (1990) claimed that the construction industry is commonly classified as a high risk industry with much greater risks of injury and death over opposing industries of employment. The National Data Set (NDS) reported that between the years of 2007 - 2008 and 2011 - 2012 the construction industry accounted for 11 per cent of all serious workers' compensation claims and that 212 workers died from injuries related to their work (Safe Work Australia 2012).

Safety is a key area that construction projects leaders need to focus on. Previous studies have identified that safety leadership is critical to promote safety culture and prevent injuries and fatalities. However, it is still unclear how different leadership styles (e.g., authoritarian, democratic and lassiez-Faire) of frontline supervisors impact on their workers' safety consciousness in construction sites. The aim of this research is to investigate the impact of the different leadership styles of supervisors on workers' safety consciousness.

LITERATURE REVIEW

Styles of Leadership

Leadership style is defined as the behaviours of leaders, focusing on what leaders do and how they act (Northouse 2012, p.52). Authoritarian Leadership is known as the more aggressive style of leadership where the leader needs to control subordinates and place emphasis in the fact that they are in control (Northouse 2012, p53). Leaders with this particular style of leadership style tend 'to centralise authority, dictate work methods, make unilateral decisions and limit employee participation' (Robbins et al 2008, p57). Lewin, Lippett & White (1939) found that the Authoritarian style of leadership was the second most productive style of leadership ahead of Lassiez-Faire. It was found that leaders are often 'ego-centred' (Cassel 1953, p437) and are always in control. It is also believed that Authoritarian leaders are in competition with other leaders and are more driven to use a dictator like style of leadership. Schun & Zhang (2012) found that Authoritarian leaders use the power-asymmetry between leaders and followers to assure dominance and to centralise control over subordinates. Cheng et al (2004, p90) defined Authoritarian leadership as 'leaders behaviour that asserts absolute authority and control over subordinates and demands unquestionable obedience from subordinates.' Authoritarian leaders strive to maintain a distance between themselves and their subordinates (Schun & Zhang 2012) and always intend to be in total control of their team. These characteristics are not dissimilar to those of pseudo-transformational leaders (Bass & Steidlmeier 1999).

The Democratic style of leadership is described as a 'Leader who tends to involve employees in decision making, delegate authority, encourage participation in deciding work methods and goals, and uses feedback as an opportunity for coaching employees' (Robbins et al 2008, p27). Democratic leaders tend to 'treat subordinates as fully capable' (Northouse 2012, p56) rather than directly dictating every individual component of the task that is required to be undertaken. This style of leadership is often seen as the most fair and supportive towards subordinates as it helps them to make decisions and complete tasks but not in a 'pessimistic, negative and discouraging' (Northouse 2012, p53) way like that of Authoritarian leadership. 'Democratic leadership results in greater group member satisfaction, commitment and cohesiveness' (Northouse 2012, p56) and was found by Lewin, Lippett & White (1939) to be the most productive style of leadership ahead of Authoritarian and Lassiez-Faire leaders. Democratic leaders 'tend to be social- or group-centred' (Cassel 1953, p437) and will often make decisions using their groups input and advice. It is believed that a Democratic leader will not be a dominant force but rather use courtesy, honesty and cooperation. Russel N. Cassel (1953) developed an essential criteria for Democratic leadership. This criteria includes items such as provisions for change, recognition of interests, cooperative attitudes and willingness to follow. This criteria defines essentials that every Democratic leader should possess to be successful. Bhatti et al (2012) wrote that Democratic leadership increases job satisfaction of employees and team members as it invites them to become a part of the decision making process. And although a Democratic leader will still make the final decision, inviting team members to take part in the decision making helps them to feel a sense of self.

Laissez-Faire leadership is quite different from both Authoritarian and Democratic leadership, as the leader plays almost no role in the decision making process of subordinate. Generally speaking, a leader who displays the traits of a Lassiez-Faire leader, 'is a nominal leader who engages in minimal influence and takes a hands off, let it ride approach' (Northouse 2012, p57). This style of leadership will almost always fail as subordinates are given virtually total freedom to do whatever it is that they wish. The majority of outcomes that Lassiez-Faire provides are negative as workers are at a loss to what they have to do. Lassiez-Faire was found to be the most unproductive style of leadership behind Democratic and Authoritarian (Lewin, Lippett & White 1939) as no positive outcomes came from a leader with no direction or drive. A Lassiez-Faire leader will generally make very little 'interference or participation' (Cassel 1953, p437) to group tasks and will allow complete freedom for individual and group decision. 'The laissez-faire leadership style involves a non-interference policy, allows complete freedom to all workers and has no particular way of attaining goals.'(Bhatti et al 2012, p198) This leadership style often has a negative impact on subordinates.

Safety Consciousness

Safety consciousness refers to the values, attitudes and beliefs that underlie the awareness of safety hazards and the ability to handle potentially dangerous situations effectively (Forcier et al 2001, p55). This awareness works on both a cognitive and behavioural level (de Koster et al 2011, p755). The idea that particular employees have a greater chance of injury due to their level of safety consciousness is an imperative part of safety analysis within a company. Today, it is widely accepted that the majority of accidents are caused by some sort of human error (Kamp 1994, p32) and certain personality characteristics are associated with a higher risk of being involved in an accident (Hansen 1991, p802). These characteristics include extroverted, aggressive, socially maladjusted, neurotic, and impulsive characteristics (Forcier et al, 2001). This evidence shows the relationship between particular characteristics of a person and their possibility of having an accident is greater. This is an important piece of information for companies and business implementing a safe work culture. Forcier et al (2001) defined a simple model of safety consciousness which has relevance to preventing industrial accidents. It can be observed from the model (Forcier et al., 2001) that there are three measures that impact on the safety consciousness of an employee:

- Safety Locus of Control – Refers to the level at which the individual person believes self-determination functions within their lives (Rotter 1966). It is believed that people with an external locus of control believe things happen due to chance or luck.

- Risk Avoidance – Refers to the way people avoid the sensation for the need to feel excitement. This measure is taken from Zuckerman's (1979) theory of sensation-seeking. It is believed that employees that are seen as high sensation-seekers have a much greater chance of injury due to chances taken to achieve this sensation.

- Stress Tolerance – Refers to an individual's ability to cope with stress from particular situations, periods or times of pressure. During these particular periods of time, the ability of someone to cope relates to their stress tolerance.

RESEARCH METHODS

This is a correlation research study that seeks to explore the impact of supervisory leadership styles on construction workers' safety consciousness. A quantitative research approach was adopted to achieve the research aim. Data were collected through questionnaire survey. The data collection instruments were developed based on the literature review. Because the research examines leadership styles at the supervisory level and the safety consciousness of employees, two separate data collection instruments were designed.

The leadership styles survey instrument consisted of a series of 18 statements derived from Northouse (2012) relating to the three particular leadership styles. The respondents were required to rate each of the 18 statements using the 5-point Likert scale. By summing the responses of particular questions based on the three leadership styles, a score between 6 and 30 were obtained for each of the three styles. These numbers were then used to assess the degree of the leadership style a supervisor has. Table 1 shows the questions from the survey instrument that intends to assess the particular leadership style of each supervisor. By adding the scores of each of the questions in each column a score of leadership style was achieved.

Table 1: Leadership style questions

Authoritarian	**Democratic**	**Lassiez-Faire**
Employees need to be supervised closely, or they are not likely to do their work.	Employees want to be part of the decision-making process.	In complex situations, leaders should let subordinates work problems out on their own.
It is fair to say that most employees in the general population are lazy.	Providing guidance without pressure is the key to being a good leader.	Leadership requires staying out of the way of subordinates as they do their work.
As a rule, employees must be given rewards or punishments in order to motivate them to achieve organisational objectives.	Most workers prefer supportive communication from their leaders.	As a rule, leaders should allow subordinates to appraise their own work.
Most employees feel insecure about their work and need direction.	Leaders need to help subordinates accept responsibility for completing their work.	Leaders should give subordinates complete freedom to solve problems on their own.
The leader is the chief judge of the achievements of the members of the group.	It is the leader's job to help subordinates find their 'passion'.	In most situations, workers prefer little input from the leader.
Effective leaders give orders and clarify procedures.	People are basically competent and if given as task will do a good job.	In general, it is best to leave subordinates alone.

The safety consciousness survey instrument was derived from Barling et al (2002) and amended to suite the construction industry context. Sample statements in the safety consciousness survey instrument include 'I am aware of the safety risks involved in my job' and 'I would know what to do if an emergency occurred on my shift'. The statements in this instrument were also assessed on a 5-point Likert scale. The data collected from the employees survey relating to safety consciousness will be recorded for each individual person within each group and then averaged across all the employees within each group to come up with a group employee safety consciousness score.

A pilot study was conducted prior to the commencement of the formal surveys for both supervisors and employees. Six site supervisors completed each of the surveys and it was found that both of the survey instruments were deemed to be suitable for distribution.

The unit of analysis in this study is individual construction work groups which consist of a supervisor and a number of workers. The survey questionnaires were distributed to all the construction sites currently operated by a construction company in Sydney Australia (Company A). This company is a representative of low to mid-tier building companies across Australia. Their works range from between $0 and $50 million and are well respected within their field. The construction projects that were involved in the data collection process include: (1) an 88 unit hotel comprising of two levels of basement and nine storeys above ground level; (2) a 5000 square metre high bay warehouse consisting of a portal frame structure, precast and metal clad walling and associated amenities block; and (3) a 68 unit residential development encompassing one level of basement, one level of ground floor parking and six levels of residential apartments. The three abovementioned sites represent three typical styles of buildings being constructed by low to medium tier builders across Australia.

Out of the 35 groups of surveys distributed to supervisors and employees throughout building sites across Sydney, 30 groups of papers were completed. The response rate for this group is 86 per cent. For each group, the supervisor completed the leadership style survey and at least 3 workers completed the safety consciousness survey. The respondents came from a number of different trade backgrounds and areas of speciality, had vast ranges of experience and a large expanse of education qualifications.

RESULTS AND DISCUSSION

The leadership styles of the supervisors surveyed was determined through the aid of Northouse’s (2012) leadership analysis method. Whereby the results of the supervisors survey were calculated into three categories as can be seen in Table 1. The scores given relating to each of the statements on the Likert scale were totalled to give a rating for each of the three leadership styles for each supervisor. It can be observed that of the 32 respondents, 4 (12%) were found to have an Authoritarian leadership style, 23 (72%) were found to have a Democratic leadership style and 5 (16%) were found to have a Lassiez-Faire leadership style.

The result shows that the Democratic leadership style appears to be most common leadership style used by the construction supervisors.

Correlation analysis was used to test the relationship between supervisors' leadership scores and employees' safety consciousness scores. The result of correlation analysis was presented in Table 2. It shows that both authoritarian and democratic leadership styles are positively correlated to employees' safety consciousness; whilst lasssiez-faire leadership style is negatively correlated to employees' safety consciousness. Moreover, democratic safety leadership style has a stronger positive correlation with safety consciousness than authoritarian leadership style does.

Table 2 Correlation Analysis Results

	Authoritarian	Democratic	Lassiez-Faire	Safety Consciousness
Authoritarian	1	.507**	.360	.266
Democratic		1	.174	.466*
Lassiez-Faire			1	-.366*
Safety Consciousness				1

*p < 0.05 (2-tailed); **p < 0.01 (2-tailed).

The results indicated that the democratic leadership style is the most popular leadership style used within the Australian construction industry. Democratic leaders are said to make decisions to tasks not in a 'pessimistic, negative and discouraging way' (Northouse 2012, p56). This type of decision making may be the reason that supervisors choose this style to manage their teams of employees. Using positive techniques to manage workers is seen as a positive way to motivate and drive employees. The result found by Lewin, Lippett & White (1939, p278) that 'Democratic leadership results in greater group member satisfaction, commitment and cohesiveness' is supported by construction supervisors in their supervision employees and the way in which they make decisions incorporating their team members' opinions. The finding that the most common leadership style used in the Australian construction industry is a result that could have a profound impact on both the supervisors of trades and teams and the building contractors that employ these supervisors. Through the development of leadership techniques of supervisors, contractors may have more positive workplaces for all employees.

The correlation analysis between the Democratic leadership style and safety consciousness found that the Democratic leadership style had the most positive impact on safety consciousness. This is a very affirmative result for Democratic supervisors as it reinforces the positive style of leadership that they are using. Democratic leaders 'tend to involve employees in decision making, delegate authority, encourage participation in deciding work methods and goals' (Robbins et al 2008, p57) in relation to all facets of work including safety. This attitude towards safety encourages employees to be active in improving safety climate and being aware of the impact of their supervisor's decisions on construction safety. Due to the fact that Democratic leaders tend to 'treat subordinates as fully capable' (Northouse 2012, p56) they maintain a positive effect on their employees safety consciousness. This is because employees know that they are trusted to be safe and not ordered to do particular tasks to keep them safe, rather allowed to make decisions to ensure their safety. The correlation analysis between the Lassiez-Faire leadership style and safety consciousness showed that this particular leadership style had a negative effect on construction safety. This negative effect may be due to the general influence that the Lassiez-Faire leadership style has on subordinates. This result is not to say that there is absolutely no use for a leader to use the Lassiez-Faire, it simply dictates that there is no positive effect on construction safety for this leadership style.

CONCLUSIONS

This study examined the impacts of different leadership styles of supervisors on their workers' safety consciousness. The most popular and effective leadership style of supervisors within the Australian construction industry is the Democratic leadership style. The supervisors with lassiez-faire leadership style are less likely to promote their workers' safety consciousness on construction site. Based on the findings of this study, it is recommended for construction contractors that the training programs aimed at developing a democratic leadership style be provided to their front-line supervisors. Through the nurturing of supervisor's leadership styles, a safer work environment may be created. A limitation of this study needs to be highlighted. The data were collected within multiple construction sites of a single construction company. The findings of this study may need meticulous explanation when applying to other companies. Nevertheless, the results are still relevant and useful to the Australian construction industry as the company used for the study represents the typical building company in Sydney, Australia and the projects involved in the data collection covered commercial, residential and industrial projects. Moreover, the methods used in this study may be used in future research to collect data with multiple construction companies.

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CHOOSING AN APPROPRIATE PROJECT DELIVERY METHOD FOR COST MINIMIZATION AND ON-SCHEDULE DELIVERY

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ABSTRACT

Construction technology has changed rapidly in recent times but the uptake of new technology has not kept pace. In particular, on-site construction processes have evolved slowly compared to the rapid advances in off-site manufacture (OSM) currently being adopted in China. A number of factors are impeding the uptake of OSM including design challenges, procurement options, availability of specialist trades and production facilities, as well as workplace safety and culture. This paper discusses some of the aspects associated within the early stages of value management and value engineering that could assist contractors to refocus on the alternatives that are available to them. It is based on the personal experiences of two industry practitioners with over 80 years of experience in both mainstream and offsite construction. It is a reflexive paper, exploring relevant issues and future studies of OSM within a changing workplace environment subject to a loss of traditional skill sets.

Keywords: Skill Shortage, STEM, MCC, Procurement, Design Limitations

INTRODUCTION

The tender process for new construction works is a competitive, costly and time-consuming process. A successful contractor will have exhausted all aspects of the value engineering process[1] to secure a building contract. During this process, alternate systems, products and services procured from overseas may not be readily available across the sector. Some contractors may have strong supply networks, whilst others may not have access to the same solutions. A number of impediments are associated

[1] "Value engineering is a systematic approach that seeks to enhance value by eliminating unnecessary cost while maintaining function"(Green & Popper, 1990)

with this process and these are discussed later in this paper. This paper considers the current construction environment and how the industry in Australia has progressed thus far.

Australia has unwittingly been at the forefront of change for some considerable time but it would seem that the pace of change has waned in recent years. The end of WWII brought back the reality of years of low domestic construction and the need to resettle returned service men and women who were keen to restart their lives and have families (Farlow & Phippen, 2008). This gave the Australian economy a tremendous economic boost. The creation of new homes triggered an increase in the manufacture of building components as well as household goods. For example, in the inner suburb of Ryde/Gladesville, the council undertook the construction of 2500 homes via a scheme employing a "panel of ten distinguished architects" (Farlow & Phippen, 2008, 103).

This growth captivated the minds of designers, architects, builders and manufacturers. The birth of the 'brick-veneer' home, pioneered by Gavin and Shallala (Gavan Property, 2016), was a tremendous initiative and was emulated by the mass housing project home builders of the day (including LendLease). Traditionally, and up until the early 1980's, structural frames were cut and assembled on site from off-the-shelf timber. With the advent of personal computers in the early 80's, the industry was in the early stages of rapid change. The PC revolution enabled timber merchants to design and produce timber frames and trusses that were connected with nailplates (Knowles, 1978). The knowledge and skills required to cut and assemble roof frames rapidly became obsolete. Computer systems enabled operators to offer innovative designs and to respond to clients' design whims almost instantaneously. When combined with factory production-line processes, roof construction evolved into an assembly of factory produced components. This inevitably led to a reduction carpenters' skills. They have become installers specialising in the erection of frames and trusses.

'Stegbar Windows' followed the factory production trend and pioneered 'off-the-shelf' windows that were available via a catalogue. Many manufacturers of repetitive products now adopt this sales tactic. The introduction of materials such as aluminium made possible the mass production of new window, cladding and roofing products. Australia was also responsible for the 'Favco' crane, a merged company comprising Favelle and Coles who pioneered the self climbing luffing crane that dominated the Australian skyline as well as overseas (Favelle, 2015).

The construction industry in Australia changed and adapted rapidly to this computer-driven and technologically-led landscape. Indeed, change continues and Australia currently faces several unique obstacles created, in part, by location and population. These are explored below.

IMPEDIMENTS AND OBSTACLES

Australia is an isolated island. It is dependent on a strong local manufacturing base as imports have traditionally been expensive. This has changed over the years. Globalization has been embraced as the new world order and in recent times there has been a constant stream of imported building products entering our domestic markets. This new phenomena has brought significant choice, change as well as challenges and difficulties. For example, some products like ceramic tiles are now predominately imported from overseas (the last major ceramic manufacturers operated by Johnson Bros and PGH ceased operating nearly 20 years ago). Bricks is another commodity that is currently under threat. Recent disputes between Boral (Devine, 2014) and the Construction Forestry Mining Employees Union (CFMEU) may have sparked a rethink by major manufacturers about continuing local production. Recently the ABC reported that a national brick company, Brickworks, are importing bricks from Spain as it is cheaper than transporting their own products from Perth (Trembath, 2016). Furthermore, Brickworks recently merged with PGH (PGH, 2016) thereby reducing the number of companies producing bricks in Australia.

Fairbrother, Paddon and Teicher (2002) provide a context for the ways industry has evolved, noting that, from the mid 1980's, the "Labor federal government of the day began to introduce aspects of privatization". They continue "The drivers for change were a deteriorating set of economic relations, a series of critical reviews about organization and operation of the national economy, particularly state-owned and supported industries, and an attempt to 'modernise' the public sector" (Fairbrother et al., 2002,8). The direct result of these changes was the closure of state-owned brickworks, government rail and bus body works such as 'ComSteel' and Eveleigh Railway Workshops (Office of E&H, 2016), and the closure of departments such as the Public Works Department and the Commonwealth Works Department. These changes have had long-term effects and may still give rise to further issues. Arguably they have made it difficult for large manufacturing industries to remain in Australia today. What are the impediments and obstacles that have contributed the status quo in the Australian built environment? The following section explores some of these including critical mass and cyclical environment, skills shortages, certification, design limitations and modern construction methods and science, technology, engineering and mathamatics.

Critical Mass (CM) and Cyclical Environment

Australia has a population that has recently peaked at 24 million (Statistics, 2016). There are cities in the world with a similar population and countries with substantially larger populations. These are able to leverage the benefit of critical mass to develop and produce components. Manufacturers with lower production cost bases also have opportunities to export their products. Australia does not operate in the same environment. In particular, countries currently engaged in Off Site Manufacture (OSM) (e.g. in Europe and China) have been in this market for some time. However, in Australia, numerous attempts have been made to engage with OSM but have been hampered by start-up companies that collapse due to their inability to supply projects that accompany their product. The result has been the importation of OSM products from China and other countries. However this process has been marred by poor quality, lack of certification, installation difficulties as well as difficulties relating to payment being required before goods are shipped (as opposed to payment being made on receipt of a progress payment). These challenges have made local builders hesitant to use OSM products from overseas.

The Australian construction industry is cyclical in nature, having peaked in 2014 and 2004 respectively (Kumar et al., 2014). This cyclical environment has meant further challenges to manufacturing and the development of constant employment and education as described below.

Skills Shortages and STEM

The skills of the construction labour force have eroded over recent years. This is a major topic of concern for the industry (Toner, 2006). There have been numerous discussions about poor apprenticeship uptakes resulting from employers being reluctant to engage apprentices, to the lack of applicants interested in working in the industry (Keene, 2015). The quality of education has also been highlighted. The RTO's have produced poor outcomes and the restructuring of TAFE has left many bewildered (Bagshaw, 2015). Government support for apprenticeships has reduced dramatically over the past twenty years. The lack of skills has contributed to a lack of quality that has become most noticeable over recent years (Easthope et al., 2012).

OSM is ideally placed to address this impasse. Similar to the automotive industry, OSM processes may be undertaken by semi-skilled workers who can be trained in the workplace. Companies like Westrac have recently created a large workshop at Tomago where they disassemble machinery components from large mining equipment. These are then refurbished and reinstalled in an assembly line process (MHD, 2013). This has reduced the need for specialized automotive engineers and mechanics. This model could be replicated for the manufacture of OSM components, particularly for the housing sector due to there nature of repetitive designs and prescriptive regulations.

The construction sector requires employees trained in science, technology, engineering and mathematics (STEM). In a recent report by Price Waterhouse Coopers, "Australia is lagging on a number of key STEM indicators" (PricewaterhouseCoopers, 2015,4). The report further suggests that "shifting just 1 per cent of the workforce into STEM roles would add $57.4 billion to the GDP (net present value over 20 years)". The Federal Government recognises this need and has established the National Innovation & Science Agenda as a pathway for business, educators, investors and young Australians to embrace STEM and prepare for the future (Commonwealth of Australia, 2016). The Australian Industry Group report on STEM indicated that work placement and experience gained a high response of 60% for stimulating students (AIG, 2015) (Figure 1), as opposed to the education sector showing 10%-30% in influencing students into STEM roles. This supports international reports indicating that 75% of the fastest growing occupations require STEM attributes (Chubb AC, 2014,iv). These include advances in BIM, 3D printing, point cloud applications and advances in software applications.

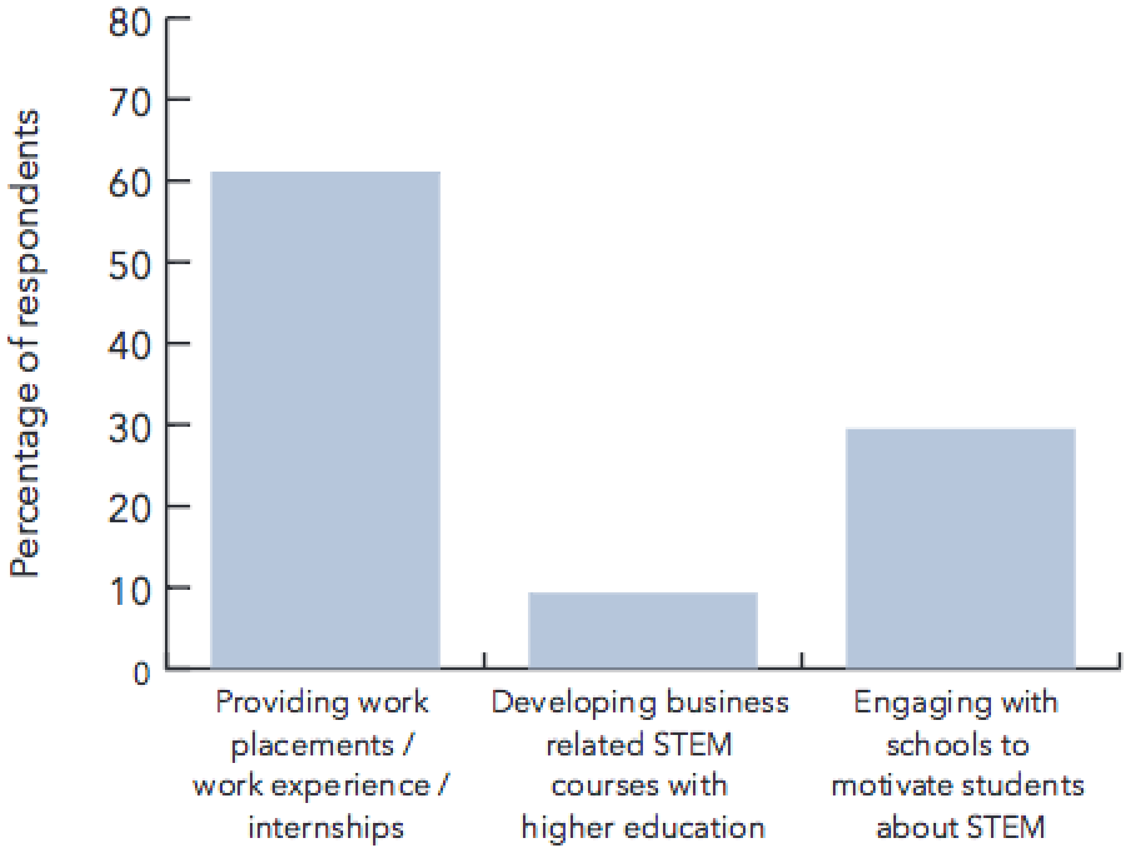

Figure 1-Business Promotion of STEM skills

Certification

Manley and Steinhardt (2015) note "other influences that dampen demand for prefabrication is negative consumer perceptions and a regulatory environment that is not tailored for prefabrication" (Manley and Steinhardt, 2015,26). The process of assessing completed building works has slowly moved away from municipal councils to private certifiers. Whilst this process is on-going, the acceptance of new technology has not been as rapid. The issues currently facing council as well as private certifiers include a lack of mandatory inspections and the public perception that they are undertaking a quality control audit. However, certifiers are only concerned about compliance with codes, standards and approved documentation, as required by the BCA. Herein lies the concern. With the proliferation of building methods currently underway in Australia, certifiers are currently stretched. The number of new entrants to the profession has not significantly increased to meet the demand. Furthermore, the importation of goods and, in particular, manufactured goods like bathrooms and kitchen modules poses new challenges. Establishing whether these materials and the workmanship contained therein comply can be a formidable task. Examples of cases where these issues have attracted high public visibility include the recent media expose of façade cladding in Melbourne (Chua, 2015) and the high-pressure water pipes used in some new hospitals (Butt and Lucas, 2015). Both have failed even though one of these products carried the Australian 'Watermark' stamp. OSM within Australia, working within an enclosed systemic environment similar to "Westrac" could improve the compliance of prefabricated components assembled to a quality standard.

Design Limitations

Traditionally, value management systems are implemented during the schematic design stage of a project (Gray and Hughes, 2009). They are conducted by architectural firms responsible for entire projects. Today, fully documented projects are seldom seen and are more often replaced by design and construct contracts. This form of procurement is said to account for 80% of major projects today (Bulmer, 2013). This provides an opportunity for the OSM industry to grasp *value engineering* as an opportunity to assist tendering contractors with the wide range of alternatives available to them. The more contractors are aware of OSM options, greater are the possibilities of that use.

Howe (2015) questioned whether or not OSM will limit bespoke design. He quotes Aladin Niazmand, saying the high cost of developing new hospitals is the result of their bespoke nature for a primarily functioning building (Howe, 2015). Here, Niazmand, compares the successful manufacturing process and cost of the Airbus A380 against hospital construction costs. A recent case study of Saint Josephs Hospital in Denver USA identified cost savings due to repetitive aspects of design. It was also found that the use of prefabricated units created a safe working environment in an area usually occupied by several service trades (Antillon et al., 2014). This study focused on overhead MEP[2] utility racks, patient headwalls, exterior wall panels and modular bathrooms. The net result was that these components did not necessarily govern or hamper bespoke design, a concept that is contrary to popular perceptions.

[2] MEP-Mechanical, Electrical, Plumbing.

Modern Construction Methods

The concept of change in construction methodologies and the acceptance of these changes requires stakeholders to embrace the digital age. Young graduates of today have grown up as digital natives and see the internet as the norm (Combes, 2008). They are tech-savvy and embrace new technologies and cautiously scrutinize their impact and relevance. Their world will have procurement systems that operate within the global sphere, engaging with changes to monetary transactions and contracts to reflect that new economy. There will be new breed of specialists who will embrace STEM. STEM underpins BIM, 3D printing, point cloud, OSM, Design for Manufacture and Assembly (DfMA) and other new developments. The results of these implementations could see substantive savings in construction as suggested below,

- At least 20% reduction in construction costs
- At least 40% faster on-site construction durations
- At least 40% of current on-site workforce reductions
- At least 80% reduction in construction injuries
- At least 80% reduction in on-site waste
- At least 80% reduction in defects and non compliance (Chandler, 2016)

Universities and industry will be required to lead these changes. Wide-ranging development of curricula will be required so that universities and industry execute the specific roles indicated in Figure 2.

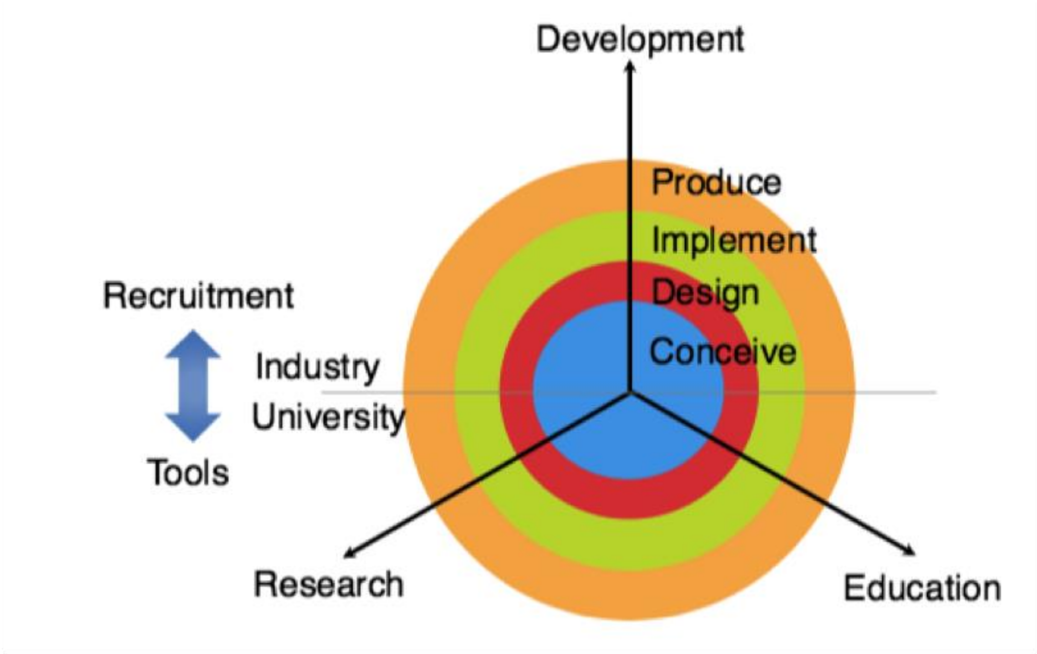

Figure 2: Industry – university interaction (Mohtadi et al., 2014)

OSM-V-TRADITIONAL PROCUREMENT

For a project manger today to choose between traditional procurement methods/D&C over OSM, the PM would need to evaluate several considerations. Take for example a new hotel development requiring bathroom pods. The attraction of importing a product manufactured overseas solely based on cost may seem attractive but in reality could have many significant hidden costs.

Firstly, the PM has little control over the materials chosen for the fabrication process as highlighted in the drywall scandal in New Orleans (Times-Picayune, 2014). As a result of the New Orleans flooding, remediation began and although contrary to US requirements, drywall material was imported from overseas. This resulted in uncertified drywall sheeting used and exposed to high humidity causing failures to electrical and plumbing installations as well breathing difficulties for occupants caused by caustic vapours. Therefore, the requirement of having the pods fully certified to Australian standards prior to shipping is an imperative.

Secondly, transportation and wharf delays may disrupt the supply line from overseas to site. The reasons for such delays are numerous and, if they occur, could considerably delay the project schedule, imposing additional costs.

Thirdly, services that have been assembled overseas may not necessarily have been completed by qualified trades, potentially leading to additional rework on site.

A further consideration is the *plug & play* concept. Will a module's services connect to the existing services? In particular, will reticulation of water, waste penetrations and fire collars be possible?

This is not to suggest that the use of imported pods only attracts problems. In time, imported pods are likely to become accepted, as demonstrated in the car manufacturing industry in the late 1960's when the quality and cost of Japanese cars improved considerably.

Lastly, how is the transfer of funds for payment administered? The standard form of contract administration is to pay for goods when they are installed in a project and form part of its entirety. Imported goods require payment upon shipping. This exposes contractors to costs that cannot be claimed until the goods are secured in place, which could take several months.

CONCLUSION

In conclusion, the prefabrication and OSM industry in Australia is well positioned for the foreseeable future. However, stakeholders must recognize the environment it currently shares with traditional methods of construction and embrace the opportunities OSM provides. This will involve acknowledging changes to existing business models. In addition, industry and universities need to collaborate to prepare the new constructors of tomorrow. OSM also has the ability to curb skills shortages. It can also deliver quality products that can be certified for compliance prior to leaving the place of manufacture.

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HEAD CONTRACTORS PERCEPTION OF TRUST ISSUES AMONGST THEIR CONSTRUCTION RELATIONSHIP WITH SUBCONTRACTORS

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ABSTRACT

Trust is an essential factor in achieving successful project completion in the construction industry. Relationships between head contractors and subcontractors are commonly surrounded by untrustworthy behaviour that promotes the development of trust issues between the parties. This research considers the various types of trust issues that can arise, whether characteristic, process, or institutional based, and focuses on which type head contractors perceive as being the most important to their contractual and project relationships. Empirical data was gathered from semi structured qualitative interviews and analysed using a one-way between groups analysis of variance. Findings revealed that head contractors perceived institutional based trust to be their most important and valued type of trust. The findings also implied that the identification of the head contractor's perspective of trust could assist in improving their performance throughout the construction project.

Keywords: characteristic based trust, head subcontractor, institutional based trust, process based trust, relationship

INTRODUCTION

Trust affects construction partnerships throughout all stages of the supply chain and throughout all stages of a project. The varying nature of construction projects and the numerous partnerships formed makes construction relationships difficult to develop and maintain and can cause multiple trust issues to develop throughout the project. The development and maintenance of these relationships is heavily impacted by the perceptions that both head contractors and subcontractors have on their relationship, which is heavily influenced by stereotyping.

The relationship between head contractors and subcontractors is arguably the most important in the construction industry as subcontractors represent roughly 85% of the industry (Mbachu, 2008). The published literature in journals highlights a range of issues surrounding the relationship between head contractors and subcontractors, particularly in Australia and the United States. However, limited research has been carried out and reported in journals on the nature of the commercial relationship between head contractors and subcontractors in Australia in particular if they have varying perceptions on prevalent trust issues in the construction industry. Research is needed to address this gap as the identification of the type of trust that head contractors value most in their relationship will assist in improving the understanding of the head contractor and subcontractor relationship to improve project efficiency and outcomes.

LITERATURE REVIEW

Context

The construction sector in a number of developed and developing countries tends to be characterized by the predominance of large head contractors, with multiple layers of small contractors and subcontractors working under their umbrella (Reeves, 2002). The common practice of subcontracting in the construction sector is partly due to the specialist nature of most construction works and the strategic choice by large construction firms to emphasize flexibility as a source of competitive advantage. Although, due to tight project time constraints and the large number of subcontractors employed onsite to complete a project, the development of a trusting relationship is sidelined. This research aims to determine how head contractor’s perceive trust in their construction relationship with subcontractors.

A person’s perception of another affects how they act towards that person and the people that person associates with, therefore contextualizing their relationship. Stereotypes contribute greatly to a person’s perception of a group of people. It is easy to assume that because one group of people or culture behave a certain way then the whole group or culture acts the same way. Sub-cultures have been evident throughout the construction industry since its professionalization. These sub-cultures are influenced by: varying beliefs, attitudes, values, languages, rituals, codes of conduct, expectations and practices. Strong occupational stereotypes have since developed due to the ever-changing nature of construction activity (Loosemore and Tan, 1999). Munns, (1996) argues, that in a transitionary society, people are more likely to base their relationship upon preconceived and standardized expectations of other's motives and behaviour patterns.

Hartman, (2012) and Zucker, (1986) observed the following three types of trust amongst construction relationships. These theories of trust in relation to industry partnerships, theorizes how people form and develop relationships in the industry and will be used throughout this study to determine head contractors perception of trust.

Characteristic-based trust: Personal characteristics such as ethnic background, religion, age, sex, etc. Based on sense of shared commonality with other parties. Open communication is critical to enhance or gain partners characteristic based trust.

Process based trust: Based on social exchanges between individuals and organisations. Exchanges may be obtained directly from previous successful experiences in building trust and indirectly from established reputation brands etc. This trust is the perception, which is hardly affected by the instant performance of the parties but the long-term relationships among them.

Institutional based trust: Produced through a third party and is tied to broad societal institutions on intermediary mechanisms and is based on the perception of others ability to perform the required work. Partners' institutional trust can be gained by observable proofs like track record, experience or connections with professional bodies.

Head Contractors, Stereotypes and Perceptions

The ability of the head contractor and consultants to deliver the project within time, quality and cost targets set by the client depends largely on the performance of the subcontractors. It is the head contractor's priority to ensure they obtain the right subcontractors to assist in achieving time, quality and costs targets throughout construction and project completion. Prior research indicates that the best way to achieve successful project performance is through the development of a trustworthy relationship between both parties (Cheung et al., 2013).

Performance is often used as the critical indicator of success of construction organizations. However, defining and evaluating project performance differs when different perspectives are evident (Chan and

Chan, 2004). For instance, in a multidisciplinary project team with architects, engineers, and surveyors, these members have different individual predetermined goals, and thus have different expectations on project performance (Lim and Mohamed, 1999). Clients often focus on the satisfaction and needs of the stakeholder, whereas contractors aim at minimizing the project cost and duration (Bryde and Robinson, 2005). In practice, the definition of project performance is often based on the client's needs and requests (Chan and Chan, 2004). A project is commonly considered a success when all team members turn over a profit (Lim and Mohamed, 1999).

The aptitude of a multifunctional project team to execute a project successfully is reliant on its capacity to integrate the relevant knowledge and skills that are dispersed among team members. This integration of the capabilities in the team is reliant on how they cooperate together and their interpersonal relationships, such as the degree of trust. Therefore trust is relatively important in these teams, because many sub-tasks are interdependent, with team members relying on the functional expertise of their colleagues. Relationship duration is of particular importance for trust development in a project team setting (Levin et al., 2010). The inherent need for collaboration and the high interdependency facing this form of work require trust between project team members. This is because trust has been identified as an important component of teamwork and researchers have acknowledged its critical role in the development of effective work processes and the successful performance of traditional operational teams.

Although, people have a tendency to categorize others into distinct social groups and subjectively generalize about their traits, which differentiate all the members of those groups from each other and this can obstruct the development of trusting relationships (Loosemore and Tan, 1999). Stereotyping is a common cognitive process of categorization that allows people to simplify uncertain situations that have infinite stimuli (Hogg and Abrams 1988). Subcontractors often stereotype head contractors by the past experiences they have had with other parties of similar nature and vice versa. This affects how they value their relationship and the length of time taken to develop trust with them.

Brewster-Smith, (1972) and Manis, (1996) argue that stereotypes are grounded in people's belief systems, which shape their attitudes and, in turn, their behaviour, towards each other in a social setting. The contemporary view is that stereotype beliefs are held in the form of mental images and, that over time, they become deeply ingrained into a person's belief system, making them resistant to change. Since beliefs are essentially preferred channels of communication information from new experiences tends to be filtered of non-conforming elements to produce a self-fulfilling prophecy (Ashmore and Del Boca, 1981).

Stereotyping along with price can affect a head contractor’s decision on who to select when choosing subcontractors throughout the tendering process. Industry gossip can provide an image of an entire company based on word of mouth from one individual and affect a head contractors selection. Although a particular subcontractor may have the best price when the head contractor tenders for the job, following the award of the primary contract the head contractor will normally select a more reputable subcontractor and using bid shopping techniques will drive their price down. This leads to unsatisfactory responses from subcontractors and this can affect the development of trust between the parties. The research by Shash, (1998) on subcontractors’ bidding practices found that enquiries tend to be poorly prepared and contain abstract information. On acceptance, a subcontractor prepares and submits quotations to all inviting contractors just a few hours before the primary-bid opening time. Some subcontractors attempt to induce head contractors to disclose other subcontractors’ quotations but the majority of head contractors refuse to release such information. This further affects the relationship between the parties.

Construction relationships between head contractors and subcontractors are influenced by problems such as poor documentation, poor health and safety (H&S) standards and substandard workmanship, all of which contribute to the lack of trust on projects (Arditi and Chotibhongs, 2005). Despite the undisputed contribution of subcontracting to organisational and managerial flexibility as well as provision of specialised services, the management of relationships between head contractors and subcontractors during projects can be quite complex and problematic. Subcontractor’s inability to adopt modern quality management practices, and failure to embrace technological advancements or invest in human resource development, and therefore lack of cooperation with the Head Contractors systems and processes can reduce the likeliness of a trustworthy relationship to develop.

The communication system utilised in an organisation defines the channels for interactions of that organisation. These interactions can be identified as either close or distant contacts and can determine the type of relationship experienced between parties. It can be argued that the more positive close interactions you have with a party the higher the level of comfort and trust you experience with that party (Wong et al., 2008). Zaghloul and Hartman, (2003) argued that a good communication system alleviates risks and increases reputation of all concerned parties. Although, the development of new communication systems and digital technologies such as BIM demands subcontractors to upgrade their capabilities and infrastructure to effectively contribute in supply chains without a guaranteed workload and therefore can be seen as a large risk for subcontractors (Laryea and Lubbock, 2014). Therefore poor communication and limited face to face interactions can develop trust issues between parties and with increased technology such as mobile phones, computers and programs can create a challenge for smaller subcontracting firms to upgrade their technology systems to stay competitive within the industry.

METHODOLOGY

A mixed-methods approach was adopted in this research to allow a comprehensive collection of data. Qualitative and quantitative components were combined to stipulate both emergent themes and numerical representation of participants' opinions and experiences. This approach was designed to overcome the limitations of a strictly qualitative or strictly quantitative study (Cresswell, 2007). Merging research methods can alleviate bias and allow prominent head contractor perspectives to emerge while providing a solid basis of numerical data for a better understanding of the topics (Gliner and Morgan, 2000). To allow valuable, broad-based information to be obtained from participants, an interview was developed that had elements combining deductive and inductive questioning (Patton, 2002).

The sampling frame for the head contractors were randomly obtained from the MBA (Master Builders Australia) Newcastle website. 25 companies in total were contacted via telephone with 6 individuals from separate organisations agreeing to participate in the interview.

The research protocol included the analysis of past literature to create interview questions that fell into three different trust types, followed by the conduction of the semi-structured interview with those questions.

A semi-structured interview was used to gather information. Respondents were asked to rank from 1-3 what they believed was the most relevant answer with 1 being the least relevant and 3 being the most relevant.

Data was analysed using a one-way between groups analysis of variance for the analysis of head contractors against characteristic based, process based and institutional based trust. The one-way ANOVA analysis was used as it determines whether head contractors obtain statistically different results in terms of what trust type they value most whether characteristic, process or institutional based trust.

Relevance scores from the interview were sectioned into each form of trust then were accumulated and averaged, and then compared. An alpha level of 0.05 was used for all statistical tests. Statistical analysis was conducted using IBM SPSS version 19 (IMB, Armonk, NY, USA).

RESULTS

Out of the 25 Head Contractors contacted for the semi-structured interview, only 6 were interested and returned their consent form by the cut-off date set for the receipt of responses. All 6 responses were found usable. This implied a low 24% effective response rate. This poor response implied that the views of the majority of the respondents were not represented and could limit the extent to which the findings could be generalized across the population of head contractors. However, the random sampling of respondents from the target sampling frames ensured that all respondents had equal opportunity of being sampled; this approach has the potential for eliminating or minimizing bias inherent in a limited number of samples (Leedy and Ormrod, 2004).

The respondents were predominantly male from New South Wales in Australia. The respondents were largely involved in small to medium sized companies and were involved in roles such as Project Management, Contract Administration and Health and Safety roles, therefore the findings should be interpreted in this context. Overall, the survey responses were from key individuals in their respective firms who had long experience of the construction industry majority over 10 years experience. The experience of the respondents meant that quality inputs were received, which could enhance the reliability and validity of the conclusions drawn from the findings.

A one-way between groups analysis of variance was conducted to explore the type of trust Head Contractors value the most in their relationship with Subcontractors, as measured by the Life Orientation Test (OT). The Subject's responses were collected into three groups of trust (Group 1: Characteristic, Group 2: Process, Group 3: Institutional). There was a statistically significant difference at the $p<0.05$ level in LOT scores for the three types of trust $F(2,15) = 9.632$, $p= 0.002$. Despite reaching statistical significance, the actual difference in mean scores between the groups was quite small. The effect size calculated using eta squared, was 0.31. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for Group 1 ($M= 12.33$, $SD= 2.11$) was significantly different from Group 2 ($M= 9.83$, $SD= 3.67$) and Group 3 ($M=14.33$, $SD=2.92$) was significantly different from both Group 1 and 2. This shows that institutional trust is significantly different from both characteristic and process based trust and hence is the most valued by Head Contractors as expressed in Figure 1 below.

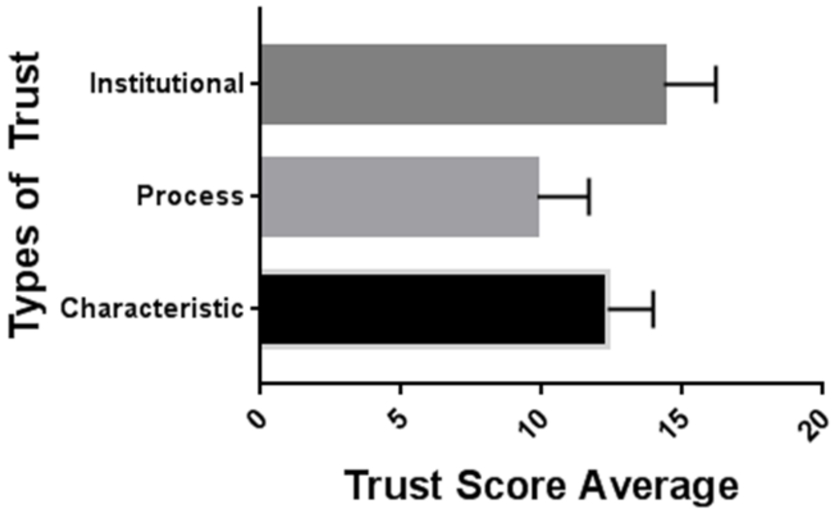

Figure 1: Head Contractors Trust Score Verse Types of trust

DISCUSSION

This paper attempts to address the imbalance of literature associated with the relationship between head contractors and subcontractors in the construction industry and focuses on the head contractors perception of the trust issues amongst their construction relationship. While previous studies had identified that head contractors do identify different trust issues prevalent in their relationship with subcontractors they were unable to identify if head contractors do have alternate perceptions on trust issues in their relationship as a whole and what type of trust they value most in their relationship. The interview was therefore conducted to confirm the type of trust they value the most.

Following the review of past literature, three forms of trust were identified these were characteristic, process and institutional based trust. These three forms of trust were tested in the interview process and it was found that head contractors perceive institutional based trust as the most important form of trust based on their relationship with subcontractors. Institutional based trust is based on the perception of others ability to perform the required work. As this study has found that head contractors have varying influential factors that guide their perception of trust, it would be intriguing to further examine and identify what exact factors influence their type of trust to allow a better understanding of how each group functions in the industry. Also as trust has been shown to positively affect project performance between subcontractors and head contractors, it is reasonable to further explore means by which both parties can improve the state of trust that they should be seeking to cultivate.

This study has provided a new perspective on how trust issues are developed and perceived between head contractors and subcontractors in the construction industry. Further, this study offers some intriguing implications for the type of trust that may be valued by subcontractors and head contractors. At a minimum, these findings should function as a starting point for future empirical analysis of the trust construct and its implications for project success. In addition it validates and makes additional research necessary on the means by which subcontractors and head contractors can enhance their partnering and relationship management, as these are both essential topics in the study and practice of project management.

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UNDERSTANDING GLOBAL STUDENT MOBILITY: EXPLORING NEW WAYS OF CAPTURING INTERNATIONAL EXPERIENCES USING IN-COUNTY OVERSEAS STUDENTS

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ABSTRACT

Australian universities have large numbers of overseas students who do not engage meaningfully with local students about their international experience. The objective of this research, an initiative that was part of a project funded by Australian Government Office for Learning and Teaching (OLT), entitled the Global Canopy, was to develop pedagogy to promote local students' awareness about international study based on an in-country teaching program. The research study aimed to develop new knowledge about how domestic students understand global mobility through interacting with international students enrolled in the same university. The initiative included two workshops that brought together a number of project team members, three overseas students and academic staff mentors, representatives from Deakin Global Student Mobility office, and 31 undergraduate domestic students. Data was collected from a series of in-depth interviews with students involved in the program. Initial findings suggested that the workshops were successful, with 12 undergraduate students enrolled in winter schools in India after completion of the program. The paper concludes with lessons learned from the initiative and calls for exploring new ways of identifying international experiences that can be facilitated within discipline curriculum of the home university.

Keywords: construction, global mobility, international education, and international students

INTRODUCTION

Australian universities have a richly global cohort of students, with almost half a million overseas students representing 193 countries (Australian Education International, 2014) and up to 16,000 outbound mobility Australian students undertaking international study experiences per annum. Nevertheless, these two "strands" of student activity rarely interact, resulting in reduced student engagement in structured learning and teaching activities. For the most part, the recruitment, placement, learning, and teaching activities of inbound overseas students are handled separately from similar activities of outbound domestic students, and many of the opportunities for their learning interactions, improved global connectedness, and cross-cultural understandings are left unrealized. The Global Canopy project was initiated to address this gap by investigating coherent approaches of integrated teaching and learning between these two cohorts at six different sector-representative universities. Deakin University was one of these universities.

- The Deakin Global Canopy initiative in the School of Architecture and Built Environment had two primary aims:
- Raising awareness of opportunities to study at Centre for Environment Planning & Technology (CEPT) University in India; and
- Using learning and teaching pedagogy to promote awareness about international study abroad generally in the School of Architecture and Construction.

The project was based upon a targeted approach to raise domestic students' awareness of summer and winter schools conducted at the prestigious CEPT University in India. Working in partnership with the Deakin Study Abroad personnel, the Head of School, and academic staff, the project identified a gap in current exchange programs and student mobility. Although Deakin University has a very active student mobility program through Deakin Global Study Mobility, very few, if any, architecture, planning and construction students have undertaken study at CEPT University. Data collected by the project team indicated students were unaware of the advantages of participating in the summer and winter schools offered at CEPT. As CEPT University focuses on understanding, designing, planning, constructing, and managing human habitats, it fits neatly within the goals of the School of Architecture and Built Environment at Deakin University. Its teaching programs build thoughtful professionals and its research programs deepen understanding of human settlements. CEPT University also undertakes teaching projects to further the goal of making habitats more liveable.

The teaching programs at CEPT University focus on building professional capacities and therefore they are centred on 'studios' or 'labs'. Students engage with well-designed life-like problems. Coursework, seminars, and research assignments, are aimed to develop conceptual and analytical abilities of students, and skill-enhancing workshops support learning in studios and labs. CEPT students are also required to enrol in travel and documentation programs, and to intern in professional offices to widen their exposure. The belief that educating professionals requires practicing professionals and academics to work closely together firmly underpins CEPT University's pedagogic philosophy. Therefore, CEPT University works as a collaborative of academics and practitioners. At CEPT University, students work with practitioners adept at decision-making, who bring their experience to the classrooms to impart a more thoughtful and critical approach. This made CEPT University a desirable global mobility target. The very large number of international undergraduate students who came from India to study in Australia at the School of Architecture of Deakin University further justified the focus on CEPT University.

LITERATURE REVIEW

Current and previous learning and teaching research studies have examined learning and teaching opportunities around inbound overseas students (Leask, 2009, Leask & Carroll, 2011) and outbound domestic students (Scharoun, 2015, Gothard et al., 2012), separately. However, very little research has examined learning interactions and cross-cultural understandings between these two cohorts of students and opportunities for improved global connectedness (Mestenhauser, 2011). Whilst current research provides evidence on the benefits of peer relationships and connections developed through learning activities (Arkoudis et al., 2010, Eames and Stewart, 2008, Huijser et al., 2008, Ryan and Hellmundt, 2005, Gothard et al., 2012), very little focuses upon creating structured learning activities to connect inbound overseas and outbound domestic students. As Arkoudis *et al.* (2010) note peer interactions need to be "planned and organised within teaching and learning that are linked to learning outcomes and assessment." However, in the existing support systems for domestic outbound students, little is included to take advantage of the potentials of international connections arising from the inbound overseas student cohort. Similarly, the importance of pre- and post-mobility learning opportunities for outbound domestic students is not recognised as part of the mainstream curriculum (Gothard et al., 2012).

RESEARCH METHOD

The aim of the project was to create an intervention to determine if students would increase their interest in internationalisation, without travelling overseas. As a result a five-step process was initiated to achieve the case study aims including:

1. Student Announcements
2. Mentor Workshop

3. Introductory Student Workshop
4. Final Review Student Workshops
5. Reflection and Documentation of Student Experience

The process centred upon two workshops to heighten awareness and build opportunities for learning exchanges across the disciplines of planning, construction, surveying, and architecture. The project team members drew upon Deakin international students, especially Indian students, and staff as mentors. Detailed student announcements were circulated via webpages, notices, emails, and other student media to encourage students to enrol into the workshops. Over time, students may receive credit for these workshops as elective studies, but initial workshops were uncredited in the program. Approximately 45 students enrolled into the workshops, with preference given to second year students to ensure that students had ample time during their program to undertake mobility programs.

Global Mobility Workshops

The two Global Mobility workshops took place in the School of Architecture and Built Environment at Deakin University, Geelong Waterfront campus over Trimester 2, 2015. Students enrolled in one of the courses/programs of construction management, surveying, architecture, planning, and double degrees in these discipline areas attended the two workshops. The majority of international students at Deakin are from India, yet there are no domestic student studies in India from the School of Architecture and Built Environment. As currently no students engage in global mobility programmes with India, the workshops were organised to increase awareness of international opportunities to study abroad, in particular with CEPT university in India. The second aim was to encourage interactions between domestic students and international students (Indian students in this case) as mentors. The main activities designed for the first Global Mobility workshop are summarised in Table 1. In addition to the OLT project partner investigators and representatives from the Deakin Global Student Mobility centre, a number of Indian students acted as student "Mentors." In the second workshop, students were engaged in a more detailed and focused study of the potential short courses that they might do in CEPT and the equivalent Deakin course credit (Table 2).

The first workshop consisted of presentations by Deakin Study Abroad and an academic staff member from India. Students were asked to work in groups with their mentors to discuss a range of questions about study and life in India. The mentor activities ran through the first Global Mobility workshop that highlighted the role of the mentors and the projected issues and needs of the workshop participants (Activity 2, Table 1). Group work, problem-solving, and opportunities for cultural understandings were designed into the discipline-based activities within the workshops.

Mentors used the opportunity to give feedback and advice about Indian culture, climate, money, food, lifestyle, and study. Further presentations about CEPT University were given and students were asked to consider the opportunities for study at CEPT against their own degree outcomes. Students were required to complete "homework" around graduate attributes of a Deakin degree and CEPT graduate outcomes and identify potential credit opportunities and gaps in learning outcomes. At the second workshop there were about 20 students present, including some who had not previously attended. Deakin Global Student Mobility gave students short presentations about potential costs, practical timeslots and documentation. Mentors and students again worked together to identify learning issues associated with being a student in India.

Table 1 List of activities of the first Global Mobility Workshop at Deakin University

	Activity	**International Mentors**	**Local Students**
1	Introduction by OLT researchers and Deakin teaching staff	Aims, Objectives, contacts, Introduction to CEPT	Aims, Objectives, contacts, Introduction to CEPT
2	Exploratory discussions	Reflect on University experiences in India. - What are the differences between the two countries? - What do prospective local students need to know?	Ice breaker session. Who are you-Me in a minute Pre-workshop Student Survey
3	Workshop comprising student activities that demonstrates a cultural observation and/or appreciation	Presentation Exploratory discussions between students and mentors	Presentation Exploratory discussions between students and mentors
	Student discussion of their understanding of the course and culture	All	All
4	Feedback on workshop	Post-workshop Mentor reflections	Post-workshop Student Survey

Data Collection

In the first workshop, students completed a pre-workshop survey. Similarly, the second workshop ended with students completing a post-workshop survey in order to examine how students' perceptions and attitudes towards study abroad have changed following the experience of the two workshops. The two surveys were designed to match students' responses to the pre-questionnaire with similar questions in a post questionnaire and determine if students' responses change before and after their involvement in global mobility workshops. Given this, the surveys started with four questions to produce a unique identification. Students were then asked to re-enter this information in the post survey to link with their previous responses. These identification questions were followed by a number of demographic questions i.e. the institution, the course/program enrolled, the year level, age and gender. Students were also asked whether or not they have ever travelled overseas before, both for any reason i.e. holiday and specifically for study. The next section of the two surveys included statements on attitudes and intentions towards studying overseas (Table 3) and students were required to rate their agreement or disagreement with them.

Table 2 List of activities of the second Global Mobility Workshop at Deakin University

	Activity	**International Mentors**	**Local Students**
1	Introduction by OLT researchers and Deakin teaching staff i.e. CEPT timelines & programs	Aims, Objectives, contacts, Introduction to CEPT	Aims, Objectives, contacts, Introduction to CEPT
2	Peer-to-peer discussions	Look through the CEPT winter school courses/workshops and comment	Discussion of the proposed CEPT workshops that students might want to do and identifying units in Deakin to get credit
3	Group discussions on workshop proposals, travel & visas in India	Exploratory discussions between students and mentors	Exploratory discussions between students and mentors
4	Reflection on the workshop i.e. group discussion & interviews	Post-workshop Mentor reflections/Interviews	Post-workshop Student Survey
5	Presentation by Deakin Global Mobility Centre	All	All

RESULTS

The purpose of the study was to gauge student's level of interest in having an overseas learning experience as part of an undergraduate course. The research project was not supposed to encourage travel as part of a vacation or holiday. As a result two mechanisms were used to gather information about their thinking, namely surveys and interviews.

Surveys

All the 17 students who attended the first workshop completed the pre-workshop survey. Of this number, 14 students attended the second workshop and completed the post-workshop survey. Survey respondents were enrolled in one of the three programs: (1) Bachelor of Architecture (Design); (2) Bachelor of Construction Management; and (3) Double degree/Architecture + Construction Management. Almost all the students were in their second year, except for one survey respondent who was enrolled in the 1st year of the program. Of the students participating in the workshops, only 12 felt they had previously been informed about specific study abroad opportunities in Asia applicable to their program.

Table 3 Pre- and post-workshop survey responses re students' attitudes and intensions to study overseas

Attitudes and Intentions to study overseas, Mean (1-7)	**Pre**	**Post**
1. A study abroad program in Asia will help me achieve my professional goals quicker	5.35	6.14
2. I would like to participate in a study abroad program in Asia	6.47	6.50
3. Study abroad programs in Asia are too expensive for me	4.29	3.36
4. I would not pay for a study abroad program in Asia even if I could	2.12	1.71
5. My family thinks that a study abroad program in Asia is valuable for my personal development	5.88	5.71
6. Even if I can afford to spend on study abroad programs in Asia, I will not do so	1.65	1.57
7. I do not think study abroad programs in Asia are worth it	1.35	1.57
8. I aspire to go on a study abroad program in Asia	6.29	6.43
9. I plan to go on a study abroad program in Asia	6.06	6.21
10. Skills obtained through study abroad in Asia would allow me to advance in my career at a greater pace	6.18	6.21
11. It is my intention to participate in a study abroad program in Asia	6.24	6.29
12. Studying abroad in Asia will give me a competitive advantage in the job market	6.12	6.36
13. My family thinks that a study abroad program in Asia is valuable for my professional development	5.71	5.86
14. My family encourages me to go on study abroad programs in Asia	5.65	5.43
15. I aim to go on a study abroad program in Asia	6.24	6.36
16. The university's study abroad office appears to care for my safety while abroad	5.41	6.21
17. I desire to go on a study abroad program in Asia	6.24	6.43
18. I am determined to go on a study abroad program in Asia	6.06	6.36
19. I wish to go on a study abroad program in Asia	6.29	6.43
20. The university's study abroad staff seems helpful in providing necessary information	5.53	6.21
21. I can afford to participate in a study abroad program in Asia	4.53	5.21
22. Participating in a study abroad program in Asia is within my financial means	4.41	5.14
23. The university's lecturers seem qualified at leading study abroad programs in Asia	5.59	6.21
24. The university's study abroad staff seems adept in dealing with problems	5.47	6.14
25. The university's study abroad office and staff has a good reputation	5.35	6.14
26. I mean to participate in a study abroad programs in Asia	6.06	6.21
27. Study abroad programs in Asia are attractive to me	6.29	6.43
28. The university seems to have the required expertise for study abroad programs in Asia	5.82	5.93
29. The university staff on the study abroad programs seem to have the knowledge to lead me on the program	5.65	5.93
30. I am eager to go on a study abroad program in Asia	6.47	6.36
31. I intend to participate in a study abroad program in Asia	6.12	6.14

The data on students' perceptions and attitudes towards study abroad in Asia, presented in Table 3, only show a very slight increase in students' intention to participate in a study abroad program in Asia (see Table 3, Statements 2, 8, 9, 11, 15, 18, 19, 26, 30 and 31). However, students' perceptions of cost associated with study abroad in Asia has changed to some degree, that is they are more likely to believe that they can afford to participate in a study abroad in Asia and it is within their financial means (see Table 3, Statements 3, 4, 21 and 22). One of the key changes is the perception of the value of study abroad in India or Asia. Students in the workshops seem more motivated to pay for the experience, recognising the value of such study. Students also have greater intention to pursue such study. The survey results indicate that students' perceptions of the university lecturer and study abroad staff have changed for the better, with students seeing these staff as helpful, caring for their safety while abroad, adept in dealing with problems, having a good reputation and qualified at leading study abroad programs in Asia (see Table 4: Statements 16, 20, 23, 24 and 25). Students are also more likely to think that "a study abroad program in Asia will help me achieve my professional goals quicker" following the attendance in two Global Mobility workshops. This supports much of the literature around the advantages of study abroad opportunities and reflects incentives to increase domestic students global mobility (Arkoudis et al., 2010; Leask, 2009).

Interviews

In addition to the surveys, seven interviews were also conducted with the students at the end of the second workshop. Students were asked the following questions: (1) What did you actually discuss with the mentor in the first workshop?; (2) What value do you think you gained from the discussion with the mentor?; and (3) Do you have any suggestion about how we could do better in similar workshops next time?.

Students and mentors discussion mainly revolved around two topics: (1) course structure and standards of education in India; and (2) safety matters and every day life in India e.g. cost of living, weather, cultural norms.

> *Obviously we were interested in the **course structure** and the **standard of education** … Australian education is quite **process-orientated** but their education is quite **result-orientated** … We mostly discussed the **social aspects of going to India**, like the food that will be there, what to wear and that sort of things.*

In terms of the impacts of workshops on students' perceptions and willingness to participate in study abroad in India, students generally appear to be more interested in going to India and study in CEPT winter/summer schools. Among the outcomes of the workshops for students were: (1) developing understanding and appreciation for other cultures; and (2) becoming aware of job opportunities and contacts.

> *… being able to just **learn about the different culture** and being able to travel in that country as well … a lot of companies are now coming over from South East Asia … there is going to be more **job opportunities** in this.*

In addition to these outcomes, students are now more familiar with the courses in CEPT and the ones that they can possibly get credit at Deakin University.

DISCUSSIONS AND CONCLUSIONS

The two Global Mobility workshops undertaken as part of the OLT Global Canopy project proved to be successful. One important measure of success was the 12 students (seven female and five male undergraduate students) who were confirmed for travel to India to undertake one of the four CEPT winter schools. This is significant increase in the number of students undertaking global mobility in India from the School. A further plan to embed the workshops into an existing second year course is in progress, with the aim to add International experiences into the curriculum. Initial discussion with a number of key staff at Deakin University has resulted in keen interest. The. School of Architecture and Built Environment was also asked to invest in a series of exchanges with CEPT in India. This will involve staff visits, staff exchanges, PhD supervisions and inbound mobility from students in India.

These results have also prompted the development of a new strategy of identifying international experiences that can be facilitated and undertaken within the home university. The aim is to create international experiences that do NOT require the student to travel overseas at their own expense. These experiences may revolve around international projects, or assignments that require the student to study some aspect of an international issue. The student will then be required to reflect on the issues associated with undertaking a piece of assessable work that is outside of their local environment. The international contexts of the work must be part of the assessment process, and included as the core component of the degree. Such international projects can be facilitated by a staff exchange from the overseas university and Indian inbound students acting as cultural ambassadors. This may involve a staff member from CEPT providing a case study of a project that would be undertaken in India. The CEPT staff member would be available to act as a mentor or tutor to a class of students who will be required to be mindful of the Indian context. A number of key findings arise from this project. The role of international students in learning interactions around global mobility is increased and the value of such students as mentors for domestic students is critical to success. Secondly the value of core subjects rather than electives within the curriculum undertaken as an international experience is also critical. And thirdly, the value of supportive pedagogy and teaching to facilitate global mobility is vital. If Australian domestic students are to participate in changing global workplaces, the value of this project and the results cannot be underestimated.

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IMPACT OF CONSTRUCTION COMPUTING SOFTWARE (CCS) 'CANDY' COURSE: CONSTRUCTION MANAGEMENT STUDENTS' PERCEPTIONS

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ABSTRACT

Students' post-course perceptions provide insight relative to their understanding and appreciation of a module, including the impact thereof within the context of the wider course content and its enhancement of a candidate's holistic knowledge. Hence the study reported on to determine construction management students' post course perceptions regarding a CCS 'Candy' course presented at a South African university. The students were surveyed via an e-mailed self-administered questionnaire at the completion of the course. The salient findings include: 'planning – programming' predominates in terms of the extent Candy training contributed to an increase in knowledge; planning, and estimating predominate in terms of an enhancement of skills; general management, and administration and information technology predominate in terms of contributing to an improvement in students' understanding and appreciation of the functions in an organisation; cost predominates in terms of an improvement in students' understanding and appreciation of the project parameters; the training contributed to the integration of subjects in their undergraduate programme, and to an improvement in students' understanding and appreciation of the construction process, built environment processes and construction activities. Conclusions include that the CCS Candy course had an impact in terms of: an enhancement of both knowledge and skills aligned with the planning function; a better understanding and appreciation of the practice of construction management, and students understand and appreciate the importance and role of the course in terms of greater knowledge development. It is recommended that the 'add-on' certificated CCS Candy course continue to be included and that the research be conducted annually.

Keywords: CCS Candy course, Construction Management, Perceptions, Planning, Students

INTRODUCTION

The Department of Construction Management at Nelson Mandela Metropolitan University (NMMU) is the only 'pure' Construction Management department in South Africa and therefore prides itself on providing the most relevant and learner centered education in the discipline. Specialist planning skills education was identified as an area that needed greater focus within the department and as a result it was decided to align the department with the most widely used planning and estimating package in the South African construction market, CCS Candy. The CCS Candy system is used to control a projects construction process and financial performance from tender stage to the final account stage. Candy has a planning application but is much more than a planning and estimating package due to its dynamic link between money and time providing a wealth of information for both management and clients. (CCS Candy, 2013). The subject matter of the course has become highly topical with greater emphasis being placed on the use of software for the planning and estimating of construction projects, with greater interest being shown from commercial entities in students having a practical certification of competency alongside their theoretical knowledge garnered in the course of the degree programme.

In addition, universities are increasingly focused on delivering a product fit for market and therefore realigning their programmes to best align with the needs of their students and industry. Added to this, the need to entice top students through enhanced programme offerings as a result of 'competition between higher education institutions' (Floyd et. al, 2009) has led institutions to focus on the type of learning students are exposed to with an emphasis on 'learner centered activities'. By engaging with the external training provider of the software supplier, the department has been able to structure the course content to better align students basic understanding of the built environment processes with a more holistic overview of the use of software to deliver projects, simultaneously providing a certificated additional module and a certification that provides those who complete the course a ready entry into the labour market.

However, it was of the utmost importance that the department understand whether this new intervention was indeed adding to the students' education and where in particular it was of assistance, so as to potentially look to improve other subjects in the undergraduate programme. This is particularly relevant due to the increasing demands 'for teaching excellence in higher education' (Nicholls, 2002) alongside increased scrutiny of the relevance of course content from accreditation bodies and industry that has led the department to foster a culture for continuous research in lecturing and learning in order to better understand student perceptions relative to the course, and the relevance of its content to their future as built environment professionals.

Literature review

In "today's challenging business environment the possession of subject skills alone is no longer sufficient for a new graduate in meeting employer requirements" (Wickramasinghe & Perera, 2010). In a saturated employment market where "40 percent of employers believe that there is a significant skills gap between graduates and requirements" (Finch et al., 2016), providing students with the right skills to fill those gaps becomes fundamental to the business of education as well as construction. Incorporating coursework that provides an opportunity to develop such competences as "learning ability, analytic competences, working independently and working in a team positively contribute to the development of competences in the later careers of graduates and are competences that employers demand." (Yorke 2007 cited in Stiwne & Jungert, 2010).

"Employers were dissatisfied with the relationship between the academic world and the workday world" (Stiwne & Jungert, 2010) highlighting the perceived "gap between skill requirements for entry-level graduate employment and skill levels of the entry-level graduate" (Wickramasinghe & Perera, 2010) When students enter university they need to 'constantly be assessing highly dynamic employer needs' and that 'their formal education is only one dimension' that needs to be 'developed both inside and outside the classroom'. (Finch et al., 2016). However, as 'University students view their academic career' as a 'four-year product development cycle in isolation from the customer' it has therefore become the "mission of higher education in a 'knowledge society'" to create programmes that provide the "generic and transferable competences, as well as key competences within a specific field of knowledge." (Stiwne & Jungert, 2010) "Employability of an individual depends upon assets in terms of knowledge, skills and attitudes" (Wickramasinghe & Perera, 2010) which institutes of higher education need to focus on in order to produce quality graduates employers want to include in their graduate programmes.

"The concept of 'employability', as seen from the point of view of presumptive employers, suggests that an employable person holds knowledge, skills and characteristics that will make that person useful and valuable in a specific context." (Stiwne & Jungert, 2010) Interaction between university departments and industry bodies through meetings, liaison bodies and research leads to greater awareness of the needs of industry both at a local, national and international level and provides focus for the constant review process undertaken within departments in order for them to retain their status. As a result "the possession of employability skills by graduates is essentially manifested in priorities given and steps taken by graduates and university lecturers during the undergraduate degree programme." (Wickramasinghe & Perera, 2010) As "universities are spending much time and effort to provide their students with the best educational experience possible" and as the 'students usually have more than one choice of higher education institution' (Floyd et al., 2009) creating a positive learning environment that improves student perceptions of the value of a course in terms of employability has become a focus of higher learning institutions.

Student perceptions of a course's merit can be influenced by many factors, with studies conducted across multiple disciplines showing that "engagement, perceived course value, and the use of deep learning strategies" are all 'integral to a student's positive learning experience' (Floyd et al., 2009). With positive learning experiences likely to lead to positive reinforcement of a course within the student body, relating the perception through deeper learning to the course content becomes a fundamental means to influencing that perception. "The quality of contents of majors and of curriculum design were significantly related to the presence of generic and reflective competences according to the perception of graduates." (Stiwne & Jungert, 2010) The implementation of 3rd party learning environments is thus a manifestation of these needs but also provides challenges to existing rigour within the academic environment. As a result getting to know "How the learning experience is perceived by the learner is probably the best source of intelligence on how education can be improved" (Edstrom, 2012).

As the approach of students to learning depends on their interest in the task and their previous experience of the area to which it relates (Ramsden, 1997), enabling students to understand relevance, and provide sufficient motivation to them can be challenging. This is exacerbated by the students generally not having experienced an environment where they can relate theory to practice, which has led to an increased need to engage with students in order to create curricula that can "support student learning and personal development through providing a meaningful and motivational context" (Edstrom, 2012). "Motivation is an important factor in student learning" (Liu et al., 2012) and "self-motivation of students is a prime requirement for their active engagement" (Kamardeen, 2013), which means that the course content needs to stimulate interaction within the study sessions and also into other courses within each discipline's course structure. "When graduates are equipped with necessary skills they will become motivated and efficient in fulfilling their job tasks" (Wickramasinghe & Perera, 2010), so appreciation of the courses' ability to enhance their skills and determining its impact within the context of the wider course content, including its enhancement of a candidate's holistic knowledge, is essential.

As has also been demonstrated, "the students' perception of course value, in the form of personal relevance and meaningfulness of tasks, is a very important concept in enhancing and evaluating a student's learning experience" (Floyd et al., 2009) and therefore "research looking at students' own descriptions of their experiences of the learning context has crucial implications for the teaching and learning in higher education"

(Ramsden, 1997). Given that the presenting department is endeavouring to improve the general perception of the CM course as a forward thinking, dynamic and reflective course for the workplace environment to be encountered by the students upon completion of their degree, giving them an opportunity to report on the intervention provides powerful proof of its willingness to engage openly thereby fostering stronger relationships ahead of Honours registration. "Higher educational institutions need to identify demanding different working patterns that graduates might engage in and ensure that they possess employability skills that employers prefer them to possess." (Wickramasinghe & Perera, 2010) Furthermore, the engagement of the department with the students through research surveys, influences the direction of the course through identifying areas of study that need enhanced attention.

Additional research has shown that "students' approaches to study and their motives are determined by a number of aspects of the higher education system, including their perception of the department" (Newstead & Hoskins, 2005), which can be greatly influenced by engagement with the student body and eliciting their input to improving the delivery of the subject matter. Furthermore, "the departmental context also plays a part, it would appear, in influencing students' attitudes towards studying – whether they feel that academic work is worthwhile" (Ramsden, 1997). Getting the students to view the Department of Construction Management, who present the course, in a positive light, is an important aspect in influencing the students' perceptions of the value of the course to their overall education.

Research method

The two-day certificate CCS Candy course is an additional intervention included in the BSc (Construction Studies) programme relative to the subject Construction Management 3. In order to assess the impact of the CCS Candy course, students were surveyed immediately upon completion thereof to determine the extent to which the CCS Candy training contributed to an: increase in knowledge; enhancement of skills; improvement in understanding and appreciation of the functions in an organisation, the functions and activities of management work, the various project parameters, and built environment processes, and the construction process and activities, and the integration of subjects. The questionnaire consisted of 7 closed-end questions and 97 sub-questions, and 1 open-end question. The closed-end questions entailed a response to a five-point Likert scale preceded by an 'unsure' and 'did not' contribute option. Therefore, respondents effectively responded to a six-point Likert scale. Based upon the number of responses to the six points, a measure of central tendency in the form of a mean score (MS) was computed to enable a relative comparison and rankings. Given that there were effectively six points on the scale the MS ranges between 0.00 and

5.00, the midpoint of the range being 2.50. 28 Students' responses were included in the analysis of the data.

Research findings

Table 1 indicates the extent to which the Candy training contributed to an increase in knowledge relative to thirty knowledge areas in terms of percentage responses to a scale of 1 (minor) to 5 (major), and mean scores (MSs) between 0.00 and 5.00. It is notable that 29 / 30 MSs are > 2.50, which indicates that the contribution of the Candy training to an increase in knowledge is major as opposed to minor. Given that effectively a six-point scale ('did not' linked to a five-point) was used, and that the difference between 0 and 5 is five, ranges with an extent of 0.83 (5 / 6) are used to discuss the degree of central tendency. 4 / 30 (13.3%) MSs > 4.17 ≤ 5.00, which indicates that the Candy training made between a near major to major / major contribution to an increase in knowledge. The knowledge areas include 'planning – programming', 'estimating', 'planning – strategic', and 'project management'. With the exception of 'planning – strategic', the aforementioned findings are not unexpected. 13 / 30 (43.3%) MSs > 3.33 ≤ 4.17, which indicates that the Candy training made between a contribution to a near major / near major contribution to an increase in knowledge. 'Productivity', is followed by 'cost control', 'information technology', 'measuring (quantities)', 'cost engineering', 'financial management', 'procedures', 'cash flow forecasting', 'materials management', 'specifications', 'management (business)', 'methods (construction) – building', and 'plant and equipment management'. 12 / 30 (40%) MSs > 2.50 ≤ 3.33, which indicates that the Candy training made between a near minor contribution to a contribution / contribution to an increase in knowledge. 1 / 30 (3.3%) MSs > 1.67 ≤ 2.50, which indicates that the Candy training made between a minor to a near minor / near minor contribution to an increase in knowledge.

Table 1: Extent to which the Candy training contributed to an increase in knowledge relative to thirty knowledge areas

Knowledge area	Response (%)							MS	R
	U	Did not	Minor ……………………Major						
			1	2	3	4	5		
Planning - programming	3.6	0.0	0.0	0.0	3.6	14.3	78.6	4.78	1
Estimating	0.0	0.0	0.0	0.0	14.8	29.6	55.6	4.41	2
Planning - strategic	0.0	3.6	0.0	3.6	3.6	25.0	64.3	4.39	3
Project management	0.0	3.6	3.6	0.0	7.1	32.1	53.6	4.21	4
Productivity	0.0	0.0	0.0	0.0	14.8	63.0	22.2	4.07	5
Cost control	0.0	0.0	0.0	14.8	7.4	37.0	40.7	4.04	6
Information technology	0.0	7.1	0.0	7.1	3.6	39.3	42.9	3.96	7
Measuring (quantities)	0.0	0.0	3.6	10.7	17.9	39.3	28.6	3.79	8
Cost engineering	0.0	7.1	0.0	7.1	25.0	32.1	28.6	3.61	9
Financial management	0.0	7.1	0.0	10.7	17.9	35.7	28.6	3.61	10
Procedures	0.0	7.1	3.6	7.1	10.7	46.4	25.0	3.61	11
Cash flow forecasting	0.0	3.6	7.1	10.7	14.3	32.1	32.1	3.61	12
Materials management	0.0	0.0	7.1	7.1	25.0	42.9	17.9	3.57	13
Specifications	0.0	3.7	7.4	14.8	14.8	25.9	33.3	3.52	14
Management (business)	0.0	10.7	0.0	7.1	14.3	50.0	17.9	3.46	15
Methods (construction) - building	0.0	3.6	7.1	10.7	25.0	32.1	21.4	3.39	16
Plant and equipment management	0.0	7.1	0.0	14.3	21.4	42.9	14.3	3.36	17
Contract documentation	0.0	7.4	7.4	7.4	22.2	33.3	22.2	3.33	18
Final accounts	0.0	10.7	0.0	17.9	14.3	35.7	21.4	3.29	19
Materials	0.0	3.6	7.1	21.4	21.4	28.6	17.9	3.18	20
Work study	0.0	10.7	3.6	14.3	32.1	25.0	14.3	3.00	21
Purchasing	3.6	10.7	10.7	10.7	17.9	28.6	17.9	3.00	22
Subcontractor management	3.7	3.7	14.8	11.1	33.3	18.5	14.8	2.96	23
Benchmarking	0.0	17.9	0.0	25.0	10.7	28.6	17.9	2.86	24
Human resources	3.6	7.1	7.1	25.0	21.4	25.0	10.7	2.85	25
Remuneration	3.6	17.9	3.6	10.7	17.9	35.7	10.7	2.85	26
Design	0.0	10.7	7.1	21.4	17.9	35.7	7.1	2.82	27
Training	0.0	17.9	10.7	10.7	21.4	21.4	17.9	2.71	28
Methods (construction) - civil	0.0	14.3	7.1	17.9	25.0	32.1	3.6	2.64	29
Risk management	3.6	14.3	7.1	28.6	25.0	14.3	7.1	2.41	30

Table 2 indicates the extent to which the Candy training contributed to enhancement of twenty-seven skills in terms of percentage responses to a scale of 1 (minor) to 5 (major), and MSs between 0.00 and 5.00. It is notable that 21 / 27 (77.8%) MSs are > 2.50, which indicates that the contribution of the Candy training was major as opposed to minor. 2 / 27 (7.4%) MSs > 4.17 ≤ 5.00, which indicates that the Candy training made between a near major to major / major contribution. The two skills are 'planning' and 'estimating', which are not unexpected as CCS Candy is planning focused and estimating oriented. 13 / 30 (43.3%) MSs > 3.33 ≤ 4.17, which indicates that the Candy training made between a contribution to a near major / near major contribution. 'Computer' skills is followed by 'costing', 'measuring – quantities', 'controlling', 'organising', 'measuring – productivity', 'procedures development', 'coordinating', 'financial', and 'systems development'. 12 / 30 (40%) MSs > 2.50 ≤ 3.33, which indicates that the Candy training made between a near minor contribution to a contribution / contribution. 1 / 30 (3.3%) MSs > 1.67 ≤ 2.50, which indicates that the Candy training made between a minor to a near minor / near minor contribution.

Table 2: Extent to which the Candy training enhanced twenty-seven skills

Skill	Response (%)							MS	R
	U	Did not	Minor ....Major						
			1	2	3	4	5		
Planning	0.0	3.6	0.0	0.0	7.1	32.1	57.1	4.36	1
Estimating	0.0	3.6	0.0	3.6	7.1	28.6	57.1	4.29	2
Computer	0.0	7.1	0.0	0.0	10.7	35.7	46.4	4.07	3
Costing	0.0	3.6	3.6	3.6	25.0	32.1	32.1	3.75	4
Measuring - quantities	0.0	7.1	3.6	3.6	21.4	21.4	42.9	3.75	5
Controlling	0.0	7.1	0.0	10.7	14.3	32.1	35.7	3.71	6
Organising	0.0	7.1	0.0	0.0	28.6	39.3	25.0	3.68	7
Measuring - productivity	0.0	7.1	3.6	10.7	10.7	32.1	35.7	3.64	8
Procedures development	0.0	10.7	0.0	3.6	17.9	39.3	28.6	3.61	9
Coordinating	0.0	10.7	0.0	3.6	17.9	42.9	25.0	3.57	10
Financial	0.0	7.1	0.0	10.7	28.6	25.0	28.6	3.50	11
Systems development	7.1	7.1	0.0	7.1	10.7	39.3	28.6	3.46	12
Technical	0.0	7.1	0.0	10.7	39.3	25.0	17.9	3.29	13
Decision making	0.0	10.7	3.6	7.1	25.0	32.1	21.4	3.29	14
Communicating - graphic	0.0	10.7	3.6	14.3	21.4	17.9	32.1	3.29	15
Communicating - written	0.0	7.1	10.7	17.9	14.3	17.9	32.1	3.21	16
Supervisory	0.0	10.7	3.6	14.3	25.0	28.6	17.9	3.11	17
Administrative	0.0	14.3	10.7	0.0	32.1	35.7	7.1	2.86	18
Training	0.0	10.7	10.7	17.9	25.0	25.0	10.7	2.75	19
Auditing	3.6	14.3	10.7	10.7	25.0	28.6	7.1	2.57	20
Initiating	7.1	17.9	3.6	14.3	21.4	21.4	14.3	2.54	21
Work study	0.0	21.4	7.1	0.0	50.0	14.3	7.1	2.50	22
Negotiating - subcontractors	0.0	25.0	7.1	10.7	21.4	21.4	14.3	2.50	23
Motivating	0.0	14.3	17.9	28.6	14.3	10.7	14.3	2.32	24
Statistical	7.1	25.0	7.1	14.3	10.7	25.0	10.7	2.21	25
Negotiating - plant hire	0.0	32.1	7.1	14.3	28.6	14.3	3.6	1.96	26
Plan reading	3.6	28.6	28.6	17.9	7.1	10.7	3.6	1.46	27

Table 3 indicates the extent to which the Candy training contributed to an improvement in understanding and appreciation of the functions in an organisation in terms of percentage responses to a scale of 1 (minor) to 5 (major), and MSs between 0.00 and 5.00. Only 6 / 9 functions in an organisation were presented as the Candy training could only have made such a contribution relative to these 9 functions. It is notable that all six MSs are > 2.50, which indicates that the contribution of the Candy training to an improvement was major as opposed to minor. 2 / 6 (33.3%) MSs > 4.17 ≤ 5.00, which indicates that the Candy training made between a near major to major / major contribution – 'general management (planning etc.)' and 'administration and information technology'. Given that Candy is planning focused software, the aforementioned findings are not unexpected. 3 / 6 (50%) MSs > 3.33 ≤ 4.17, which indicates that the Candy training made between a contribution to a near major / near major contribution – 'financial', 'production (site)', and 'procurement'. The aforementioned is notable as Candy should assist substantially with respect to the management of the three functions, particularly at operational management level, and to a fair degree at middle management level. Although the MS of 'human resources' is > 2.50 ≤ 3.33, which indicates that the Candy training made between a near minor contribution to a contribution / contribution, Candy should assist relative thereto, certainly relative to workers, first line supervision, and supervision, but also higher levels of operational management.

Table 3: Extent to which the Candy training contributed to an improvement in understanding and appreciation of the functions in an organisation

Function	**Response (%)**							**MS**	**R**
	U	**Did not**	**Minor ....Major**						
			1	**2**	**3**	**4**	**5**		
General management (planning etc.)	0.0	0.0	3.7	3.7	0.0	25.9	66.7	4.48	1
Administration and information technology	0.0	3.6	0.0	0.0	10.7	32.1	53.6	4.29	2
Financial	0.0	3.6	0.0	7.1	21.4	21.4	46.4	3.96	3
Production (site)	0.0	3.6	3.6	7.1	10.7	46.4	28.6	3.79	4
Procurement	3.6	10.7	3.6	3.6	17.9	32.1	28.6	3.36	5
Human resources	0.0	7.1	7.1	32.1	32.1	7.1	14.3	2.68	6

Table 4 indicates the extent to which the Candy training contributed to an improvement in understanding and appreciation of the functions and activities of management work. It is notable that 15 / 20 (75%) activities of the planning, organising, leading, and controlling functions of management work and the coordinating function have MSs > 2.50, which indicates that the Candy training contributed to more of a major than a minor improvement. In terms of the functions, based upon the mean MSs, planning (3.93) achieved the first ranking followed by controlling (3.35), coordinating (3.25), and then jointly by organising and leading (2.54). The aforementioned are expected. It is notable that programming (4.71) is ranked first with the function (WF) of planning, and overall (OA), followed by scheduling (4.57), forecasting (4.27), developing objectives (3.82), and developing procedures (3.68). Furthermore, given that the first two MSs are > 4.17 ≤ 5.00, the increase in understanding and appreciation of the functions and activities of management work can be deemed to be between near major to major / major.

Table 4: Extent to which the Candy training contributed to an improvement in understanding and appreciation of the functions and activities of management work

Function / Activity	Response (%)							MS	R WF	R OA
	U	Did not	Minor ……………………Major							
			1	2	3	4	5			
Planning:										
Programming	0.0	0.0	0.0	0.0	3.6	21.4	75.0	4.71	1	1
Scheduling	0.0	0.0	0.0	0.0	3.6	35.7	60.7	4.57	2	2
Forecasting	0.0	7.1	0.0	7.1	7.1	28.6	50.0	4.00	3	3
Developing objectives	0.0	7.1	0.0	3.6	21.4	28.6	39.3	3.82	4	4
Developing procedures	0.0	3.6	3.6	7.1	28.6	21.4	35.7	3.68	5	5
Budgeting	3.6	3.6	3.6	10.7	14.3	32.1	32.1	3.57	6	8
Developing organisation structure	0.0	11.1	7.4	11.1	22.2	18.5	29.6	3.19	7	12
Mean								3.93		
Organising:										
Developing organisation structure	0.0	10.7	14.3	14.3	25.0	17.9	17.9	2.79	1	15
Delegating	7.1	7.1	21.4	7.1	32.1	10.7	14.3	2.46	2	16
Establishing relationships	7.4	7.4	25.9	7.4	25.9	11.1	14.8	2.37	3	17
Mean								2.54		
Leading:										
Decision-making	3.6	0.0	7.1	3.6	25.0	32.1	28.6	3.61	1	6
Communicating	7.1	7.1	10.7	10.7	25.0	10.7	28.6	2.93	2	14
Selecting people	3.6	21.4	21.4	14.3	10.7	14.3	14.3	2.11	3	19
Developing people	3.6	17.9	21.4	17.9	14.3	14.3	10.7	2.11	4	18
Motivating	3.6	21.4	17.9	21.4	21.4	3.6	10.7	1.93	5	20
Mean								2.54		
Controlling:										
Performance measuring	3.6	3.6	3.6	10.7	10.7	35.7	32.1	3.61	1	7
Developing performance standards	0.0	3.6	7.1	7.1	35.7	21.4	25.0	3.39	2	9
Evaluating performance	3.6	7.1	3.6	10.7	21.4	25.0	28.6	3.32	3	10
Correcting performance	3.6	7.1	3.6	17.9	25.0	21.4	21.4	3.07	4	13
Mean								3.35		
Coordinating	0.0	15.0	5.0	10.0	15.0	20.0	35.0	3.25	1	11

Table 5 indicates the extent to which the Candy training contributed to an improvement in understanding and appreciation of nine project parameters. It is notable that 7 / 9 (77.8%) parameters have MSs > 2.50, which indicates that the extent of the contribution is major than minor. However, only 1 / 9 (11.1%) parameters have MSs > 4.17 ≤ 5.00, namely cost, which indicates that the extent of the contribution is between near major to major / major. Thereafter, 2 / 9 (22.2%) MSs > 3.33 ≤ 4.17, namely time and productivity, which indicates that the extent of the contribution is between a contribution to a near major / near major contribution.

Table 5: Extent to which the Candy training contributed to an improvement in understanding and appreciation of the various project parameters

Parameter	Response (%)							MS	R
	U	Did not	Minor ....Major						
			1	2	3	4	5		
Cost	0.0	0.0	0.0	7.1	14.3	32.1	46.4	4.18	1
Time	0.0	7.1	0.0	0.0	14.3	32.1	46.4	4.04	2
Productivity	0.0	7.1	3.6	7.1	21.4	32.1	28.6	3.54	3
Developmental objectives	7.1	7.1	7.1	3.6	14.3	46.4	14.3	3.14	4
Client satisfaction	3.6	17.9	3.6	10.7	21.4	17.9	25.0	2.86	5
Quality	0.0	14.3	10.7	10.7	25.0	21.4	17.9	2.82	6
Customer satisfaction	3.6	14.3	7.1	10.7	21.4	25.0	17.9	2.82	7
Environment	7.1	17.9	25.0	10.7	10.7	28.6	0.0	1.93	8
Health and Safety	7.1	21.4	25.0	17.9	10.7	10.7	7.1	1.71	9

Table 6 indicates the extent to which the Candy training contributed to the integration of subjects in the undergraduate year concerned, and in the undergraduate programme. It is notable that both MSs are MSs > 3.33 ≤ 4.17, which indicates that the Candy training made between a contribution to a near major / near major contribution.

Table 6: Extent to which the Candy training contributed to the integration of subjects in the undergraduate year and the programme

Programme	Response (%)							MS	R
	U	Did not	Minor ....Major						
			1	2	3	4	5		
Undergraduate **year**	4.0	0.0	0.0	0.0	20.0	36.0	40.0	4.04	1
Undergraduate **programme**	4.2	0.0	0.0	0.0	16.7	45.8	33.3	4.00	2

Table 7 indicates the extent to which the Candy training contributed to an improvement in understanding and appreciation of built environment processes, and the construction process and activities. It is notable that the MS relative to construction activities is > 4.17 ≤ 5.00, which indicates that the extent to which the Candy training contributed to an improvement is between a near major to major / major extent. However, relative to built environment processes and the construction process the extent to which Candy training contributed to an improvement is between some extent to a near major / near major extent. The aforementioned findings are as expected as Candy focuses on activities and the relationships between them. However, the construction activities collectively constitute the construction process.

Table 7: Extent to which the Candy training contributed to an improvement in understanding and appreciation of built environment processes, and the construction process and activities

Aspect	Response (%)							MS	Rank
	U	Did not	Minor ....Major						
			1	2	3	4	5		
Construction activities	0.0	7.1	0.0	0.0	0.0	42.9	50.0	4.21	1
Built Environment processes	0.0	7.1	0.0	3.6	7.1	32.1	50.0	4.07	2
Construction process	0.0	7.1	0.0	0.0	14.3	32.1	46.4	4.04	3

Students were afforded the option of providing comments in general regarding the Candy training. Comments include the following:

- "It makes planning easy";
- "It is valuable to students and should be incorporated in built environment programmes."
- "It's a great instrument that should be standardised in the construction industry."
- "The course is very in-depth and can be confusing when one is used to MS Project."

CONCLUSIONS AND RECOMMENDATIONS

Based upon the findings it can be concluded that the two-day certificate CCS Candy course had an impact in terms of enhancement of both knowledge and skills, and an understanding and appreciation of the practice of construction management in general, and more specifically the functions and activities of management work and the project parameters, in addition to the planning function and time as a parameter. Furthermore, the students understand and appreciate the importance and role of the CCS Candy course. It is recommended that the two-day certificate CCS Candy course continue to be included as an 'add-on' course, and that the research reported on be conducted on an annual basis. Limitations include that this is the first such study reported on and that the study should be evolved into a longitudinal study.

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IMPACT OF THE INTEGRATIVE PORTFOLIO PROJECT: CONSTRUCTION MANAGEMENT STUDENTS' PERCEPTIONS

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ABSTRACT

Students' perceptions of a portfolio project intended to integrate knowledge and skills acquired across a range of modules and study years provide insight relative to their understanding and appreciation of such modules and challenges that they encountered. Furthermore, post-project perceptions can be used to determine the impact of the project, and where adjustments need to be made.

The purpose of the study reported on is to determine the post-portfolio project perceptions of construction management students based upon a self-administered questionnaire survey conducted in a South African university. The students were surveyed at the completion of the project at third year level.

The salient findings include the portfolio project contributed to an increase in knowledge and an enhancement of skills primarily relative to the focus areas of the integrative project. However, it also realised an increase in knowledge and an enhancement of skills relative to non-focus areas of the portfolio project, and contributed to an improvement in understanding and appreciation of the functions in an organisation, the functions and activities of management work, the various project parameters, the built environment processes, and the construction process and activities, and the integration of subjects in the undergraduate programme.

Based upon the findings it can be concluded that the portfolio project had an impact in terms of enhancement of both construction management knowledge and skills and an understanding and appreciation of the practice of construction management in general. Furthermore, students understand and appreciate the importance and role of the portfolio project. It is recommended that the research reported on be conducted on an annual basis.

Keywords: Construction Management, Integration, Perceptions, Project, Students

INTRODUCTION

Love, Haynes, and Irani (2001) argue that the unique nature of the construction industry coupled with the challenges of global competitiveness and changing regulatory environments have created the need for highly educated and competent construction management graduates. They also refer to the distinction between education and training and cite Hammer & Champy (1993) who state that education increases insight and understanding, the 'why', whereas training increases skills and competence, the 'how'. They further cite Haltenhoff (1986) who asserted that educated people are less productive when first employed.

The findings of a survey conducted among built environment academics and postgraduate students underscore the importance of initiatives directed towards the integration of tertiary education courses and subjects in order to address challenges emanating from the fragmentation of delivery methods adopted by tertiary institutions (Manthe and Smallwood, 2007). Though, the findings addressed the built environment disciplines in general, it has implications for the discipline of construction management, since construction management graduates are expected to have a greater understanding and knowledge of technological development, as well as practical construction methods and techniques used on-site (Love et al., 2001). Furthermore, educationalists in the discipline of construction management have been continually subjected to criticism with respect to the ability of offered undergraduate programme's content and approaches to meet the demands of practice (McGeorge, 1993 cited by Smallwood, 2000). The documented lapses and inadequacies provide a platform for the promotion of integrative projects in tertiary education programmes. The adoption and subsequent promotion of integrative projects is in tandem with the overall objective of capstone projects, which is to engender critical thinking and an interdisciplinary approach to problem-solving among senior students in undergraduate tertiary education programmes (Stefani, 2009).

Given the abovementioned, the research reported on investigates the impact of an integrative portfolio project at third year level included in the subject Construction Management 3 of the BSc (Construction Studies) programme.

REVIEW OF THE LITERATURE

Developments with respect to Construction Management and related education

Stefani (2009) states that documented reports indicate that not only Governmental policies have been promoting more explicit relationships between higher education and the labour market, but also other sources of pressure have been brought to bear on universities to redefine the 'transferable disciplinary specific and learning skills' in addition to 'absorbing disciplinary based knowledge'. In other words, change is being canvassed in the content and approach used for programme delivery in higher educational institutions. The content and mode of delivery of construction project management (CPM) programmes and other associate disciplines in South Africa has constantly been under scrutiny. Specifically, Rwelamila (2007) maintains that there are strong indications to suggest that South African higher learning institutions are not aware of what is required to produce a future CPM with appropriate knowledge, that is, most CPM programme courses are dominated by the technical knowledge base with little coverage of the social cultural knowledge base. In this context, the technical knowledge base refers to modules such as scope, work breakdown schedules (WBS), schedules, resource allocation, baseline budgets, and status reports, while the social cultural knowledge base refers to modules such as leadership, problem solving, teamwork, negotiation, politics, and customer expectations. Miller, Haupt, and Chileshe (2005: 187) suggest that content driven subjects offered at first year civil engineering programmes such as construction methods and management, need urgent attention. Relying on the findings of a survey that targeted first year civil engineering students, Miller *et al.* (2005) advocate for the extension of the integrated teaching approach relative to these subjects so that students can make improvement thereon.

According to Love *et al*. (2001: 591), it is no longer sufficient for construction management courses to focus solely on specific details relevant to the principles and practice of the profession because there is a need for other applications, which prepare students for a variety of roles in the industry. They say construction management courses need to be broader in their curriculum in order for them to exceed the expectations of employers, and particularly, undergraduate courses should strive to provide graduates with skills required by the industry, and courses should focus on providing graduates with:

- a degree of specialist knowledge which reflects the latest research and its application in the workplace;
- an understanding of 'how' information and communication technologies can be used to improve business practices;
- an ability to communicate in writing and orally with different professions within the industry, and
- problem-solving skills applicable to solving complex problems where the answer cannot easily be found in a text book and where solutions may be ambiguous.

Education Frameworks

'Construction Management' is the third of seven sections of 'The Education Framework for Undergraduate Degrees' of the Chartered Institute of Building (CIOB) (CIOB, 2012), and includes the following themes: process management; human resource management; planning and scheduling projects, and performance management. The second section 'Construction Environment' includes five themes, *inter alia*, legal environment, and economic principles and financial management. The fifth section 'Health, Safety and Welfare' includes four sections, namely legislation and practice, personal responsibility, management, and enhancement.

Construction Management Competencies

According to Crafford (2007), the top ten of thirty-two Construction Management competencies in terms of current importance are: skills to work with emerging contractors; planning and organising skills; construction contract practice; time management; quality management / control; cost control; project management; coordinating, and leadership and general management skills. In terms of the practice of construction management, a study conducted by Smallwood (2006) determined the top ten knowledge areas in terms of the mean frequency of use across all three levels of management to be: construction methods (building); cost control; quality management; contract administration; subcontractor management; contract documentation; planning (programming); customer service; project management, and productivity. Furthermore, the top ten skills were: communicating (oral); communicating (written); decision making; organising; administrative; leadership; coordinating; planning; interpersonal, and controlling.

RESEARCH

Research method and sample stratum

The subject Construction Management 3, included in the BSc (Construction Studies) programme, includes a portfolio project which is an integral part of the two-semester subject. The integrative project was included in the programme in order to promote the integration of subject knowledge and skills. The project entailed the generation of fifteen elements / outputs over the two semesters relative to a student accommodation project. The elements / outputs are presented in the findings section below, the objective of the portfolio project being to promote the integration of knowledge relative to the subjects presented in the undergraduate years.

In order to assess the impact of the portfolio project, Honours graduates were surveyed to determine the extent to which the integrative project contributed to an: increase in knowledge; enhancement of skills;

improvement in understanding and appreciation of the functions in an organisation, the functions and activities of management work, the various project parameters, and built environment processes, and the construction process and activities, and the integration of subjects. The questionnaire consisted of 7 closed-end questions and 157 sub-questions, and 1 open-end question. The closed-end questions entailed a response to a five-point likert scale preceded by an 'unsure' and 'did not' contribute option. Therefore, respondents effectively responded to a six-point likert scale. Based upon the number of responses to the six points, a measure of central tendency in the form of a mean score (MS) was computed to enable a relative comparison and rankings. Given that there were effectively six points on the scale the MS ranges between 0.00 and 5.00, the midpoint of the range being 2.50. It should be noted that there was not a single response to any 'did not' option and therefore the tables do not reflect the 'did not' responses. Seventeen graduates' responses were included in the analysis of the data.

Research findings

Respondents were required to indicate the extent to which the portfolio project contributed to an increase in knowledge relative to seventy knowledge areas. 51 / 70 (72.9%) knowledge areas achieved MSs > 2.50, which indicates that the integrative portfolio project contributed more of a major than a minor increase in knowledge relative to these knowledge areas. The extent to which the portfolio project contributed to an increase in knowledge is indicated within parentheses after the respective elements / outputs of the portfolio project. The MSs and the consequent ranking indicate the extent of the increase and the relative increase respectively.

- Project program (Planning – programming: 3.94 - 1st);
- Site layout (Work study: 2.71 - 44th);
- Project organogram (Project management: 3.94 - 2nd);
- Construction Management theory and principles that are critical for the completion of the project (Management (business): 3.88 – 3rd);
- The roles of the stakeholders involved in the project (Subcontractor management: 3.47 - 12th);
- Identify challenges facing the project (Research: 3.20 – 22nd; Risk management: 3.00 – 31st);
- Identify required production constants on the critical path (Measuring (quantities): 3.65 – 9th; Methods (construction) – building: 3.35 – 18th);
- Identify different options towards material purchasing and identify the preferred method (Materials management: 3.41 – 16th);
- Review the JBCC form of contract and identify five crucial clauses with respect to the contract (Contract documentation: 3.06 – 29th; Law – commercial: 2.68 – 48th);

- Compile a drawing register off all the drawings issued (Project management: 3.94 - 2nd);
- Evolve methodologies and anticipated systems with respect to managing labour, materials, and plant (Industrial psychology: 2.69 – 45th; Materials management: 3.41 – 16th; Materials: 3.06 – 30th; Plant and equipment management: 3.59 - 11th);
- Prepare builders quantities for all the concrete work (Measuring (quantities): 3.65 – 9th; Methods (construction) – building: 3.35 – 18th);
- Prepare a method statement for the concrete work (Productivity: 3.82 - 6th; Work study: 2.71 - 44th);
- Project health and safety plan (Health and safety: 3.65 – 7th), and
- Prepare an HIV and AIDS programme (Health and safety: 3.65 – 7th).

Respondents were also required to indicate the extent to which the integrative project contributed to an enhancement in skills relative to fourty-two skills. 35 / 42 (83.3%) skills have MSs > 2.50, which indicates that the integrative project contributed to more of a major than a minor enhancement in skill relative to these skills. The extent to which the portfolio project contributed to an enhancement in skills is indicated within parentheses after the respective elements / outputs of the project. The MSs and the consequent ranking indicate the extent of the increase and the relative increase respectively.

- Project program (Planning – 4.13 - 1st);
- Site layout (Work study: 3.63 - 12th);
- Project organogram (Organising: 3.88 – 4th; Team building: 3.80 – 6th);
- Construction Management theory and principles that are critical for the completion of the project (Planning – 4.13 - 1st; Organising: 3.88 – 4th Leadership: 3.17 – 8th; Controlling: 3.69 – 9th; Coordinating: 3.63 – 13th);
- The roles of the stakeholders involved in the project (Organising: 3.88 – 4th; Leadership: 3.17 – 8th;
- Identify challenges facing the project (Planning – 4.13 - 1st; Research: 3.64 – 11th);
- Identify required production constants on the critical path (Measuring - quantities: 3.38 – 17th);
- Identify different options towards material purchasing and identify the preferred method (Systems development: 2.62 - 34th);
- Review the JBCC form of contract and identify five crucial clauses with respect to the contract (Planning – 4.13 - 1st);
- Compile a drawing register of all the drawings issued (Administrative: 3.13 – 23rd; Systems development: 2.62 - 34th);
- Evolve methodologies and anticipated systems with respect to managing labour, materials, and plant (Planning – 4.13 - 1st; Work study: 3.63 - 12th; Procedures development: 2.88 – 27th);

- Prepare builders quantities for all the concrete work (Measuring - quantities: 3.38 – 17th);
- Prepare a method statement for the concrete work (Planning – 4.13 - 1st; Work study: 3.63 - 12th; Procedures development: 2.88 – 27th);
- Project health and safety plan (Planning – 4.13 - 1st), and
- Prepare an HIV and AIDS programme (Planning – 4.13 - 1st).

The portfolio project contributed to an improvement in understanding and appreciation of the nine functions in an organisation to a major as opposed to a minor extent, as all the functions have MSs > 2.50. Although no functions had MSs > 4.17 ≤ 5.00, six functions had MSs > 3.34 ≤ 4.17, which indicates that the portfolio project contributed between some extent to a near major / near major extent: general management (MS = 3.88); production (MS = 3.71); procurement (MS = 3.53); human resources (MS = 3.47); administration and information technology (MS = 3.41), and financial (MS = 3.41). It is notable that general management and production functions are ranked first and second as the focus of the portfolio project is thereon. The MSs of marketing (MS = 3.13); public relations (MS = 3.06), and legal (MS = 2.63) are > 2.50 ≤ 3.34, which indicates the contribution is between near minor to some extent / some extent.

Table 1 indicates the extent to which the portfolio project contributed to an increase in understanding and appreciation of the functions and activities of management work. It is notable that all nineteen activities of the planning, organising, leading, and controlling functions of management work and the coordinating function have MSs > 2.50, which indicates that the portfolio project contributed to a major as opposed to a minor extent.

In terms of functions, based upon mean MSs, organising (3.61) is ranked first, followed by leading (3.52), planning (3.49), coordinating (3.47), and controlling (2.92).

In terms of activities, programming (4.12) is ranked first, followed by communicating (4.12), scheduling (3.76), establishing relationships (3.75), and developing objectives (3.65). Given that the MSs are > 3.34 ≤ 4.17, the portfolio project contributed between some to a near major / near major extent to an increase in understanding and appreciation.

Table 2 indicates the extent to which the integrative portfolio project contributed to an improvement in understanding and appreciation of eleven project parameters. It is notable that all eleven parameters have MSs > 2.50, which indicates that the portfolio project contributed to more of a major than a minor improvement in understanding and appreciation of the parameters. Although no MSs > 4.17 ≤ 5.00, 9 / 11 parameters have MSs > 3.34 ≤ 4.17, which indicates the portfolio project contributed between some extent to a near major / near major extent to an increase in understanding and appreciation.

Table 1: Extent to which the portfolio project contributed to an increase in understanding and appreciation of the functions and activities of management work

Function / Activity	U	Minor ……………………Major					MS	Rank (WF)	Rank (OA)
		1	2	3	4	5			
Planning:									
Programming	0.0	0.0	0.0	29.4	29.4	41.2	4.12	1	1
Scheduling	0.0	0.0	5.9	41.2	23.5	29.4	3.76	2	3
Developing objectives	5.9	0.0	5.9	23.5	41.2	23.5	3.65	3	5
Forecasting	0.0	6.3	12.5	31.3	37.5	12.5	3.38	4	12
Budgeting	0.0	6.3	18.8	25.0	37.5	12.5	3.31	5	13
Developing procedures	6.7	0.0	6.7	46.7	33.3	6.7	3.20	6	14
Developing policies	14.3	0.0	7.1	42.9	21.4	14.3	3.00	7	18
Mean							3.49		
Organising:									
Establishing relationships	0.0	6.3	0.0	37.5	25.0	31.3	3.75	1	4
Delegating	0.0	6.3	12.5	18.8	37.5	25.0	3.63	2	6
Developing organization structure	0.0	6.3	6.3	43.8	25.0	18.8	3.44	3	10
Mean							3.61		
Leading:									
Communicating	0.0	0.0	5.9	11.8	47.1	35.3	4.12	1	2
Motivating	0.0	5.9	23.5	5.9	41.2	23.5	3.53	2	7
Decision-making	0.0	11.8	5.9	29.4	29.4	23.5	3.47	3	9
Selecting people	0.0	11.8	11.8	23.5	29.4	23.5	3.41	4	11
Developing people	0.0	11.8	17.6	29.4	35.3	5.9	3.06	5	16
Mean							3.52		
Controlling:									
Evaluating performance	0.0	12.5	12.5	25.0	50.0	0.0	3.13	1	15
Performance measuring	0.0	12.5	25.0	18.8	37.5	6.3	3.00	2	17
Correcting performance	0.0	12.5	12.5	56.3	12.5	6.3	2.88	3	19
Developing performance standards	5.9	5.9	29.4	35.3	23.5	0.0	2.65	4	20
Mean							2.92		
Coordinating	11.8	0.0	5.9	17.6	41.2	23.5	3.47		8

Table 2: Extent to which the portfolio project contributed to an improvement in understanding and appreciation of eleven project parameters

Parameter	**U**	**Minor ……………………Major**					**MS**	**Rank**
		1	**2**	**3**	**4**	**5**		
Cost	0.0	5.9	0.0	11.8	52.9	29.4	4.00	1
Productivity	0.0	6.3	0.0	25.0	31.3	37.5	3.94	2
Time	0.0	0.0	5.9	17.6	58.8	17.6	3.88	3
Client satisfaction	0.0	0.0	6.3	25.0	43.8	25.0	3.88	4
Project health and safety	0.0	0.0	18.8	25.0	12.5	43.8	3.81	5
Customer satisfaction	5.9	0.0	5.9	11.8	52.9	23.5	3.76	6
Quality	0.0	5.9	11.8	23.5	23.5	35.3	3.71	7
Public health and safety	0.0	0.0	25.0	18.8	18.8	37.5	3.69	8
Environment	0.0	6.3	6.3	37.5	43.8	6.3	3.38	9
Developmental objectives	12.5	0.0	6.3	43.8	12.5	25.0	3.19	10
Worker satisfaction	0.0	29.4	0.0	41.2	23.5	5.9	2.76	11

In terms of the extent to which the portfolio project contributed to the integration of subjects in the undergraduate programme, the 3.12 MS indicates that it contributed between a near minor to some extent / some extent to the integration.

The portfolio project contributed to an improvement in understanding and appreciation of built environment processes (MS = 3.65), and the construction process (MS = 3.76) and its activities (MS = 3.76) between some extent to a near major / near major extent as the MSs > 3.34 ≤ 4.17.

CONCLUSIONS

The portfolio project contributed to an increase in knowledge and an enhancement of skills primarily relative to the focus areas of the integrative project. However, the integrative project also realised an increase in knowledge and an enhancement of skills relative to non-focus areas of the integrative project.

The portfolio project contributed to an improvement in understanding and appreciation of the functions in an organisation, the functions and activities of management work, the various project parameters, the built environment processes, and the construction process and activities, and the integration of subjects in the undergraduate programme. Furthermore, students understand and appreciate the importance and role of the portfolio project. Therefore, the portfolio project achieved its objective, namely to promote the integration of knowledge relative to the subjects presented in the undergraduate years.

RECOMMENDATIONS

The conclusions indicate that all undergraduate construction management programmes should include an 'integrative' project. Furthermore, given the benefits thereof, 'integrative projects' should be implemented earlier in the construction management programme at say second-year level.

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BUILDING RESILIENCE: DEVELOPING A RESILIENCE TOOLKIT FOR EMPLOYABILITY IN BUILT ENVIRONMENT GRADUATES

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ABSTRACT

Upon graduation from University many students lose access to support structures such as peers, academic mentoring, etc. This may lead to tension, stress and failure to perform effectively in new workplaces, especially if the workplace itself is stressful. This is particularly the case for graduates who move into work within construction, as this industry provides a uniquely stressful environment where the development of resilience is imperative for success. The ability to cope and draw on resilience skills provides answers for built environment graduates. The development of resilience skills is not included as learning outcomes within courses, units of study or programs of learning within the built environment discipline. This dilemma, from a student's perspective, draws us to the rationale of the proposed research and its aim to show the development of a resilience toolkit for built environment students. There is considerable evidence that incorporating resilience skills into undergraduate curricula in built environment disciplines will have positive outcomes. Outcomes from an initial review of 3 participating University undergraduate programs, devised to determine resilience training for undergraduates is presented. A compilation and collection of noteworthy examples where resilience learning and teaching exists in undergraduate curricula will also be identified.

Keywords: Resilience, Employability, Built Environment, T&L, Stress

INTRODUCTION

Research by the team has identified that the broader concept of resilience, including the ability to cope in a potentially stressful work environment is not the focus of learning in University environments. Graduates leave universities in built environment (BE) disciplines with little or no training in resilience skills and commence work in a stressful, complex industry (Haynes & Love, 2004). This project describes a resilience toolkit for BE students that will underpin their discipline studies whilst providing them with tools for coping in a stressful industry upon graduation. This study is unique in that it tackles the under-researched area of resilience in undergraduate education in this discipline. The need is significant as Sutherland & Davidson (1993) note:

> *"Graduates often experience extreme stress and high role conflict as a consequence of the trade-off between cost, time and quality performance in construction projects... we need to better prepare our young graduates for this industry or we lose them forever." (p.281)*

CONSTRUCTION RESILIENCE

Construction and built environment companies operate in a highly competitive market with relatively low profit levels. Projects run with tight deadlines and have budget constraints. The industry is the epitome of a project-based environment where graduates work on projects that are planned, designed and built by a complex contractual web of individuals and companies. This complex web of project interfaces often results in project fragmentation, disjointed work, unexpected delays, changes, conflicts, adaptations and disruption. With the threat of significant penalties for time and cost overruns, one-off type projects, poor onsite and safety conditions and the stress of managing in a project environment, young graduates are often un-prepared for the mental strength required of them in such environments. Resilience is a term with roots in ecological systems theory (Holling, 2001) that has evolved to be defined slightly differently by various disciplines. In the context of this project, resilience can be defined as "good outcomes in spite of serious threats to adaptation or development" (P.391). Within this study, the term resilience will apply to behavioral, attributional or emotional responses to shocks and challenges graduates will inevitably face upon entering the construction industry.

Dainty (2004) notes the enormous pressure on construction graduates by providing insights into the psychological expectations of construction managers which further highlights the importance of resilience in stressful, unplanned situations. In comparison to managers of other disciplines, the level of stress encountered by construction project managers is significantly higher than that of managers in other industries (Haynes & Love, 2004). Construction workers are more than twice as likely to suicide as any other group of people in Australia, and are six times more likely to die by suicide than through a workplace accident. With nearly one million construction workers in Australia, mental stability on construction sites is now a serious industry concern. (MBAV, 2014, Mates in Construction, 2009)

It is widely recognised that mental health is 'fundamental to physical health, quality of life and productivity' (Beltman & MacCallum, 2006) and particularly important in young adults, as it underpins health and wellbeing throughout later life. Consistent with international trends, developing resilience has been a recent focus in policy and practice in a number of disciplines in tertiary education in Australia. However, whilst a number of other industries have recognised the importance of resilience training and its inclusion in undergraduate curricula, the built environment discipline, including construction management, has failed to address resilience or emotional work-readiness at the undergraduate level in Australia. The most recent research examining the stress of built environment work (Lingard & Francis, 2006) and the need to address resilience at an industry level (MBA, 2014) has failed to translate into meaningful national curricula or useful resources for academics teaching into these disciplines. Despite calls by employer groups to address its significance and prevalence amongst built environment professionals (Sommerville & Langford, 1994; Haynes & Love, 2004), resilience has not been addressed systematically in undergraduate curricula in this discipline.

PROPOSED OUTCOMES AND DELIVERABLES

This project will value-add to construction management curricula preparing students for built environment industries by examining existing construction management curricula for any best practice examples of resilience learning and teaching. The project will complete an audit of resilience learning and teaching in undergraduate programmes and incorporate these best practice examples into a "resilience toolkit" which can be accessed by all academics in this discipline. The Toolkit, by being made available to students will provide practical guidance and reference. Disseminating the toolkit at the national conference of all built environment disciplines at the Australian Universities Building Educators (AUBEA) conference and engaging academics in resilience discussions will lay the foundations for further applications to be added to the toolkit into the future, as well as extension of the project beyond the built environment discipline.

Construction and built environment activity is a critical engine of innovation and growth for a nation's economy. Retention of work-ready, high quality graduates, able to cope with challenges and industry stress, are a critical underpinning for Australia's future. Whilst the emphasis remains on preparing graduates with high-level technical skills only, the loss to the industry of skilled graduates and the cost to the Australian economy are considerable. Developing and reviewing the role of resilience in built environment programmes and providing a toolkit for discipline academics to utilise has the potential to improve work-readiness, career outcomes and long-term employability for all built environment graduates and to add to industry productivity.

This project is a partnership between three tertiary providers of built environment education in Australia: RMIT; Deakin; and the University of Newcastle and has a number of distinct features enabling project delivery:

- An audit of a representative sample of built environment programmes in Australia to identify extent and quality of resilience training.
- An online toolkit/ resource site of case studies & practical resilience problem solving exercises for use by all built environment academics in Australia.
- Improved understandings of built environment academics on the value of resilience training.
- Project dissemination through academic journals, final report and presentations at AUBEA 2016/17 conference.

VALUE/ NEED FOR THE PROJECT

The Importance of work-ready, resilient graduates in built environment disciplines - Preparing work-ready graduates for current and future industry workplaces requires resilience skill training for undergraduate students. Reducing the unacceptably high levels of poor mental health that contributes to a suicide rate, which is the highest of any industry in Australia (MBAV, 2014). Sutherland and Davidson (1993) suggest that built environment students have to cope with severe tension in their life balance and many leave the industry altogether. According to Sommerville and Langford (1994), this is largely due to the nature and characteristics of the built environment industry within which they operate. There is also evidence that suggests male construction professionals, in particular, experience extreme occupational stress, related to the type of work undertaken onsite (Lingard & Francis, 2006). Dainty (2004) also notes the enormous pressure on built environment graduates by providing insights into the psychological expectations of construction managers. His research highlights several key issues contributing to industry personnel stress, such as recognition of contribution to the organisation, training, job security, career development, consultation and communication with employees, support with problems, and handling unexpected issues in the workplace. It is likely that all of these have an impact and create pressure on graduates entering the industry for the first time from university. This project will address these needs by direct communication (documentation and dissemination of the value of embedding resilience skills in the curriculum) with Professional Associations (AIB, AIQS), Employer groups (MBA, HIA) and higher education associations (AUBEA). This will be followed with the production and distribution of a resilience toolkit as a resource for professions/ industry and tertiary staff in built environment disciplines.

The strategic value and significance of the Australian construction/built environment industry and its workforce

The built environment and construction industry is vital to the Australian economy and a major contributor to economic growth. According to the Australian Bureau of Statistics the industry accounted for 9.5 % of GDP in 2013 and 9.1% of the total workforce (ABS, 2014). It is the fourth largest industry in Australia by both economic value and employment. The need for this project has been identified by employer groups and graduates (MBAV, 2014, Mates in Construction, 2009) and because of the size and value of the industry, the need for a resilient professional workforce is critical.

The importance of current, industry input into built environment curricula

there is considerable evidence that incorporating resilience skills into undergraduate curricula in built environment disciplines will have positive outcomes. Hiltrop (1996), in examining mechanisms that secure a positive relationship in built environment professionals, concluded that there are a number of useful activities that could enhance the student experience and promote resilience in graduates. These included the promotion of construction as a team oriented project-based endeavour with team responsibilities; activities that identify lines of communication that support empowerment and illustrations of the positive and negative aspects of the role to undergraduates. This project will include consultation with employer groups through the industry roundtable around the type of resilience training required for construction graduates.

The recognition of personal development and professional satisfaction in graduate outcomes

resilience can be described as a class of phenomena characterized by good outcomes in spite of serious threats to adaptation and development (Beltman et al., 2006). The importance of resilience as a graduate outcome is steadily increasing in built environment disciplines due to the nature of the work and its changing practices. Since resilience is conceptualised in terms of 'rebounding back after adversity', or overcoming adversity to 'achieve good developmental outcomes' its development in built environment curricula can be seen as contributing to strong capacity in individuals, in particular graduates undertaking management roles in industries such as the built environment. This project will advance this concept through its dissemination processes and toolkit resources.

The value of resource sharing and collaboration in curriculum development

this project value-adds to existing initiatives aimed at building resilience into undergraduate programmes by producing an audit of programmes. It will draw out any existing best practice resilience learning in current built environment curriculum and supplement it with other industry examples. The resulting "resilience toolkit "will be introduced to all 15 providers of built environment education at the annual AUBEA conference in 2015, thus enabling resource sharing and collaboration.

PROJECT APPROACH

This project will be undertaken in four distinct stages over a 12-month period. The project team consists of senior members of the built environment academic cohort, who, through their roles in AUBEA and programme accreditation, are familiar with academic staff at all 15 institutions teaching this discipline. This will facilitate each of the project stages, as well as add credibility to the project.

STAGE 1. RESILIENCE AUDIT AND MAPPING

This stage will consist of a review of the tertiary courses in built environment disciplines at all (or most of) 15 universities offering the programme. Courses will be audited for evidence of resilience skill training. Interviews will be held with academic staff and students to assess their understanding of resilience and its position in the undergraduate curriculum of this discipline. An industry roundtable will be held to determine industry requirements in resilience training for undergraduates.

As the project is in an early part of stage one a preliminary review of the project team members Universities is offered.

CONSTRUCTION MANAGEMENT AT UNIVERSITY OF NEWCASTLE

The Bachelor of Construction Management (Building) at the University of Newcastle (UoN) provides a holistic view of the building and construction management environment. Through a variety of teaching approaches that simulate the real-life situations facing construction professionals, students develop the skills needed to monitor and control the technical process of construction. They also learn how to manage the legal and financial aspects associated with the building industry.

Table 1 identifies several courses within the CM University of Newcastle program and a Learning Outcome Identifier that suggests the inclusion of resilience training. It is suggested further in depth review has the potential to show where resilience training would most likely eventuate. Column 3 represents an early iteration of the audit, in depth analysis and interview of the various academic and industry stakeholders identified will follow ethics approval to populate a comprehensive analysis document.

CONSTRUCTION MANAGEMENT AT RMIT

Auditing resilience as a theme in Built environment undergraduate education at RMIT is complex, and like all graduate outcomes, not easily or neatly measured. Evidence of resilience skill training is not specific in any one course or series of courses, yet students have the opportunity in a range of courses around management, leadership, communication and professional practice/capstone to discuss and develop resilience. The actual development of resilience is not measured and is seen as a maturation process as students move through the degree. What is clear is that much of the resilience development is implicit rather than explicit in any built environment degree. No specific course deals with the stress and management resilience required in the industry, although management skills are addressed. However, the focus is upon graduate entry-level skills development primarily in construction and project management. To date no emphasis is placed upon resilience.

CONSTRUCTION MANAGEMENT AT DEAKIN

At Deakin University the core skills for work (getting on with colleagues, making critical decisions, solving problems) are refined further and are based on the Core Skills for Work (CSfW) Developmental Framework (DIIRSTE & DEEWR, 2013) which is useful for understanding resilience in these three broad areas:

- navigating the world of work including managing career and work life, and understanding work rights, roles and protocols.
- interacting with others including communicating for work, connecting and working with others, and recognising and utilising diverse perspectives.
- getting the work done including planning and organising, making decisions, identifying and solving problems, creating and innovating, and working in a digital world.

Graduate attributes are often referred to as 'soft skills' and provide the foundation career building blocks for students. The development of a student's graduate attributes is often centred on skills related to "getting the work done". Although some student activities focus on "interacting with others" this is often delivered in the context of learning rather than work. The Deakin Bachelor of Construction Management builds on Graduate Learning Outcome (GLO) 6. Self-management: working and learning independently, and taking responsibility for personal actions, is the one that we use to encompass resilience.

Table 1

	COURSE	LEARNING OUTCOME IDENTIFIER	RESILIENCE AUDIT AND MAPPING COMMENTS
3	Introduction to the Construction Industry	2. Articulate the structure, behaviour and stakeholders of the construction industry from a number of perspectives.	Identifying to students the nature and complexity of construction management in the early stages of a course is positive.
6	Cost Planning and Estimating	3. Price conforming tenders with available information.	The process of providing conforming tenders would identify to students some of the pressures in the sector.
7	Construction Procurement and Tendering	3. Analyse and select an appropriate procurement method and standard form of contract to meet stakeholder requirements	An understanding of the continuum and alternatives of project delivery would help students understand the benefits of relationships in the industry
9	Construction Business Management	1. Review the management function in the context of a firm operating in the construction industry.	Providing students with a broad understanding of SMEs operating in the sector shows the complexity of interactions.
11	Contract Administration	3. Implement and advise on administrative procedures necessary for the successful running of a construction contract.	Showing students potential interactions in project delivery and the network of engagement in the supply chain would deepen their understanding of resilience
12	Construction Entrepreneurship	3. Simulate the management of a construction companies	The ‘real-world’ of simulation embeds positive attributes in managing tensions

Stage 1 sets out the review and preliminary desktop research stage, following the researchers describe 3 following stages that include; identification of resilience best practice resources, development of the resilience toolkit and dissemination of the final toolkit that will complete the project.

NEXT STEPS: STAGES 2-4

Stage 2. Identification of Resilience Best Practice Resources

This stage will involve the compilation and collection of best practice examples of resilience skill training in the undergraduate curricula. The examples will be developed into broad problem-solving cases for ready use by other academics with other examples added to the initial resources arising from this project's development.

Stage 3. Development of Resilience Toolkit

In this stage a "resilience toolkit" will be developed. Selected examples from universities, supplemented with non-construction case studies will be complied into a toolkit for trialling.

Stage 4. Dissemination and trialling of toolkit at other universities

In this stage, the toolkit will be trialled and evaluated at the 3 project team members' universities. Appropriately revised toolkits will be disseminated to all universities providing built environment education through the AUBEA conference. It is anticipated that the toolkit will also be available online for access by all discipline academics.

CONCLUSION

In the foregoing the researchers have presented an introduction to, and identified the need for resilience training in construction and built environment related courses. It is suggested that there is little activity in this area and the proposed project will fill a gap in the current body of knowledge associated with resilience and coping skills training in built environment programmes. A preliminary survey has been undertaken at three universities where construction management is taught, it has been identified that whilst there is an awareness of the need for resilience training within construction management courses there is little in the way of explicit and structured content currently included in present curricula. The project presented proposes to redress this through the balance of the year.

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CAN THE UNITED KINGDOM CONSTRUCTION INDUSTRY (UKCI) IMPLEMENT INNOVATIVE SUSTAINABLE PROCUREMENT STRATEGIES?

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ABSTRACT

The aim of this study was to examine the implementation of innovative sustainable procurement techniques within the United Kingdom Construction Industry (UKCI) to allow the authors to make recommendations for improvement, promoting the adoption of good practice. The research identified not only a range of benefits from the implementation of sustainable procurement strategies but also barriers to the success of such initiatives. The research extended a previous scoping study and employed a cross-sectional study utilising semi-structured interviews to test the initial findings. The findings from this further research suggests that companies should embrace innovative sustainable procurement strategies in their entirety, embedding strategies fully within the organisation to achieve maximum benefits and cost savings. The cost of implementation should be communicated widely to quell the myth that implementation is expensive. The supply chain should work collaboratively to increase the knowledge of less experienced organisations, leading to increased participation from those more resistant to change. The UK Government should continue to encourage the supply chain to act innovatively and sustainably by improving the awareness of such topics. The research also suggested that where a local supply chain is employed, smaller organisations should be fully supported to access to the correct goods and services, allowing the freedom to employ innovative sustainable procurement policies, therefore meeting the requirements of contractors and clients. Although the UKCI would benefit from a more integrated supply chain, the authors question where support may come from to achieve this.

Keywords: innovative, sustainable procurement, supply chain, United Kingdom Construction Industry

INTRODUCTION

Sustainable procurement is defined by the UK Government in The National Sustainable Procurement Action Plan 'Procuring the Future' as "a process whereby organisations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only to the organisation, but also to society and the economy whilst minimising damage to the environment."(DEFRA, 2005). It is widely considered that sustainable procurement is becoming more significant in a construction industry that is beginning to recover from an economic downturn. CIOB (2010) identify that "Sustainability is now incorporated in construction projects of all size, type and value", the Government is using its purchasing power to encourage implementation within the UKCI supply chain (RIBA 2012).

LITERATURE REVIEW

Sustainable procurement is defined by the British Standards Institute (BSI, 2010) as "purchasing goods & items or services whose production, use and disposal minimize negative impacts & encourage positive outcomes for the environment, economy & society." Welsh Housing Quarterly (2012) describe how sustainable procurement delivers the main objective of sustainable development through the innovative consideration of social issues, community benefits and Targeted Recruitment & Training (TR&T).

The Department for Environment, Food and Rural Affairs (DEFRA, 2013b) support the notion that "Sustainable procurement helps ensure value for money and lower operational costs whilst protecting the environment and bringing us wider societal benefits".

The International Standard for sustainable procurement ISO/PC 277 and the British Standard BS8903 are considered the globally recognised standards (Action Sustainability, 2012). They offer guidance for "organisations to consider and implement sustainable practices within their procurement process." (BSI, 2010)

"The UK Government, as a major construction client, has an important role in driving the sustainability agenda" (OGC, 2004). The UK is currently "the only EU member state which has a broad strategic process for the usage of procurement to foster innovation. There is no doubt that the case of innovative procurement is unconventional and difficult, but it is gradually coming to the foreground" (Edler et al., 2005).

Following the 2012 London Olympics, DEFRA issued a guidance document for those involved with procurement in construction projects. Lord de Mauley (DEFRA, 2013a) boasts how "London 2012 showed how sustainable procurement could be done practically and efficiently ...lessons learned should be captured and taken on board by others".

The Government and those engaged in public sector contracts are in a strong position to encourage the UKCI supply chain to act sustainably and adopt innovative approaches. Government spending is "approximately 16% of the UK's GDP (DEFRA, 2013b)". Small businesses should be engaged in supply chains for major projects, the use of intelligent public procurement can capture their innovation while realising wider benefits for local communities. (Local Government Sustainable Procurement Task Group, 2007)

Beyond legislative requirements, sustainable procurement offers many benefits for an organisation. These are summarised under 5 key business categories within BS8903 and include: Financial drivers, Risk, Organisational policy, Stakeholder expectations and awareness and Marketing.

For sustainable procurement initiatives to be effective within the UKCI, policies should be implemented by the whole supply chain to allow a fully collaborative and integrated approach. Morgan (2013) identified that subcontractors and SMEs have experienced downward pressure from contractors to implement sustainable strategies, often within a "contested, fragmented supply chain" (Cox & Ireland, 2002). Berry and McCarthy (2011) recognise the diverse supply chain that exists within the UKCI and warn that businesses should explore the reasoning behind implementing strategies which may pose a commercial risk.

Barriers to implementation experienced by companies have been highlighted by Constructing Excellence (2008).

Table 1: Barriers to implementation

Barrier	Cited By respondents
Cost	93%
Lack of knowledge	53%
Availability of products	33%
Inertia/reluctance to change/tradition/fear of the unknown	33%
Conflict between legislation/planning and environmental protection	33%
Poor regulation/accreditation of products	33%

Edler, J., et al. (2005) identify that one of the most important barriers to innovative procurement is cost. The best value of procurement is realised through calculating life-cycle cost or even through the contribution of innovation to overall economic growth.

Having said this, table 1 identifies that cost remains a major barrier for the implementation of sustainable procurement. This is debated within the industry; CIPS (2011) reinforce the view of Edler et al that cost doesn't have to be a barrier and go further in suggesting it actually reduces the cost of construction.

Morgan (2013) found that subcontractors in the supply chain were forced to absorb the costs of implementation which often resulted in a negative attitude towards sustainability. However, although the perceived cost of implementing sustainable procurement was high, the actual cost incurred was minimal.

Constructing Excellence (2008) surveyed a number of contractors who commented that due to the cost, "sustainability would only be considered if it was a specific requirement from clients or planners and unless cost savings can be achieved, products will not be adopted".

There has been an increase in media attention surrounding sustainable procurement since the introduction of BS8903 and the construction of large scale public contracts including the 2012 London Olympics. As a result, an increasing number of clients and contractors are striving for sustainable projects with green credentials and have implemented sustainable procurement strategies in order to improve their corporate image.

Despite this commitment, lack of knowledge is still considered as a barrier to implementation. Constructing Excellence (2008) found that "Whilst there is a strong desire to make progress, many organisations don't have the tools or knowledge to move forward." This is attributed to "reluctance to change, strong traditions and fear of the unknown… smaller enterprises need stronger guidance and extra assistance in adopting sustainable procurement practices."

The responsible sourcing of both labour and materials by the supply chain is seen as a burden by both contractors (Constructing Excellence, 2008) and subcontractors (McGoldrick, 2013). Previous procurement policies have caused risk averse behaviour, leading to those being less likely to engage in innovative projects (Rolfstam 2012).

A draft Global framework standard - BES 6001, has been issued by the BRE (2013) for the Responsible Sourcing of Construction Products to provide clarity on the subject.

The responsible sourcing of labour through TR&T schemes can be an additional burden for many. "TR&T represents an additional cost, not only in recruitment but training and development. Although a local, more educated workforce is beneficial, costs can be high and cash flow is restricted". (McGoldrick, 2013)

RIBA (2012) support the theory of TR&T, however they do not give regard to the logistics of procuring labour or the costs associated with training. Urquhart (2013) raises concerns that as construction output increases, a consequential shortage of local materials and labour will follow, resulting in increased costs.

"Firms are fussier about what materials their buildings use … Private-sector house builders and organisations like the NHS now say they need to use more locally-sourced supplies to reduce their carbon footprint" (Anon, 2013).

Shifting suppliers to one who is able to provide responsibly sourced materials may represent a barrier for those with established relationships elsewhere who rely on agreed fixed rates. Some subcontractors may be forced to "resort to uncertified products to meet deadlines or 'cut corners'" (Constructing Excellence, 2008).

Having reviewed the existing literature, the authors concluded that although sustainable procurement is being driven by downward pressure from clients such as the Government to increase innovation, many businesses are keen to implement and support sustainable procurement strategies of their own accord.

RESEARCH METHOD

The aim of this research was to further investigate the opportunities and barriers identified in the literature review in regards to the adoption of sustainable procurement in construction. Primary data was required to enable the authors to do so. The chosen methodological approach was a cross-sectional study. The research was concerned with understanding how sustainable procurement could be utilised in the future, including any barriers or limitations in its implementation and operation. The nature of cross-sectional studies is to collect primary data from a purposefully selected range of respondents.

The decision to utilise interviews was validated by initial communications with potential respondents. Interviews offered a subjective and more accurate method of data collection for a topic which is attitudinal based rather than numerical. The interaction within the interview process allows for the collection of detailed qualitative data that explores individuals' perspective and opinions. Table 2 illustrates the chosen purposive interview sample.

Table 2: Profile of Interview Respondents

Respondent	Sample	Turnover	Number of Employees
A	Client	£5.8 billion	6,390
B	Contractor (General Construction)	£1.9 million	200
C	Contractor (Civil Engineer)	£4 billion	15,300
D	Manufacturer & Supplier (UKCI)	£334.1 million	2,132
E	Supplier (to UK House Builder)	£1million	120

Semi-structured interviews were preferred as the authors wished the respondents to answer the questions in as much depth as possible. The interview questions were articulated from the provisional findings of the literature review. The collection of qualitative data through subjective interviews presented the opportunity for the authors to identify trends in both the literature review and the data from the purposive sample of interviewees. A systematic review of both sets of data allowed the authors to identify trends, conclude and make recommendations for future best practice.

DISCUSSION OF RESULTS

Interviewees Profile

All five interviewees had extensive experience working within the UKCI and had knowledge of commercial procurement strategies. At the time of the research, the interviewees were employees of different companies, within different sectors in the industry; contractor, client and supplier/manufacturer. Their roles ranged from site based engineers, cost consultants to head of sustainability and directors. This provided a variety of perspectives and a sample of the UKCI.

Implementation of Sustainable Procurement

Respondents A and E do not have formal policies that need to be adhered to but outlined ways in which the company chooses to implement sustainable procurement strategies, demonstrating a knowledge of the topic. All other respondents were aware of formal policies. Some stated that they are able to pass the burden of sustainability through the supply chain.

"If sustainability targets were missed, exceeded or misreported the responsibility fell with the subcontractors who we had appointed on the project."

The most common method of sustainable procurement identified was the responsible sourcing of goods and materials in order to improve the corporate image. This was through the use of a local supply chain, purchasing sustainable materials and working within the community. Some respondents demonstrated that they go further than others interviewed with the use of waste management plans and the monitoring and reduction of emissions, Respondent D also referred to his organisation's dedicated intranet service on sustainability.

A number of respondents referred to cost implications without prompt. Respondent A stated that the implementation of any sustainable procurement strategies were dependant on cost whereas respondent D disagreed and stated that their approach was to buy goods and services based on the best value and not cheapest price.

A difference in approach to implementation was identified dependant on the company; Respondent A's approach differed as they switched between client and contractor. As a client they did not place any requirements on others, but as a contractor they passed on the requirements for sustainability to the supply chain as it was a contractual requirement imposed by the Client.

It was felt that there was a requirement to act sustainably driven mainly from public sector employers, such as the NHS. Whereas private sector clients, did not have stringent requirements. Contractors and clients in the UKCI are able to pass the burden through the supply chain and therefore any responsibility and cost of implementation would therefore lie with subcontractors.

A number of the respondents felt that sustainability was embedded into the corporate values of the company and implemented by choice and not necessity.

Formal reporting on sustainable procurement methods are monitored internally by all the respondents and also externally by their clients for some respondents. Companies also recognised the need to appoint a member of staff, solely to manage the process of sustainable procurement. Any costs of monitoring sustainable procurement were found to have been absorbed by the respondents' companies.

Benefits of implementation

Despite the cost of implementation needing to be absorbed by each company, cost savings were cited as an advantage of implementation by respondent C. The use of a local supply chain resulted in more competitive prices, due to local sourcing, good relationship with a local supply chain and reduced transport costs. Respondent B stated that cost savings were increased further as a result of a reduction in programme time.

Most respondents agreed that sustainable procurement improved the corporate image of a company and led to a competitive advantage when tendering. Respondent D also believed that sustainability was able to provide a good return for the business as it provided clear focus, transparency and a competitive advantage.

Where sustainable procurement was not a direct requirement, there appeared to be an awareness of the issue and a stakeholder expectation to incorporate sustainability within the ethos of the company.

Barriers to implementation

It was felt that where the supply chain failed to meet targets imposed by contractors or employers, there can be detrimental impact on corporate relationships. A local supply chain may not always provide the best option as they may not have the financial capabilities or the correct resources available to them.

Respondents A and B identified that the cost of implementation was a disadvantage, although these were the respondents who had not embraced sustainable procurement as fully as others. Respondents who were not governed by targets in sustainability (respondents C, D and E) estimated the percentage spend to be lower than those who were. Where sustainable procurement is embedded throughout the business, it was not considered as a separate cost centre and the cost was considered reasonable.

The cost of implementation for respondents' organisations was estimated to be in the range of 0-3% of turnover.

Those who had fully embraced the concept of sustainable procurement did not perceive there to be any disadvantages at all.

Attitudes towards approach

All respondents stated that they would continue to work to implement sustainable procurement. Some believed that they do this as it has a positive impact on their reputation, they enjoyed being part of an innovative approach, or because it just makes business sense.

It was also identified that there was a moral driver to be a sustainable company and the disadvantages of implementation were outweighed by its benefits.

CONCLUSIONS

In order for sustainable procurement to be successful it should be embedded throughout the entire supply chain. However, the UKCI is often fragmented and those working within the industry are often reluctant to adopt change.

There is an apparent commitment within the UKCI to continue to implement sustainable procurement strategies and encourage innovation. Beyond meeting legislative requirements, sustainable procurement offers benefits for an organisation. These are identified within BS8903 and supported by data obtained in the research.

Conflicting evidence was found regarding the cost of implementing sustainable procurement. Some respondents believe that sustainable procurement will not be implemented unless it can result in cost savings. Whereas others disagree, stating their approach was not solely on lowest price. It is often the case that the actual cost of implementation is lower than the perceived cost and the actual cost is low in relation to turnover.

Organisations who have not fully embraced sustainable procurement policies considered cost to be a barrier to implementation. In contrast, where sustainable procurement policies are embedded throughout the business, it is not considered as a separate cost centre and the actual costs of implementation are minimal in relation to turnover. When implemented successfully, sustainable procurement can provide positive benefits and result in an innovative industry.

In addition, companies are looking to act on a moral obligation and are proud to be a sustainable company.

Where the supply chain fails to meet any requirements imposed on them, there can be a negative impact on working relationships. Suppliers and subcontractors will look to implement strategies to satisfy the requirements of contractors and clients to remain competitive, absorbing any costs of doing so.

Responsible sourcing within the supply chain is seen as a burden by both contractors and subcontractors. It is commonly assumed that due to cost, sustainability would only be considered if it was a specific requirement from clients or planners. This assumption has been somewhat disproved by those who have embraced sustainability fully and would continue to do so regardless of any requirement from the supply chain.

It is apparent that there is a driving force to implement sustainability within the UKCI, largely from public sector employers, such as the NHS. Private sector clients, such as a UK house builder, do not express as many, if any sustainable procurement requirements.

Regardless of any pressure to implement sustainable procurement strategies, there is clear evidence that most of the organisations examined by the authors are embracing sustainability. Those who have implemented strategies wholeheartedly believe that the benefits outweigh any barriers. Those who have embedded strategies within their company have reported that there are no disadvantages at all.

RECOMMENDATIONS

Based on the analysis of the published literature and primary data collected, the authors have made the following recommendations:

The Government, given its role as the key procurer of public works, should continue to encourage the supply chain to act sustainably and continue to improve awareness of sustainable procurement strategies through the publication of guidance documents.

Companies should embrace sustainable procurement in its entirety and embed strategies fully to benefit from cost savings. These cost savings should be advertised more widely to quell the myth that the implementation of sustainable procurement is expensive.

The supply chain should work collaboratively to increase the knowledge of organisations with less experience of sustainable procurement. This would increase participation from those who may be reluctant to change.

If a local supply chain is used, smaller organisations should be supported in accessing the correct goods and services to allow them to meet the requirements of contractors and clients. Although the UKCI would benefit from a more integrated supply chain, the author questions where this support may come from.

Finally the authors recommend that further research is conducted on the topic to expand on the recommendations outlined above. A larger sample should be identified to enable any future researcher to obtain evidence from a wider range of organisations within the UKCI.

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THE IMPACT OF SUSTAINABLE HIGHER EDUCATION BUILDING SPACES DESIGN ON STAFF AND STUDENTS' EXPERIENCE

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ABSTRACT

Humans spend more than 90% of time inside buildings and hence the built environment has an immense impact on our well-being, especially its influence on students' learning and their educational experience in Higher Education. The usability of innovative design in teaching and learning spaces is vital for designing sustainable workplaces and driving the sustainability agenda. A post-occupancy evaluation (POE) case study in a Higher Education building was carried out to investigate the impact of the adoption of various digital technologies on the design and performance of innovative teaching and learning spaces. The POE consisted of a users' survey as well as energy measurements. The results from this research suggest that there is a clear evidential need to develop methods based on the evaluations of user interaction with the design of space and the working environment itself, thus, focusing on broader and more relative aspects For the next generation of learning, teaching and office spaces in educational buildings, it is crucial that early involvement of potential users and building owners in the design planning processes, construction and the facilities management stages.

Keywords: Higher Education, Usability, Sustainability, Teaching and Learning and POE

INTRODUCTION

During the latter part of the 1900's and the early 2000's, the need for sustainability practices to combat the impacts of climate change began to be embraced into the broader community due to the emerging global environmental and economic problems. Currently, climate change is having a significant impact on the nature of global economies, causing instability and social disturbances. These changes have meant that the future feels far less predictable than once previously thought. Further to this, Saurin and Ratcliffe (2008) identified a number of critical sustainability challenges in terms of low availability of natural resources; Extreme increase in the world's population and thus overall consumer demand; The complex nature of economies and challenge of equilibrium; and the importance of governance, agencies and large organisations in terms of resourcefulness, productivity, sustainability and value added processes.

Despite the topic of sustainability and use of sustainable construction techniques being well-known to the construction industry and widely discussed in research and practice, there still exists a general lack of information around the implementation of sustainable design, industry related short-falls and social barriers against sustainable development (Feige *et al.* 2011). The main reason why sustainability is commonly missed boils down to the presumptive nature of an initial large investment/cost outlay (Landgon 2007). There is a general argument amongst building owners that the initial offset of a large investment in cost for a sustainable building/space is only partially relevant, as the energy costs currently are far too low to actually pay back the additional investment/upfront cost (Wallbaum & Meins 2009).

CARBON EMISSIONS AND POE

Recent decades have witnessed increasing attention paid by government policymakers, construction and industry professionals and academics on carbon dioxide emissions and relative building performance. According to USEIA (2010), global CO_2 emissions will surge to 42.4 billion metric tonnes in 2035. As a response to the aforementioned challenge of global climate change, reduction of carbon emissions has gained wide recognition in Australia and particularly that of South Australia. The crucial need to reduce carbon emissions (CO_2) is widely recognized (Intergovernmental Panel on Climate Change 2013) and is thus, an important and potentially large issue for the built environment. Many previous studies advocate the positive link between corporate environmental performance and economic performance and provide evidence that companies can achieve "win-win" in both environmental, productivity and economic performance (Aghahossein *et al.* 2013). The Australian residential building and non-residential (education, retail, commercial, public, hospital and hotels) construction sectors consume around 7.6% of total primary energy (which is that found in nature) and produce approximately 6.0% of total greenhouse gas (equivalent) (Foran, Lenzen & Dey 2005).

The first steps for higher education institutions accepting the challenge of energy consumption and reduction in CO^2 emissions is to create institutional structures and spaces within the building to guide the implementation of a sustainable design and construct plan; complete a comprehensive inventory of all greenhouse gas emissions; and develop a plan to become climate neutral, including benchmark targets and dates (Riddell et al. 2009). POE is used to consider the extent to which a building meets the needs of its end-users while also recognizing the way in which design, performance and fitness for purpose can be enhanced (Turpin-Brooks & Viccars 2006). However, Kincaid (1994) also notes that such measurements can typically be lengthy processes, involve large numbers of people and are relatively expensive to both set up and analyse. In order to simplify POE within any organisation, be it universities or commercial offices, Bordass and Leaman (2005a,b) recommend the establishment of a "portfolio" of techniques, which can be assessed and utilized where appropriate. More recent studies suggest that the use of POE is an important step toward more sustainable buildings (Mier *et al*. 2009, Hyde and Davidson 2006).

OCCUPANTS' CONTROL AND SATISFACTION

There are high expectations when it comes to workplace innovation and the use of cleverly designed space (Van der Voordt 2004). Hyde and Davidson (2006) defined employee satisfaction as the degree to which the working environment meets the requirements and the relative needs of that exhibited by the employees. The general nature of employee satisfaction is complex and is influenced by a large number of internal and external factors (Aghahossein *et al.* 2013). These factors can be relative to the actual work performed, the physical or social working environment and the interactions between these (Van der Voordt 2004, Brill *et al.* 2001). Productivity is typically used as a relative indicator of end-users' satisfaction (Brinkerhoff & Dressler 1990). It is well known that perceived productivity can sometimes be an inaccurate and questionable method of actual productivity (Van der Voordt 2004). Throughout most of the 20th century, space within university buildings had been focused mainly on singular, specialized uses and typical configurations such as a classroom, office space and study/computer pools (O'Neill 2013). Today, there is a far greater need for highly articulated space, with the main desire of students and faculty alike for greater flexible and generalized, multi-useable space that promotes learning and interaction between occupants, students, faculty members and the like. Traditionally, usability of a building is considered from the viewpoint of three key stakeholders: the client, the manager and the general user of the buildings services and facilities (Olsson *et al.* 2010). Studies show that there is a critical lack of data and therefore, feedback on issues such as how actual building facility performance affects the value of user health, well-being and productivity (Aghahossein *et al.* 2013). Typically, tools used such as LEED and BREEAM assess a building's sustainability and energy performance focus solely on those technical aspects of the building such as material usage and energy consumption. Only recently however, have there been methods developed for the purpose of evaluating the interaction of the users and the building, in terms of usability (Husin *et al.* 2011). In order to be both environmentally sustainable and lead within the building industry, it is imperative that organisations design and manage the physical, virtual and social work environment around productivity and end-user needs (Rothe *et al.* 2011).

RESEARCH METHODS

The research method consisted of the collection and critical analysis of current literature. The literature represents the current knowledge surrounding the research objectives (Naoum 2013). Qualitative and quantitative data was collected in the form of a descriptive and analytical anonymous questionnaire. The collection of both forms of data allowed for the triangulation of the data (Bell 2010). Thus, a mixed mode (Cresswell 2003) research approach was adopted. The adopted research approach consisted of both quantitative and qualitative data collection, from both primary and secondary sources. The quantitative approach looked at data collection and research around the surrounding topic. Further to this, it used the data and results of the proposed Questionnaire/Survey as a guide to the qualitative analysis and approach. The literature review involved the collection and critical analysis of secondary data from a range of sources. These consisted of journal papers, text books, technical reports, government reports and other relevant sources. Data collection for the current study ran from August 10, 2015, to September 7, 2015. In order to gain access to those occupants who the proposed questionnaire would be distributed to, the relevant faculty members who were most directly involved with the facilities maintenance of the buildings were contacted. A forty-five item questionnaire was developed, which sought to evaluate the effect of general workplace design on end-users' perceptions and opinions of one higher education building in Adelaide, in regards to their overall satisfaction with space and usability and to identify and assess solutions to improve energy consumption and carbon emissions. The survey instrument was based on the work of Aghahossein *et al.* (2013).

THE JEFFREY SMART BUILDING

UniSA's new learning centre, the Jeffrey Smart Building, is a cutting edge facility which provides access to numerous digitally enabled state of the art technology alongside: dedicated honours facilities, active learning spaces and collaborative spaces and peer and social learning spaces. This case study building was built in late April 2014 as part of a major redevelopment of the UniSA's City West Campus. The development was approved in June 2011 and was funded as part of the Federal Governments Education Investment Scheme. The buildings innovative design was awarded a five green star-rating. The buildings universal layout consists of teaching and office space, as well as student and staff facilities and services, a library as well as a restaurant/café. The back and front view of the building can be seen in Figure 1.

Back view Front view

Figure 1: Jeffery Smart Building

The building, nicknamed 'The Learning Centre' is laid out over eight consecutive floors and is the pinnacle of smart design. Levels 2,3,4,5 & 6 are dedicated to integrating space, combining smart learning space, resources and state-of-the-art technologies; while levels 1 & 8 are designed for staff and faculty alike. By combining the learning, teaching and office environments into a working collaborative space network for all relevant users, both staff and students are given a strong framework for effective social and productive learning and teaching experiences. The general floor layout for the foyer of the building can be seen in Figure 2 below.

Figure 2: General floor layout for level 1 foyer Jeffrey Smart Building

RESULTS AND DISCUSSION

From the 45 questionnaires distributed in the Jeffrey Smart Building, 24 were returned. The majority of respondents indicated that they were university faculty staff who worked in the building 20 people (83 %); while others indicated that they were undergraduate students 4 people (17 %). Of the faculty staff who took part in the study 3 (13%) were from Campus Central; 7 (29 %) were from the Learning and Teaching Unit (LTU); 1 (4%) was from the Student Engagement office; 3, (13%) were from the Facilities Management Unit (FMU); 1 (4%) was from Student and Academic Services (SAS) and 5 (21%) were from the Library staff.

The number of respondents over 30 was 17 (74 %); while only 6 (26 %) were under the age of 30. A large majority of the respondents were female 16 women (70 %), while fewer 7 (30 %) were male. The average number of days spent in the building per week was (4.48). Of this the average number of hours spent in within the building was (7.50), of which an average of (6.57) hours are spent in front of a computer screen. The amount of time spent studying/working in the building was 'a year or more' 20 people (87%) and less than a year 3 individuals (13%). Work areas were typically shared with more than 8 others 11 people (46 %); followed by normally occupied by you alone 7 people (29%). The participants whose work or study space was next to a window, versus those who did not sit at a window was split down the middle at 12 people (50%) in each group. The distance to work averaged at (35.22 minutes) and from work was averaged slightly higher at (36.52 minutes). The travel method most used by participants was the car, as a driver (12, 50 percent), followed closely by the Bus (6, 25 percent) and Tram (6, 20.83 percent).The distance to and from work was averaged 36.74 minutes; which is depicted in the graph below.

When respondents were asked to describe their typical working conditions within the building during the winter and summer months, only 2 people

(8.33 %) specified not applicable (N/A). Around three-quarters of respondents 17 individuals (70.83%) were somewhat satisfied with overall working conditions such as temperature and ventilation within the winter months of the year, rating 4 or above. This was much the same for the summer months, as vast majority of respondents 20 (83.33 %) indicated moderate satisfaction with the general working conditions within the building, rating 4 or above. Roughly two-thirds 16 (66.66 %) of respondents indicated that the overall noise levels within typical working/studying areas, was somewhat unsatisfactory, rating 4 or below. This question specifically asked respondents to classify noises from sources such as colleagues, other occupants, external influences and interruptions etc.

The majority of respondents 17 (70.83 %) rated their overall comfort of the buildings working environment as somewhat satisfactory, rating 4 or above. When compared with the general consensus around respondent health, 17 individuals (70.83%) indicated that their health was somewhat unaffected or healthier as a result, rating 4 or above; thus, a positive correlation between overall comfort and occupant health.

BUILDING ENERGY ANALYTICS

The building's energy performance data was obtained via special permission from the Facilities Management Unit at the University of South Australia, City West Campus in August 2015. Relevant building services and energy management components for the Jeffrey Smart Building, such as Green Star Rating, Building Management System (BMS), Electricity, Water usage, Heating and Cooling, Gas and overall Emissions were obtained. The energy use and relative energy data of the Jeffrey Smart Building was obtained via special permission from the Facilities Management Unit at the University of South Australia, City West Campus. When comparing the average KW/h of power used by the Jeffrey Smart building for the 2014-2015 period, an average of approximately 1,240,842 KW/h was found for 2014, compared with around 1,615,442 KW/h for 2015. This equalled an average of approximately 2,856,284 KW/h of power used for the entire period. The reasoning behind such a high average for the two year period when compared with the individual years is because when the building opened in April 2014, within the first week alone recorded roughly 21,000 user hours.

Thus, the building's resources such as its computers, lighting, heating and cooling and all other plant and equipment relative to energy use were running at a very high capacity, which meant a very high KW/h figure for 2014. For the 2014-2015 periods the total amount of electrical power used equalled an average of approximately 2,856,284 KW/h with carbon emissions of 2056 tonne CO_2e.

CONCLUSIONS

Higher Education buildings account for a large proportion of energy consumption/carbon emissions in the government and territory education building sectors. Thus sustainable measures must be in place to help reduce the built environments carbon emissions within South Australia. Improving the energy performance of the existing Australian Higher Education building stock, as well as delivering new high performance sustainable buildings is undoubtedly considered to be one of the most sustainable and feasible measures for creating a sustainably viable building industry and for improving energy consumption profiles, thereby reducing total greenhouse gas effects. A case study approach using POE was used to assess staff and students' experience in an innovative HE building. The results showed positive experience by user with lower energy consumption. For the next generation of learning, teaching and office spaces, it is crucial that early involvement in the design planning processes, particularly that of ergonomics (workstation layout, usability and functionality), as well as post-occupancy follow up activities be implemented and thus, managed accordingly by both the client, contractor and facilities management teams.

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AN OVERVIEW OF A CONCEPTUAL MODEL FOR IMPROVING PLANNING AND SCHEDULING STAGES OF CONSTRUCTION PROJECT IN UNITED ARAB EMIRATES

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ABSTRACT

The agenda of effectiveness, efficiency and economics has dominated business organisations operating in an agile environment where teamwork, accountability, transparency and responsiveness to client are paramount ingredients for business survival. Although construction organisations are not immune to these practices but they have to operate more smartly given very tight constraints associated with time, cost and quality constraints but also operate in an industry which is constrained by proliferation of austere requirements through legislation, building standards and safety. As a consequence construction organisation to have shifted the focus on pre-planning stages to eliminate or reduce the risks in the construction phases of the project. This is a working paper and is part of a wider research project which aims to provide academics and practitioners with a valuable support in this direction. This paper proposes an integrated conceptual model to enhance planning and scheduling stages. The research to date includes an extensive literature review and assesses the parameters and the elements that form the basis of a conceptual model. The model consists of Six main parameters with associated elements include: the project (size, scope and complexity), the organisation (structure, lines of responsibilities, span of control and culture), the human aspects (education, experience and support), the construction methodologies (methods, preferred techniques, resources, out-sourcing, supply chain, health and safety) and the technology (software, tools and support); the contractual framework (obligations, risks legal); and the environment (internal and external). This paper

discusses the research methodology that will form the basis for major study.

Keywords: Planning scheduling, planning process

INTRODUCTION

One of the biggest challenges facing the construction project team is planning (Zwikael & Sadeh, 2007; Zhang *et al.* 2005; Waly & Thabet, 2003;Arditi, 1985; Kenley, 2004; Koskela, 2000) and that decisions made during this phase impact enormously on the successful completion of a project (De Snoo *et al.* 2011; Berglund & Karltun, 2007; MacCarthy & Wilson, 2001; Jackson *et al*. 2004; Jackson *et al.* 2004; McKay & Wiers, 1999). Planning, in fact, is often regarded as transitioning and developing effective collaboration of supply chain through to the work phases (Sriprasert & Dawood, 2003). Planning and Scheduling can be developed at various stages of the design and construction process (Faniran *et al.* 1999). It is commonly accepted that the planning process has two aspects: macro-planning, for decisions made prior to, and micro-planning, for more detailed decisions which are made during the construction process (Waly & Thabet, 2003). However, the ultimate aim of the planning process is to ensure *buildability* of the proposed schematic design as well as ensuring the planning and controlling of the actual construction phases. In fact, the planning and scheduling process is developed to satisfy the time, cost and quality constraints of a project together with developing a construction methodology which eliminates or reduces health and safety risks. In reality however, the planning and scheduling is a very complex process and heavily relies on reasoning process (Jackson *et al*. 2004; MacCarthy & Wilson, 2001). This process relies on the construction planners to translate tender documentations (drawings, specifications, bill of quantities, schedules etc) and produce a coherent set of work tasks based on method statement(s) with their logical sequential relationships and postulate a prediction of the work flow, visualising and capturing every aspect of the project stages including providing preventative measures reducing any safety risk (De Snoo *et al.* 2011; Berglund & Karltun, 2007; Jackson *et al.* 2004; MacCarthy *et al.* 2001; McKay & Wiers, 1999; Cherneff *et al.* 1991). Inevitably this stage will involve gathering of information and interpretation, communication and negotiation with different stakeholders to make decision and unpack or solve problems. In formulating planning and scheduling, the planners integrate their knowledge of construction practices, costing and productivity together with data specific to the project design. de Vries & Harink (2007) suggests that planners not only needs to possess knowledge and experience of the construction process but must be able to estimate labour and material requirements from the design documentation.

To date researchers concentrated primarily on operational level of project planning and control and have develop numerous models and framework associated in the following areas:

- analysing causes of low productivity (through inappropriate working methods, rework, mistakes, time delays and cost overrun (Banwo *et al.* 2015; Montaleb & Kishk, 2010; Al-Kharashi & Skitmore, 2009; Faridi & El-Sayegh, 2006; Assaf & Al-Hejji, 2006; Horman & Kenley, 2005; Zhang *et al.* 2005; Al-Tabtabai & Thomas, 2004; Alwi & Hampson, 2003; Koskela & Vrijheof, 2001; Lam *et al.* 2001: Morris, 1990; Winch, 1998).
- examination of the effectiveness of project management tools and the relative merits and demerits (Yaowu & Qingpeng, 2011; Kenley & Seppanen 2010; Galloway, 2006; Harris & McCaffer, 2006; Henrich & Koskela, 2005; Kenley, 2004; Arditi *et al.* 2002; Atkinson, 1999, 2000; McKinney & Fischer, 1998; Hamilton, 1997; Jaafari, 1984; Moder & Phillips, 1970).
- Project management quality tools (Chileshe &Haupt, 2005; Ford & Bhargav, 2006)
- Stakeholder management interactions, collaborations (Becerik, 2004; Ahiaga-Dagbui, & Smith, 2014; Ahuja *et al.* 2009; Nguyen *et al.* 2009; Liu & Fang, 2006; Slattery & Sumner 2011; Wong *et al.* 2000).

However, there still remains a knowledge gap for developing a holistic model capable of capturing a range of key factors influencing the reasoning behind the strategic decision making in developing planning and scheduling for construction projects. Although these concerns have been raised by numerous researcher (King, 1976; MacCarthy & Liu, 1993; Buxey, 1989; McKay *et al.* 1988; LaForge & Craighead, 2000; MacKay *et al.* 2002) but there nothing has been presently conceptualized, implemented and tested. From an academic viewpoint, this paper formalises the conceptual model and contributes to useful directions to future research in this area.

Apart from the level of detail information contained in tender documentations which is dictated by the type of contract and procurement route selected by the clients professional advisory team e.g., design and build projects (tender documents may include but not limited to schedule of requirements, schedule of rates); traditional contracts (working drawings, specifications, schedules, bill of quantities) and in processing this tender information, the planner not only relies on his/her knowledge, experience and ability to visualise etc but there are often constrained and influenced by the external environment (contract form, communication structure within the team); internal environment in which there are working in terms of the organisation (its structure, culture, role, responsibility and level of control assigned); the technologies (working practices, preference on resources, supply chain, hard/softwares, planning tools); the human (Berglund & Karltun, 2007).

Why United Arab Emirates (UAE)

The landscape of UAE has been dramatically changing over the past 5 decades and UAE is widely known as one of the pioneer's of innovation amongst developing countries in the Middle East. UAE is associated with modern approaches to usage of land and unique built environment together unique infrastructure in terms of design and quality where cost and quality are not comprise and this has result be one-off mega construction projects building on reclaimed sea beds and desserts. Construction industry contributes 11% to the GDP (ADCCI, 2015). Every year the government invests billions in major capital projects. However, construction in UAE are not immune to delays and disruptions regardless of the cost injected to maintain building quality, according to Fairidi & El-Sayegh (2006), nearly half of the construction projects in UAE suffer from delays these are generally associated with construction companies and economic stability of the country. However, the construction industry of UAE employs diverse range of consultants (architects, project managers, cost engineers/ quantity surveyors etc); multiples international construction companies employing diverse range of workforce (from developing countries); and harsh environment setting. All these complex array of challenges and huge responsibilities placed upon the construction planners engaged in the planning process. Hence the remit of this research investigation is limited to the planning and construction phase of project's life cycle as opposed to the complete project's life-cycle.

RESEARCH DESIGN

The research methodology is showed in Figure 1. It entails two main phases: a literature review and a multiple case analysis. The current status of research can be positioned at the beginning of Step 2. The literature review revealed uncovering the constructs and variables associated with the planning process. The case studies will be aimed at exploring, theory-building patterns or linkages between the proposed constructs and variables in concept model. The objective of overall research involves the descriptive and normative study of the planning process and more importantly understand the cognitive decision making process through exploring the importance of constructs and elements and their dynamics interrelationships in terms of how there interact with each other. With this in mind this paper focuses on the first research objective and reviews previous researches and literature available on domain surrounding this subject area from an integrated perspective. This will assist in defining the main elements and constructs that constitute the formation of building blocks of the conceptual holistic approach to planning model and form a basis of further probing and investigation to vary scoping and its appropriateness to the real world. Like with any research project, there will be numerous set of research questions arising from an extensive literature review and these forms the basis for future scoping of research agenda and it is anticipated that any data collected will undergo rigorous testing using empirical investigative approaches.

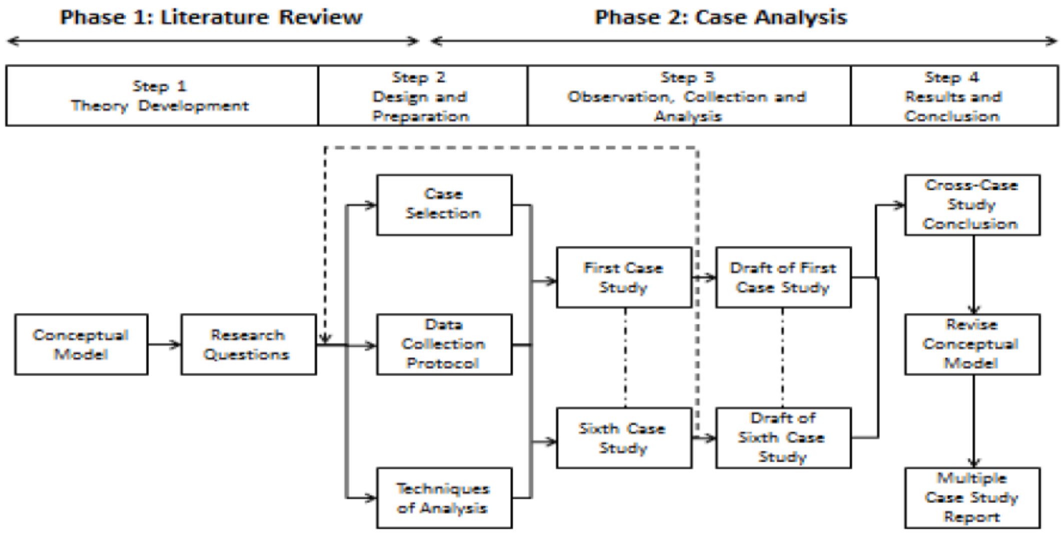

Figure 1- Main steps of research methodology (*Source:* Adapted from Yin, 2012)

The novel of the proposed conceptual model lies in the different perspective on the constructs and elements that characterises cognitive decision making approach in develop the construction planning and scheduling process. The rationale of the present research is based on the fact that the construction industry suffers from lack of efficiency comparing to other industries (Koskela and Vrijheof, 2001; Winch, 1998; Zhang et al, 2005, Horman and Kenley, 2005). The model will aid a better understanding of the complex decision making process in the planning stages which in turn affects the project being delivered within the time, cost and quality constraints as well as increasing buildability on construction sites and related benefits. The research team intends to address several gaps in existent construction literature and to best of our knowledge all research undertaken in this subject domain have focused primarily on micro aspects of the planning process.

Research proposal

The second phase of research methodology (Step 3 and 4 as in Figure 1) is not included within this paper and it will be conducted through a multiple case study analysis. It will be used with the two-fold purpose of exploring and theory-building research propositions and hypothesis related to the proposed model. The case study analysis was considered suitable to obtain in-depth results in a research area that is characterized by limited empirical research as planning process.

Conceptual model

The proposed conceptual framework is displayed in Figure 2 and capture an environment in which the construction planners are constrained by. Figure 2 illustrates the relationships between the key elements which comprise both internal and external factors influencing the planning process.

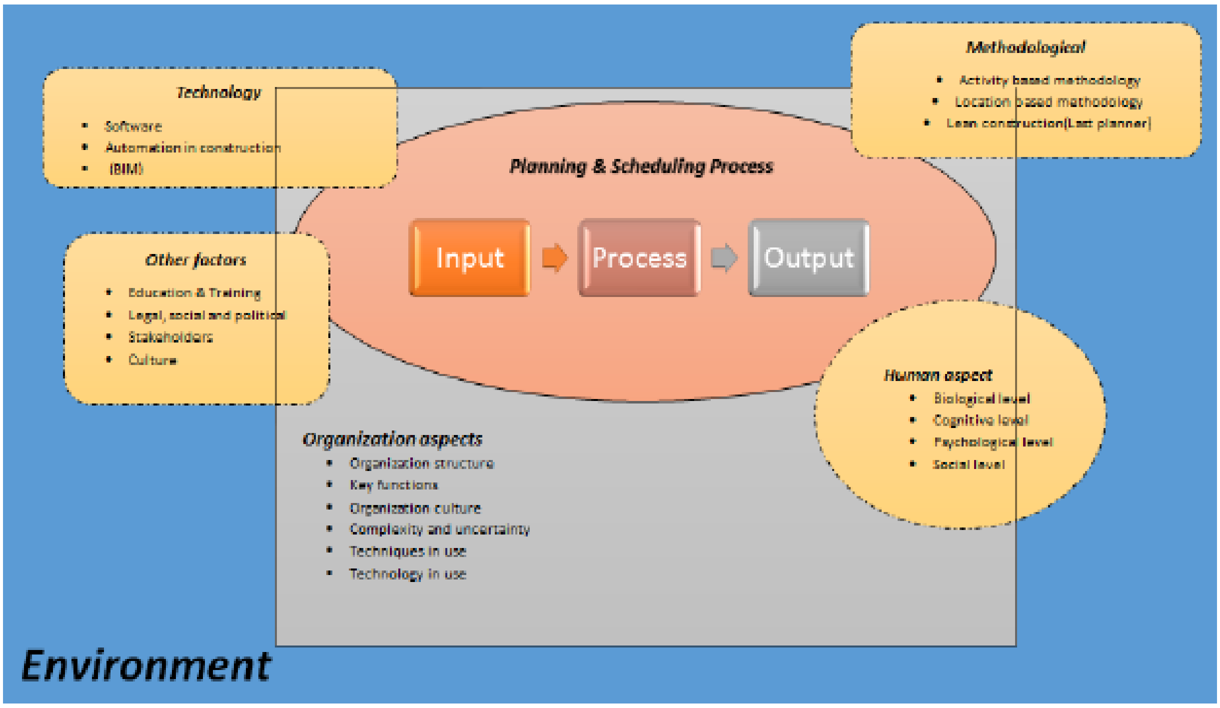

Figure 2: Proposed conceptual model of the Planning & Scheduling Process

The Human Factor

The success of execution of the planning and scheduling process hinges on the ability of construction planners to interpret, extrapolate, evaluate and synthesis the tender information to form decisions on time, resources and logical sequence. Hence this task ultimately challenges the construction planners cognitive reasoning and mental ability to visualise every aspects of the project sequences and their relative inter-relationship; communicate these to coordinate various members of the project team; and level of competency is displayed through the construction planners professionalism in terms of depth and breadth of professional experience and knowledge, educational background, personal characteristics (De Snoo *et al.* 2011; Buchmann-Slorup & Anderson, 2010; Berglund, 2000; Berglund & Karltun, 2007; Jackson *et al.* 2004; Russell & Taylor, 2003; Meredith & Mantel, 1995). In this regard several researchers (Koo & Fischer, 2000; Illingworth, 2000; Kelsey *et al.* 2000) suggests the importance of have a competent construction planner which are on the decline with increasing in project complexity (Allen & Smallwood, 2008). However, Daniellou (2001) and Berguland & Karltun (2007) suggests that the human contribution to the planning process can be categorized the following:

1. Cognitive: high flexibility demand characterizes scheduling. It helps in managing uncertainties and comprises different parallel tasks and problem solving.
2. Psychological: in-depth knowledge of production system functions is required by the scheduler. All schedulers were experienced as a result of working in the production system. This enables them to execute the complex tasks of scheduling based on their personal knowledge.
3. Social: the personal contacts of the scheduler with a variety of personnel and departmental teams across the organization.

However, a construction planner's role and responsibilities is varies considerably between organisations in terms of the job requirements, level of responsibility, expectations, obligations and the desires to succeed. Jackson *et al.* (2004) categorizes the roles as follows:

- Interpersonal role: these are embodied in the interpersonal networks developed by schedulers over time that complement the formal reporting hierarchies and organizational structure.
- Informational role: a key role performed by the scheduler with an information receiver, processor and transmitter.
- Decisional role: Schedulers are not only problem solver but problem predictors taking avoidance or opportunistic action when appropriate.

Jackson *et al.* (2004) suggests that the environment in which the construction planner operates is just as important as the competency of the planner. The environment comprise the physical technological process and materials, the organizational structure, the planning and scheduling information systems, the individuals that the scheduling functions interface with and the execution measures being used – see Figure 3.

Organizational Factor

Since the planning and scheduling process relies on team working ethics and information sharing within the organisation. The organizational structure - its culture, core values, protcols, ethics, experience, reputation, services delivery, agility and customer satisfaction affects how successful the organization is and this will directly influence the planning and scheduling process (De Snoo et al. 2011; Buchmann-Slorup & Anderson, 2010; Ajmal & Koskinen, 2008; Berglund & Karltun, 2007; Jackson, *et al.* 2004; Covin and Slevin, 1988). According to Robbins &

Barnwell (2006), there are three key components are needed to be addressed within any organization: firstly, organization's hierarchy and its operating management structure; secondly job descriptions and role responsibilities through standardized; and thirdly, decision making structure and control. Hence the planning function will often vary from one organization to another; some organizations tend to assign a planner solely dedicated on this role, whereas, in other organization the planner has to perform other duties (Berglund & Karltun, 2007; Jackson *et al.* 2004; MacCarthy & Wilson, 2001).

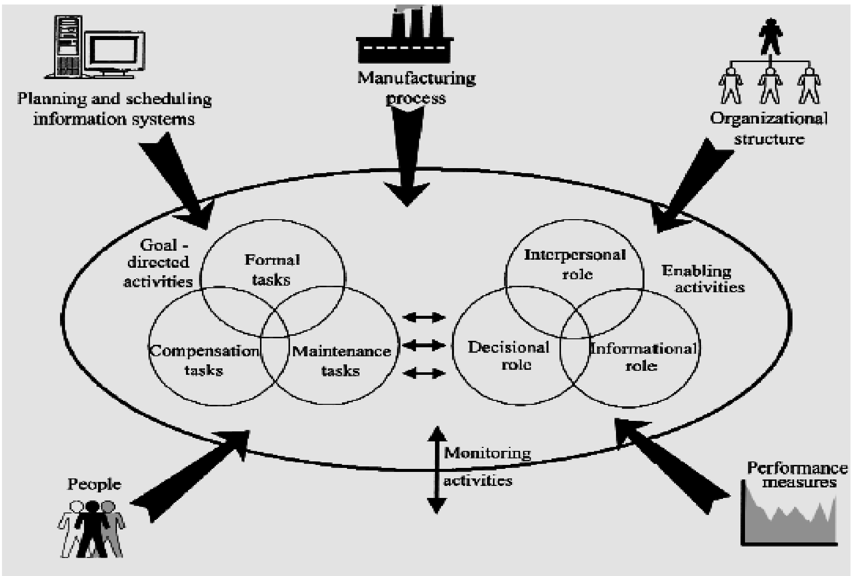

Figure 3: A new model of scheduling in manufacturing (*Source:* Jackson *et al.,* 2004)

Methodology Factor

Presentation techniques used for schedule communication are important vehicles for enabling the collaborative and coordinated work practices that are so important for the success of a building project. According to Kenley & Seppanen (2010) two main planning techniques that are designed to determine the sequence of the construction activities upon which a construction plan is developed and these are as follows:

- Activity based management: CPM (deterministic), PERT (probabilistic), Gantt Chart.
- Location Based Management: LOB (unit production), Flow line (location production)

Technology Factor

Due to increasing project complexity, there has been increased reliance in use of project management software as a tool for project tracking, time analysis, cost analysis, resource analysis and managing organizing construction projects (Liberatore *et al.* 2001; Choo *et al.* 1999; Hegazy

1999; Bounds, 1998). The most popular project management software packages Microsoft Project (MS project) and Primavera Project Planner, and these software packages are widely used with activity based management methodology (Galloway, 2006). VICO software is also available, though less popular and commonly used with location based management methodology (Kenley & Seppanen, 2010). The main technology aspects are:

- The scheduling software system availability and its ability to provide sufficient data, control and decision support.
- Automation in the construction industry: Building Information Modelling (BIM).

Environment Factor

The environment of any system lies outside the boundary limits of that system and it has negligible ability to control other systems beyond its boundary. System's boundary is used as a tool for understanding and defining the scope of an organization's interest (Cavaleri & Obloj 1993). There are some key factors within the environment of planning that influence the scheduling process:

- Education and training provision
- Legal and political
- Culture
- Stakeholders

Generally it is widely accepted that the background knowledge, experience and grooming of the individual project members has a significant impact on the project's success (Hinze and Plautz 1988; Marzano, 2004). There are other factors that will help in improving the professional knowledge of a person such as professional training, company training and project training (Hinze and Plautz 1988); higher education can foster the knowledge required to improve projects' performance, Tatum (2011). The contractors' experience affects the project quality, job efficiency, project cost and time and owner's satisfaction (Ling, 2004). Therefore, continuous education or training is important in order to raise the knowledge that is required to improve construction project performance.

Benefits

Generally, the measure of any project success (not limited to construction industry) corresponds to the extent to which customer needs are satisfied and the project objectives through time, cost and quality have been met. Cooke-Davis (2002) suggests that the realization of benefits is essential to establish project success. There are a number of tangible benefits from this research. Firstly, this research culminates into a deeper understanding of the planning process and the factors influencing the project success stem from undertaking a thorough scrutiny is paramount in avoiding project risks in terms of delays, disputes, disruptions and claims during the construction phases. Secondly a deeper understanding of factors will ensure seamless transition of effectiveness, efficiency and economic project targets are being attained and the planning model should be potentially value-enhance for all the key stakeholders within the design and construction team. Thirdly, this is especially valid for the construction sector, where there is a constant drive to implement time cost quality through innovation, efficiency and effectiveness not only from the individual company perspective but also from a multitude of participants.

CONCLUSION AND FUTURE DEVELOPMENTS

This paper has to be framed in a wider research project, which aims to unpack the key factors influencing the planning process and their interactions but also presents a holistic planning model to ensure that planning process is more effective. Organisations can provide additional support on a contingency-basis to meet the project objectives of time cost and quality. The objective of this paper was to present the results of literature review on the planning process and to propose a conceptual model with the related research agenda. The model was developed directly from the literature on this topic. It represents an initial attempt at identifying the various elements to be managed within the organisations internal and external environment and how each elements interacts within the planning process. The elements that compose the model have been described and a set of further research questions and hypothesis have been proposed.

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A CONCEPTUAL FRAMEWORK TOWARDS THE DEVELOPMENT OF TENDER PRICE INDEX

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ABSTRACT

Economic crisis and its growing antecedent continues to be a growing sensation in developing countries. The much anticipated growth by these countries can be measured by its industrial growth, especially with the construction industry. As a result, clients in the determination of prices of the products in which their money can afford and at the same time ensuring value for money has recent times become a critical issue. Thus, the motivation of this study was to critically review literature as conduit for developing a conceptual framework that underpins Tender Price Index (TPI) development. On this basis, a conceptual framework was developed based on three main concepts including *cost analysis, pricing and indices*. In addition, these concepts are influenced by two indicators namely: *Construction Industry Environment and Economic Environment*. These indicators largely influence the Tender Price Index acting as external factors. This framework offers the basis for both stakeholders and researchers in the construction industry aiming at establishing a robust understanding for the development TPI.

Keywords: Conceptual, Development, Framework, Tender Price Index (TPI)

1.0 INTRODUCTION

The future financial commitments and cost implications of a project must be communicated to the clients in advance during the design advancement stage (Ng *et al.,* 2004). This helps client to make an informed decision about their finances so as to have effective and efficient cost planning system. As a result, Quantity Surveyors are usually required to produce an estimated tender price for the client's consideration at the early stage of any project. To attain this probable tender price, it is comparatively easier to amend the historical construction cost of previous projects. It is always difficult to project the current cost up to the tendering date (i.e. the tender price) due to the unanticipated prospective state of any economy (Wong & Ng, 2000). Hence, Tender Price Index (TPI) possess an approach for solving such difficulties. It is therefore, essential for many practical purposes in the industry, including establishing the level of individual tenders, adjustment for time, pricing, cost planning, forecasting cost trends and general comparisons (Tysoe, 1981) that reflects the prevailing market conditions (Ng *et al.,* 2000). Consequently, TPI measures the tender price movements of the building industry, as it covers most of the items normally built into the price for producing the output of construction activities (Goh, 2005), which helps clients to make an informed decision. Accordingly, TPI represents the cost agreed to be paid by a client for a building and it matches the price offer made by contractors' tender price (Wong *et al.,* 2010). TPIs are compiled for the comparison of the prices of a ratio of the items within a sample of accepted tenders during a given time frame against the price of alike items in a base schedule of rates. The indices are calculated for every tender within the sample, afterwards, the average is taken as the final index for that period. However, diverse sources of information can be used in producing as a result of signalling market conditions, but the compilation methods are similar. The exactness of the tender price index is determined by their use and form, time horizon and availability of data (Ng *et al.,* 2004). It can however be practically challenging since it is highly subjective in forecasting of future market and socio-economic conditions (Ng *et al.,* 2000). In summary TPIs are attempts to measure the change over time of the contract prices between clients and contractors for constructing new buildings. This paper seeks to highlight, the framework that underpins the study of tender price index.

2.1. THEORIES OF INDICES

Theories of indices are positioned in the domain of micro-economic theories, which have been in existence over a number of centuries within various industries. Cruywagen (2014) define an index as a ratio that measures relative change, although Flemming and Tysoe (1991) state that index numbers of cost and prices provide expedient means of articulating changes over time in the cost or prices of a group of related products in a single measure. However, its usage and complexities are always misapplied or misinterpreted. According to Lippe (2001) index theory is concerned with the valuation of index formulas although it is a futile effort to count all the different index formulas that have been invented. In addition, Cruywagen (2014) opined that indices are mostly measure relative numbers and at best, only give an indication of the measure to which a variable can be compared to an earlier period. Balk (2008) defined index as a number formula which is purely a statistical contrivance acting as a coefficient of correlation. It is as irrational to vary the contrivance with the subject matter to which it is applied as it would be to vary the method of calculating the coefficient of correlation (Balk, 2008). Diewert (1988) surveyed of price index research grouped them under five distinct headings: the fixed basket approach, the statistical approach, the test approach, the Divisia approach, and the economic approach (Balk, 2005). However, the method for the application of each approach depends on the nature of the index for specific sectors within the economy it seeks to measure. Notwithstanding, the lack of consensus on the formulation of price index, Bowley (1899) suggested the use of geometric mean of the Laspeyres price index and the Paasche price index as two most important forms index used in the several industries, which construction industry is not exceptional to this rule.

2.1.2 Laspeyres Principle

It consists of constant (base period) weights, that is, quantities to be multiplied by prices, or expenditure shares to be multiplied by price relatives. Laspeyres index is a static formula because it uses a fixed composition of goods and services, it does not allow for substitution between different products (Mulligen, 2003). To compute Laspeyres price index, take the ratio of the total cost of purchasing a specified set of commodities (basket of goods) at current prices to the cost of that same set at base-period prices and multiplying by 100. The base-period index number therefore becomes 100, also periods with higher price levels take index numbers greater than 100. The Laspeyres price index, the formula for calculating the index is

$$PI = \frac{\sum \text{pnqo } x \text{ 100 (price in current period } x \text{ base weight)}}{\sum \text{poq (price in base period } x \text{ base weight)}} \, x \, 100$$

2.1.3 Paasche Principle

On the other hand, the "Paasche principle" consists of a variable of current period quantities or current period expenditure shares correspondingly (Lippe, 2001). Paasche index is often referred to as current weight index (Yu & Ive, 2008). Others criticized it for understating inflation because it does not replicate the selection of goods under the base period prices (*Ibid*). The Paasche index has the formula below:

$$PP = \frac{\sum \text{pnqn } x \text{ 100 (weight in current period } x \text{ price in current period)}}{\sum \text{poqn (weight in current period } x \text{ price in base period)}} \, x \, 100$$

2.2 THE CONCEPT OF PRICING

Price remains a critical variable in every industry because it serves as the main regulator of any economy, that is it allocates the factors of production (Kumar, 2014). Not only that, it is also a very vital variable in other crucial dimensions such as increased profitability, improved market share, preferred product image, and signalling of product quality (Guerreiro, 2012). Generally, price refers to a service or physical product for which a consumer is ready to pay. It includes tangible goods and intangible products like services which are purchased by consumers

(Kumar, 2014). In the Construction Industry, the concept is traced to the nineteenth century in the United Kingdom entrenched in the growth of the competitive tendering system (Skitmore et al., 1990). The construction industry unlike the manufacturing industry, cost and price are used interchangeably. Traditionally, cost is the prime factor in the selection process of competitive tendering. Pricing in the construction industry depends on several factors such as complexity of the project, the speed of its construction, the location of the project and its degree of unfamiliarity (Creedy, 2006) as well as company age and size (Tahmaseb et al., 2015) among others. These factors altogether determine the pricing method. The methods of pricing are usually determined by the combination of various marketing decision variables that firms use to market their goods and services or it could also be the route taken by the firm in fixing the price (Kumar, 2014). Kumar (2014) suggested two pricing methods as break-even and marginal analysis. However, within marketing literature, pricing methods often adopt the various types put forward by the scholar of marketing–Philip Kotler. Kotler proposed four pricing methods and these are: pricing based on adding a percentage to the costs, pricing based on costs, pricing based on value, and pricing based on the price of competitors' products (Tahmaseb *et al.,* 2015). Meera (2013) discussed two types of pricing methods. These are products pricing approaches and service pricing methods. Despite the two broad classifications discussed, Meera (2013) further suggested four methods which appear to be adapted from Kotler's pricing methods: cost-based pricing, break-even concept, demand based pricing and pricing related to market.

2.2.1 Cost-Based Pricing

Generally, three approaches are used under the cost-based pricing (Kumar, 2014). These include markup pricing, full cost pricing (absorption cost) and marginal cost pricing. Notwithstanding, within extant literature, this pricing method is largely referred to as marginal cost plus markup of price (Shipley & Jobber, 2001). The rationale of this method is that product's selling price is attained by the addition of a particular margin or percentage to cost (Kumar, 2014). This method is widely adopted in distributive trade and marketing firms. The probable explanation for its wide application perhaps lies in its simplicity. The full cost pricing approach is also based on the normal level of production, the estimated unit cost of the product sales (Kumar, 2014). It should also be noted that a profit margin is added to this unit cost. The actual reason for marginal cost pricing is its ability to increase the fixed costs. Marginal cost is an aggregate of all the product's direct variable costs. In marginal cost pricing, these costs are completely comprehended as well as a portion of fixed cost. Full cost pricing and marginal cost pricing differ in the sense that marginal cost pricing gives flexibility not to recover costs based on the market condition (Kumar, 2014). Despite the approach adopted, Zeithaml (2000) argued that the disadvantage of this method, is that, it disregards market conditions along with the difficulty of allocating fixed costs across different services in order to calculate the unit cost.

2.2.2 Break-Even Concept

To get a correct understanding of most of the cost-based method of pricing, the break–even concept is very key (preferred). In the production and sales of a certain volume of any product, some fixed costs as well as certain variable costs are incurred. An increase or decrease in the volume will cause the variable costs to go up or down, as this happens the fixed costs usually remain unchanged. In the midst of these changes, the firm's concern is basically with the total of the variable and fixed costs incurred for the particular volume of the product. The break-even concept is targeted at a level where the total costs and the total revenues are exactly equal, this simply implies zero profit and zero loss.

2.2.3 Demand Based Pricing

Demand is defined as the amount of goods and services a consumer is willing and able to pay for at a prevailing price. Construction demand has been defined by various authors. For instance, industry reports provided by independent company Davis Langdon, (2010) define construction demand as "the number of" or "the number requirement" of buildings to be constructed. From this definition, it is inferred that stronger (higher) demand is an analogous to a larger amount of projects available in the market for bidding and weaker demand that reflects less projects available in the market (Soo & Oo, 2014). Ngai *et al.* (2002) also provided a similar definition for construction demand, suggesting that lower demand would lead to lower capacity utilisation in the industry (i.e. that contractors would have less jobs at hand). In construction, many decisions are determined through demand since it is part of the large domain of market conditions (Soo & Oo, 2014). In addition, decisions revolving around demand force contractors to make judgments in an attempt to balance out the market opportunities and risks (Soo and Oo, 2014). This automatically affects their bidding behaviour in order to achieve their firms' objectives.

2.2.4 Pricing Related to Market

The essential fundamental concern of any competitive tendering process is the estimation of the market price of the contract-facility. As far back as three decades ago, Skitmore and Patchell (1989) posited that the dominant theme running through the techniques of contract price forecasting is estimating that relates to market conditions. This is reflected in the rate build-up for special items involving new materials and components by Quantity Surveyors. The practice has been established to find out the manufacturer's price and subsequently making allowance for installation and other associated cost involved. This is more understandable because as aptly argued by Skitmore (1990) the fundamental aim of construction forecast is to provide an estimate for construction projects. If that is the case, then the basic form of pricing should be the market price of the components making allowance for installation and profit.

2.3 CONCEPT OF COST ANALYSIS

Cost analysis originates with a consciousness of activities that proceed breed costs (Groth and Kinney, 1994). Essentially, cost analysis in the early stage of a project demands the development of specific cost functions, if accurate and reliable estimation is carried out (Gillot *et al.,* 1999). Consequently, cost analysis engages the effort to assess and value all the costs related to a project (Antwi-Oppong, 2008). According to Tsang (1988), a healthy analysis of cost may also disclose severe policy mistakes that have to be dealt with. However, in most developing economies, central government data are what is obtainable and accessible for examining cost (Tsang, 1988). Subsequently, risk and uncertainty acquired with input factors for project cost analysis may differ from project to project (Li and Madanu, 2009). Tsang (1988) suggested that in assuming the broad scope of applications of cost analysis, it is not feasible to define wholly the data requirements of cost analysis. Also, the necessity to fortify the statistical base of cost analysis are patent and vital. The cost of a constituent is the opportunity cost in cost analysis, nevertheless, failure frequently results when the decision makers lack awareness of the importance of cost analysis, a lack of proficient cost analysts, or from the shortage of good data to cost analysis. On the contrary, an accurate cost analysis can offer a good basis for project control during construction while inaccurate cost analysis is prejudicial to both contractors and clients. Considering the great financial implications of construction projects, costs planning is an integral part of cost analysis and its therefore remains the focus point in the field of construction project management. Cost planning covers all aspects of cost control undertaken during the design stage of a project in order to deliver a building which fulfills the client’s goal of attaining a building within budget, at the desired quality and delivered within the agreed time (Eliufoo, 2000).

3.1 SNAPSHOT OF THE FRAMEWORK DEVELOPMENT

Generally, framework for a study relates to the philosophical basis for the research and forms the connection between theoretical aspect and practical constituents of the investigation undertaken. Conceptual framework represents an outcome of a number of related concepts explaining or predicting a given event or given a clearer understanding of the phenomenon interest of the research problem at hand. The process of concluding on a conceptual framework is similar to an inductive process whereby piece of concepts is joined together to give better perspective of possible relationship. To this end, conceptual framework is derived from concepts, hence, from literature point of view TPI is built on concepts and theory that is the concept of price (see section 2.2), concept of cost analysis (see section 2.3) and the theory of indices (see section 2.1). Furthermore, these concepts are affected by various indicators which are explicit and implicit. The implicit indicators were known as construction industry environment indicators in this study, it represents the in-built factors that determine prices of tender (See Table 1) whilst the explicit indicators were known as economic environment indicators representing general economic factors that influences the general prediction of TPI (See Table 1) these are normally produced by Statistical Service (See Figure 1: conceptual framework for the study).

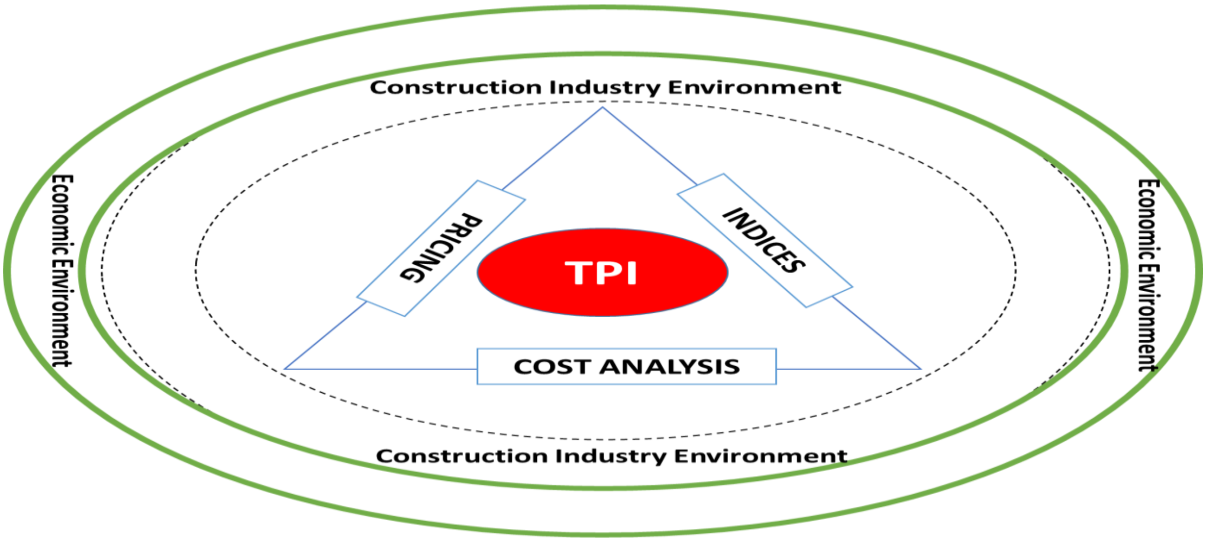

Figure 1: Conceptual Framework for TPI Development.

Table 1: Components in the conceptual framework

Components	Variables
Cost Analysis	Cost Planning and Checking
Pricing	Types of pricing
Indices	Principle of Laspeyres and Paasche
Construction Industry Environment Indicators	Contractor Attributes, Project Attributes, External factors and market conditions, Client Attributes Consultant and design, Contractor Procedures and Procurement methods, Sustainable and Technological Attributes, Fraudulent Attributes and Cultural Attributes.
Economic Environment Indicators	Cedis Exchange rate, Industrial Production, Unemployment Level, Output in construction, Price to cost Indices ratio in Manufacturing, Cost Index of building, Bank rate, Implicit Cedis Deflator-market prices, Construction New order, Gross Domestic Product, Real Interest Rate, Capacity Utilisation, Bank Base Rate, Retail Price Index, All Share Index, Income per Capital-Whole Economy, Work Stoppage in the construction industry, Money Supply, Industrial and Commercial Companies–Gross Profits, Output per person Employed–construction industry, Wages/Salaries/Unit of Output–Whole Economy, Number of Registered Private Contractors, Producer Price Index–Output Prices and Corporation Tax.

4.1 CONCLUSION

It is obvious that tender price index concept has travelled various fields of construction management literature. However, the issue on the conceptual framework for the studies have not been considered among researchers hence, this study establishes the conceptual basis for the study and development of the tender price index. As a developing country, the need to consider the dynamics within which the industry operates suggest the essence of this framework. Thus, the forgoing study in an attempt to develop the conceptual framework, indicated that tender price index is hinged on three main concepts, these are: indices, cost analysis and pricing. However, there is lack of understanding of these concepts among construction professionals in their attempt to develop tender price index, due to lack of capacity of institutions mandated for such activities. It can also be taunted that these institutions do not have the prerequisite skills needed for such exercise due to their level of appreciation of the three main concepts. This clearly suggests that for effective development of TPI in any developing country, there is the need to build a stronger appreciation of these concepts. Finally, this conceptual framework establishes the basis for the development TPI and its prediction base on a robust model, which can replicate in other developing countries incognisance of variables that are similar to Ghanaian Construction Industry.

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OBSTACLES TO SUSTAINABLE CONSTRUCTION IN DEVELOPING COUNTRIES

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ABSTRACT

Creating a sustainable built environment is a growing concern for the construction industry in developed and developing countries. Enormous efforts are required of stakeholders but they face extrinsic and intrinsic obstacles that prevent a smooth transition to sustainable construction (SC) practices. This paper identifies and discusses major barriers to SC in developing countries. It adopts a systematic review of literature in a structured approach. Some of the main obstacles identified include: poor understanding and awareness, lack of education and training among construction professionals, poor public attitude towards sustainability, poor implementation of sustainability principles and lack of accurate data and integrated research. Based on these findings, we have categorised the obstacles as follows: professionals' judgements, clients' philosophies, government mechanism and structure of the industry. In conclusion, the paper presents a framework of obstacles to sustainable construction in developing countries.

Keywords: Construction industry, developing countries, obstacles, sustainable construction, sustainability

1.0 INTRODUCTION

An obstacle refers to anything that blocks one's way. It prevents movement from one stage to another. Obstacles are part of development and can inhibit the success of projects. In the construction industry, obstacles to successful completion of a project include: limited budget, inclement weather, approvals or permits, workers and force majeure. Delays in completion, increased cost of construction and sustainability issues are some of the effects of these obstacles.

Sustainable development (SD) has been widely discussed and adopted in many facets of life. It is aimed at integrating environmental, social and economic factors to achieve what is ecologically possible (Emmanuel, Ibrahim & Adogbo, 2014). The term has been accepted and used in several sectors, including sustainable built environment, sustainable agriculture, sustainable production, and sustainable health practices. These sectors have proposed different measures to achieve SD. Sustainable construction (SC) is an approach that addresses the needs of the construction industry. Its purpose is to achieve sustainable development (Abidin, 2010).

The industry has been criticised for its contribution to environmental degradation which conflicts with the principles of sustainable development (Pearce, 2005). A review of literature (e.g. Dania et al., 2007; Oko & Emmanuel, 2013; Pearce, 2005) has uncovered the marked impacts imposed on the environment by construction activities. These highlight the need for sustainable construction. Creating a more sustainable built environment is a growing concern for the construction industry in developed and developing countries. Concerted efforts have been and are still being made in developed countries to achieve it. These efforts have resulted in policies, laws and the construction of several sustainable buildings. Although, SC has had an impact in some developed countries, the challenge is now for developing countries to follow suit. SC is all encompassing and may be problematic (Leiserowitz, Kates, & Parris, 2006). It requires huge efforts from all stakeholders but these face extrinsic or intrinsic obstacles. Extrinsic obstacles are external factors such as inclement weather while intrinsic are internal factors such as limited budget. These factors prevent a smooth transition to SC practices. Furthermore, construction professionals are responsible for ensuring that they integrate sustainable development measures into their practices (Cotgrave & Riley, 2012; Mostafavi & Doherty, 2010; Newman, Beatley, & Boyer, 2009; Newton, 2012) to achieve SC.

This study investigates SC, reviews the factors that hinder implementation and explores how they can be overcome. A framework that categorises these hindrances is presented.

2.0 LITERATURE REVIEW

The term 'sustainable construction' (SC) is generally used to describe pre-construction and post construction processes. Dickie and Howard (2000) defined SC as the efforts of the industry to achieve SD. Abidin (2010) agrees, describing it as a medium through which the industry can achieve SD. Hill and Bowen (1997) described it as the management and maintenance of buildings over its lifespan aimed at reducing deconstruction waste. Also, Du Plessis (2002, p. 8) described SC as *"a holistic process aiming to restore and maintain harmony between the natural and built environments, and create settlements that affirm human dignity and encourage economic equity"*. This definition suggests a synergy between the SD principles of the economy, environment and society that are complex and challenging to achieve for most developing countries (Serpell, Kort, & Vera, 2013). Although SC has been the subject of extensive research particularly in developed countries, little has been done in most developing countries, particularly in Africa.

The foregoing definitions indicate that SC is challenging to implement. Stakeholders include clients, professionals, material manufacturers, legislatures (government), planning regulatory bodies and builders. They are expected to reduce waste, construction cost and exercise effective maintenance strategies through careful material selection and decision making (Shafii, Arman Ali, & Othman, 2006). When deployed, these activities align the industry with the sustainable development agenda (Murray & Cotgrave, 2007). Adopting SC requires adequate consideration of SD principles in construction projects' lifecycles and sustainable practices by stakeholders (Hill & Bowen, 1997; Matar, Georgy, & Ibrahim, 2008).

There has been a marked and recent upsurge of urbanisation and infrastructure developments in most developing countries. This is evident in Asia and Africa. Countries like China, Malaysia, Hong Kong, South Africa, Nigeria and Tanzania are experiencing significant growth in their construction industries. Alongside these developments are the negative environmental impacts of construction. Most developing countries struggle with the rapid rate of urbanisation, poverty, low skill levels, weak governance, institutional incapacity, social inequality and environmental development. All these make development very challenging (Du Plessis, 2007; Ofori, 1998).

Studies from developed countries have identified obstacles in implementing SC. Williams and Dair (2007) reveal stakeholders' aloofness to sustainability as the most commonly recorded barrier. In the same vein, Häkkinen and Belloni (2011) identified steering mechanisms, economics, client understanding, process (procurement and tendering, timing, cooperation and networking) and underpinning knowledge (knowledge and common language, availability of methods and tools, innovation) as barriers to sustainable building. Wilson and Rezgui (2013) explored barriers to construction industry stakeholders' engagement with sustainability. They grouped the barriers into three categories. The first relates to individually perceived barriers and include lack of knowledge about sustainable construction, uncertainty and scepticism, distrust in information sources, reliance on technology and resistance to lifestyle change. The second relates to barriers organisations perceive, including lack of enabling initiatives, lack of training, work overload and prioritising current tasks and activities, lack of time for reflective actions and capitalising on lessons learnt, lack of information and knowledge sharing. The third relates to the barriers as perceived by industry in general, including lack of government action and government focus on regulation.

Several drivers of sustainable construction have also been identified. Häkkinen and Belloni (2011) recognised the development of clients' awareness of the benefits of sustainable buildings, development and adoption of methods for sustainable building requirements management, mobilisation of sustainable building tools, development of designers' competence and team-working and development of concepts and services as drivers of sustainable construction. Pitt, Tucker, Riley, & Longden (2009) identified the drivers to include; client awareness, building regulations, client demand, financial incentives, investment, labelling/measurement, planning policy and taxes/levies.

The aforementioned literature has identified that sustainable construction is challenging and requires the joint efforts of stakeholders for successful implementation, particularly in developing countries. It has shown that construction activities contribute negatively to the environment. It identified several obstacles of SC, some of which have been alleviated in some developed countries but may remain in developing countries. It is important to identify the obstacles confronting developing countries and identify how they can be mitigated to enable a smooth transition to SC practices. This is the overall research gap that this study contributes to.

3.0 METHODOLOGY

This study systematically reviewed relevant academic literature to identify the obstacles of SC (Häkkinen & Belloni, 2011; Pitt, Tucker, Riley, & Longden, 2009; Williams & Dair, 2007; Wilson & Rezgui, 2013). Searches for relevant articles were conducted using the university online databases and Google Scholar. The keywords used include: sustainability, obstacles, sustainable construction, sustainable development, construction industry and developing countries. Searches on *obstacles to sustainable* construction and *sustainable construction in developing countries* were also conducted. As expected, these searches resulted in an extremely large numbers of results.

The search was limited to peer reviewed journals in English. The advanced search feature in Google Scholar was used to set specific criteria. The time period was limited from 2000 to 2015. The abstracts of potentially relevant papers were then examined to determine if the original research included data about obstacles to SC. Afterwards, the full text version of relevant articles were selected. To obtain additional studies, the bibliographies of the articles consulted were reviewed for articles with different terminologies. Overall, 21 articles were obtained, reviewed and analysed. Similar articles relating to sustainability in different fields were also included.

4.0 FINDINGS AND DISCUSSION

This section analyses the 21 articles identified above. The methodologies adopted in these studies are shown in Table 1 and discussed below.

Table 1: Methodology adopted in the studies

Methodology	Frequency	Percentage (%)
Survey (Questionnaire)	8	38.10
Report	2	9.52
Focus Group Discussion	1	4.76
Literature Review	5	23.81
Case study	1	4.76
Multi Case Study	1	4.76
Mixed Methods	3	14.29
Total	*21*	*100*

Table 1 shows that the majority (38.10%) are based on questionnaire surveys administered to stakeholders in the construction industry. Literature reviews (23.81%) and mixed methods (14.29%) were also employed. Some researchers used case studies, surveys, focus group discussions and interviews.

These studies indicate that the construction industry impacts negatively on the environment (Abidin, 2010; Dania et al., 2007; Emmanuel, Ibrahim, & Adogbo, 2014) and that most construction projects in developing countries are not sustainable. According to Emmanuel et al. (2014), the sustainability of infrastructure is between moderate and high. Some factors fell below moderate. These include protection of the ozone layer, grid or standardised planning and release of water (Emmanuel et al., 2014). The implication is that the less sustainable infrastructure becomes, the more the environment becomes uninhabitable.

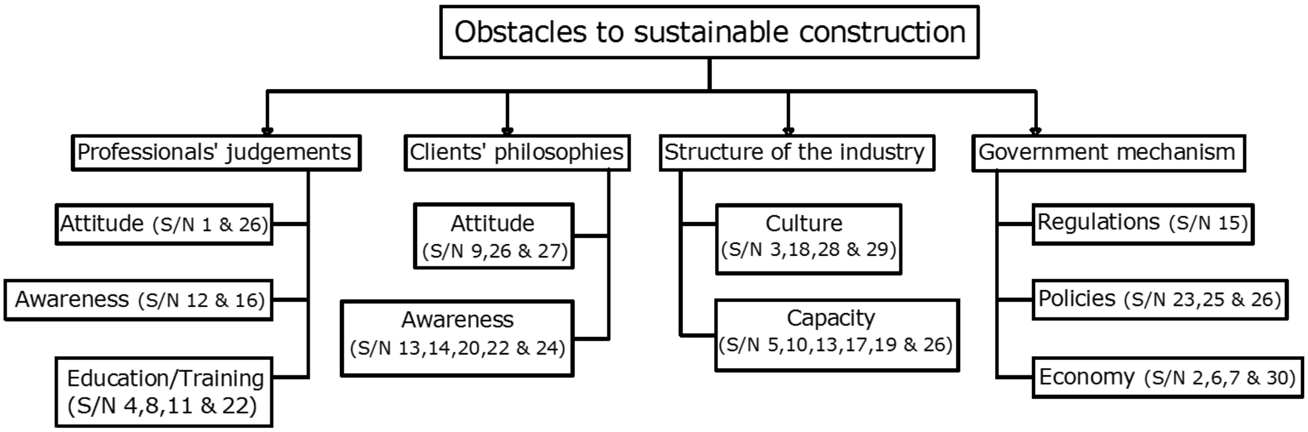
Table 2 lists the obstacles to SC and these are categorised in Figure 1. The categorisation is based on stakeholders' perspectives. Each category is sub-divided into groups reflecting literature by number and highlighted in bold text below.

Professionals' judgements are based on their attitudes, awareness, education and training. Their attitudes to SC stem from their resistance to change and inappropriate priorities (Wong & Yip, 2004). This is when professionals feel reluctant to adopt new technologies, systems and methods of construction because they fear it could waste time and incur additional costs. Professionals' attitudes to SC are very important if SC is to be achieved. Limited exposure, lack of knowledge, understanding and awareness of SC were also identified and grouped under awareness. Some are unaware of SC and its concepts. A study by Dania et al. (2013) found that practicing Nigerian construction professionals are lax in incorporating sustainable concepts. This could be attributed to their lack of exposure to the concept (Nwokoro & Onukwube, 2015).

Table 2: Obstacles of sustainable construction

	Obstacle	Author(s) and year
1.	Resistance to change	Wong and Yip (2004)
2.	Financial incentives	Wong and Yip (2004)
3.	Culture of the industry	Wong and Yip (2004)
4.	Lack of training and education	Abidin (2010); Ebohon and Rwelamila (2001); Gan, Zuo, Ye, Skitmore, and Xiong (2015); Nwokoro and Onukwube (2015); Shafii et al. (2006); Wong and Yip (2004)
5.	Lack of capacity of the industry	Du Du Plessis (2001)
6.	Uncertain economic environment	Du Du Plessis (2001); Ebohon and Rwelamila (2001)
7.	Poverty and low urban investment	Du Du Plessis (2001)
8.	Lack of accurate data	Du Du Plessis (2001)
9.	Lack of interest in SC issues	Du Du Plessis (2001)
10.	Lack of proven alternative technology	Du Du Plessis (2001); Pitt et al. (2009); Ebohon and Rwelamila (2001)
11.	Lack of integrated research	Du Du Plessis (2001); Babawale and Oyalowo (2011)
12.	Lack of knowledge, understanding and awareness of SC	Shafii et al. (2006); Abidin (2010); A. A. Dania et al. (2013); Jailani, Reed, and James (2015); Pitt et al. (2009); Dania et al. (2007)
13.	Higher cost of SC	Shafii et al. (2006); Pitt et al. (2009)
14.	Procurement issues	Shafii et al. (2006); Ebohon and Rwelamila (2001)
15.	Building regulatory barriers	Shafii et al. (2006); Pitt et al. (2009)
16.	Limited exposure of professionals	Shafii et al. (2006); Babawale and Oyalowo (2011)
17.	Lack of domestic materials production	Shafii et al. (2006); Ebohon and Rwelamila (2001)
18.	Lack of demonstration examples	Shafii et al. (2006)
19.	Lack of measurement standard	Hill and Bowen (1997); Emmanuel et al. (2014); Pitt et al. (2009); Shen, Tam, Tam, and Ji (2010)
20.	Lack of business case understanding	Pitt et al. (2009)
21.	Lack of client demand	Pitt et al. (2009); Gan et al. (2015); Abidin (2010)
22.	Vagueness of SC definition	A. A. Dania et al. (2013); Lai and Yik (2006); Du Du Plessis (2001)
23.	Lack of planning policy	Pitt et al. (2009)
24.	Clients' requirement	Gan et al. (2015)
25.	Lack of enforcement and monitoring of law and legislation	Abidin (2010); Nwokoro and Onukwube (2015); Ebohon and Rwelamila (2001)
26.	Inappropriate priority	Babawale and Oyalowo (2011); Shen et al. (2010); Gan et al. (2015); Shafii et al. (2006)
27.	Poor public attitude	Nwokoro and Onukwube (2015); Mansaray, Ajiboye, and Audu (1998)
28.	No common basis for information	Emmanuel et al. (2014)
29.	Lack of co-ordination	Ebohon and Rwelamila (2001)
30.	Huge political instability	Ebohon and Rwelamila (2001)

Figure 1: Framework of obstacles to sustainable construction



Lack of training and education; lack of accurate data; lack of integrated research and vagueness of a definition of SC were grouped under education/training. Construction professionals in developing countries lack SD adequate training. Although formal education has informed younger generations about SC techniques and equipped them for the tasks ahead, their theoretical skills have not been tested (Abidin, 2010). The lack of education and training was reported in most articles studied. Wong and Yip (2004) reveal that education and training in SC is rare due to heavy work commitments and lack of sponsorship from employers. Jailani et al. (2015) posit that the knowledge required to enhance sustainable performance has not been fully disseminated through the construction industry and that it is compounded by a lack of critical knowledge of building design and operation.

In a survey by Nwokoro and Onukwube (2015), education and training of professionals was ranked second out of ten social factors required for SC. Dania et al. (2007) discovered that construction professionals' understanding of waste management was deficient. They recommended that educational institutions should include SC in professional construction curricula and that professional bodies should use conferences and workshops to educate practicing professionals. Likewise, Lai and Yik (2006) conducted a survey to investigate the *"knowledge and perception of serving and prospective operation and maintenance practitioners in Hong Kong about sustainable buildings".* They uncovered a lack of understanding about sustainable building, indicating a clear disparity between experience, education and training. Shafii et al. (2006) also identified lack of training and education in sustainable design and construction, lack of awareness of sustainable building, lack of professionals/designers capabilities and several other factors as barriers to SC in Southeast Asia.

Clients, as initiators of construction projects, also play important roles in the successful implementation of SC. **Clients' philosophies** depend on their awareness and attitudes to SC. Their requirements, lack of demand, lack of business case understanding, and the higher cost of SC and procurement issues were grouped under clients' awareness. Literature reveals that most clients in developing countries do not require SC for projects. They tend to see SC as an expensive venture. This is evident from the requirements they articulate to their consultants which, in turn, contributes to the aforementioned procurement issues.

The structure of the construction industry also hinders the successful implementation of SC. Factors such as; culture of the industry; lack of demonstration examples; unreliable information and lack of co-ordination were grouped under culture. These hinder professionals who rely on practical examples. Similarly, a lack of capacity; lack of proven alternative technologies; inappropriate priorities; lack of domestic materials; lack of measurement standards and higher costs of SC were identified. These have a marked impact on SC. For example, the lack of a measurement standard implies that there is no accurate measurement for actions considered to be either sustainable or not (Hill & Bowen, 1997). Pitt et al. (2009) note that measurements of sustainability remain unknown. The industry relies heavily on imported materials as local sustainable materials may be scarce and / or unavailable. This in turn makes SC expensive in developing countries.

The role of government in achieving SD is very important. Government plays important roles through its **mechanisms** (policies and regulations). In addition, a favourable economic climate also helps the implementation of SC. Pitt et al. (2009) and Shafii et al. (2006) identified building regulatory barriers as one of the factors hindering SC. A lack of enforcement and monitoring of law and legislation; lack of planning and misplaced priorities were identified and grouped under policies. Gan et al., (2015) and Shafii et al., (2006) identified poverty reduction and infrastructural developments in developing countries as government priorities in achieving SD. Lack of enforcement and monitoring of law and legislation have also been identified as obstructing SC in developing countries. Abidin (2010) posits that in situations where awareness is high or moderate, implementation problems exist. Lack of institutional infrastructure promoting green buildings and professionals' capacity to incorporate green issues were also identified by Nwokoro and Onukwube (2015). Abidin (2010) identified factors that impede wider the implementation of SC as: financial constraints, lack of knowledge, passive culture, and education versus experience. In the same vein, financial incentives; uncertain economic environment; poverty and low urban investment and political instability were grouped under economy. These factors affect the economy which then distorts a smooth transition to SC.

Having identified these obstacles, the most significant challenge industry faces is "*finding a holistic approach to making sure that its contribution to the physical, economic and human development of these countries meets the requirements of sustainable development*" (Du Plessis, 2007). This results from different challenges facing different countries (Dania et al., 2013). Compared to developed countries, the construction industry in developing countries faces enormous challenges. Evidence (Du Plessis, 2002; Ofori, 2003, 2012; Plessis, 2001) identifies environmental issues and climate change, safety and health of construction workers, population issues, poverty alleviation, international construction, globalisation, technology development and innovation, information and communications technology, quality and productivity and disaster prevention and reconstruction to be some of the differences between developed and developing countries. There is thus a significant and serious gap between what is currently being done in terms of SC and what needs to be accomplished in the future.

5.0 CONCLUSION

This study reviewed literature on SC, revealing that it has become dominant in developed countries while very little has been done in developing countries. It also revealed that SC is challenging and requires the joint efforts of stakeholders for successful implementation. The research developed a framework of thirty obstacles relevant to SC in developing countries. Four categories of obstacles were identified namely: professionals' judgements, clients' philosophies, government mechanisms and structure of the industry. Professionals' judgments were further categorised pertaining to their attitude, awareness, education and training. Clients' philosophies were categorised based on their attitudes and awareness. Industry structure was peculiar to culture and capacity of the industry while government mechanisms were categorised based on regulations, policies and economy. These obstacles are dependent on each other which means that overcoming them requires robust holistic approaches. It is recommended that professionals are educated, trained and become aware of the potential of SC. This will influence their attitudes and position them to educate clients who may not be aware of the benefits of SC. The perceptions of construction professionals about sustainability and how sustainability can be measured could be a springboard for further investigation.

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NEW ZEALAND MAIN CONTRACTORS' USE OF BIM DURING THE PRE-CONSTRUCTION STAGE

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ABSTRACT

Main contractors' experiences of the benefits of using BIM for tendering of traditional design-bid-build commercial projects were investigated, as well as the challenges to more widespread use of BIM by contractors in New Zealand. Semi-structured interviews identified perceptions on the benefits of BIM for main contractors, as well as on the challenges which they face in achieving more widespread use of BIM. Significant findings that find support in the literature included the benefits to main contractors from using BIM for clash detection, increased communication and access to information (currently achieved mainly by the use of 3D visualisations), and the flexibility to seek alternative solutions, or 'optioneering' during tender stage. The only significant challenges to BIM implementation encountered by some participants were strong cultural resistance, and lack of support from senior staff; however, BIM use by main contractors on large commercial projects is well established in New Zealand, albeit usually at a fairly rudimentary level to date. Main contractors are extending into 4D (time) and/or 5D (cost) BIM, but progress is slow. Increased education of clients and other professionals to align expectations regarding BIM is recommended, as well as increased levels of early contractor involvement in the BIM process ("collaborative BIM").

Keywords: building information modelling (BIM), main contractors, New Zealand, tendering

INTRODUCTION

It is widely acknowledged that the worldwide use of BIM in the construction industry is on the increase (Eastman et al., 2011; Azhar et al., 2012; Demian and Walters, 2014). Most available research focusses on international perspectives of the client, architect/design professional or quantity surveyor, with few concentrating specifically on the main contractor. The research that is available is on the overall, general use of BIM for main contractors, the benefits and barriers to uptake, value and returns (Ku and Taiebat, 2011; Eadie et al., 2013, 2014). Main contractors are subject to different drivers and with BIM becoming more of a commercial reality, these differences should be explored to be able to understand and utilise the technology to its best advantage. The use of BIM by main contractors during tendering is not well documented, and this research aims to capture what they see as challenges to more widespread use of BIM, as well as the benefits they have experienced by its use in the pre-construction stage, and to provide a snapshot of main contractors' use of BIM during tendering in New Zealand.

BIM contextualized

BIM is a digital representation of a building's geometric and non-geometric data, and is used as a reliable, shared knowledge resource to make decisions on a facility throughout its lifecycle (National Building Information Modeling Standard [NBIMS], 2010). Various users can extract and use the invaluable data contained in the data-rich and intelligent 3D model objects. Parametric modelling facilitates the creation of a relationship between elements, and includes the specification and properties of individual elements and objects, potentially enabling the extraction of comprehensive and accurate information from the model which can be directly used for costing, i.e. '5D BIM' (Eastman et al., 2011).

A recent BIM survey (encompassing both New Zealand and Australia) found that BIM implementation by main contractors lags behind designers, with only 33% of contractors surveyed currently using BIM on 30% or more of their work, and that furthermore, only about a quarter of construction companies using BIM are doing so due to client demand, suggesting that "their BIM growth is being driven primarily by internally-generated interest" (McGraw Hill Construction, 2014, p.8). Indeed, the literature suggests that the contractor should push the client for early involvement to be able to add significant value and make the best use of the tools available, and that the contractor will lead the charge and develop their capabilities for their own competitive advantage (Eastman et al., 2011). This research hopes to provide an understanding of why this is not the case in New Zealand, where BIM use is being championed by designers, rather than contractors (or clients themselves).

RESEARCH METHOD

This research aims to address the following research question: What are New Zealand main contactors' perspectives on the use of BIM during tendering stage? This has been broken down into two sub-questions: (1) What are the potential benefits of BIM for main contractors? and (2) What are the challenges to more widespread BIM implementation by main contractors?

The research aimed to capture contractor participants' experiences of BIM at tendering stage using a survey methodology, with semi-structured interviews incorporating closed and open-ended questions in the form of a questionnaire. Face to face interviews gave participants the opportunity to have the wording of questions clarified, and the interviewer the ability to ensure that the questions were interpreted as intended. In order to minimise the potential for introduction of interviewer bias, the interview structure and questionnaire were piloted beforehand. The semi-structured nature of the interviews allowed for expansion on issues as they arose, and the interviews were voice-recorded to allow for post-hoc analysis. All six participants were from a total of four medium-large/large commercial main contracting companies, with all but one operating New Zealand-wide. Purposive, non-probabilistic sampling ensured that only those people that had some BIM experience were selected. Ethics approval was sought and obtained, and all responses were kept confidential, and participants' anonymity was ensured. Demographic questions covered areas such as participants' role within their company, their professional experience, and their level of experience with BIM. The next section queried participants on their perceptions of BIM use in the context of their particular firm. The issues raised in the questionnaire were drawn from a wide variety of sources in the literature (Eastman et al., 2011; Ku & Taiebat, 2011).

The format allowed the respondent to elaborate when needed, though also answer questions that were more targeted and closed, by using a semantic rating scale to assess the respondent's attitude towards issues. The points on the scale were attributed a number which could then be used for analysis, e.g. 1 to 5, and the ends of the scale were given opposite levels of agreement e.g. strongly disagree and strongly agree. Responses to the subjective open ended questions were analysed by identifying the themes from the participant's responses and trends were identified, and then compared with findings from the literature. The closed questions allowed the data to be translated from the raw data onto spreadsheets and tabulated.

FINDINGS AND DISCUSSION

Participant demographics

Participants' demographics are presented in Table 1. The roles and professional industry experience of participants varied, and 4 of the 6 participants were from contracting companies employing over 151 staff, and 3 of the 6 participants were from companies with an annual turnover of more than NZ$250 million. The range of BIM project experience varied widely (from one project to 35 projects). However, this is consistent with other research into the use of BIM across New Zealand, with findings that larger contractors are engaging in BIM-enabled projects and tend to be early implementers of BIM (McGraw Hill Construction, 2014).

All participants use BIM for the purposes of 3D visualisation, with 5 of the 6 participants augmenting this with external programmes (4D) created in MS Project, and 3 participants also incorporated cost data (5D) using Exactal CostX software.

Table 1 Participant demographics (n=6)

Role	Years of experience	BIM projects experienced	BIM projects by company
Bid Manager	14	3	5
National Technical Manager	28	6	6
Project Manager	3	1	1
Estimator	40	3	3
BIM Development Manager	9	35	5
Design and Engineering Manager	25	2	20

Only two of the 6 participants have a dedicated BIM bid/tendering team, but other participants have BIM specialist(s) who are involved and provide advice as and when required, but are not a 'dedicated' resource.

Potential benefits of BIM during tendering stage

Participants' ratings of the benefits of BIM for main contractors during tendering stage are presented in Table 2.

Table 2 Potential benefits of BIM during tendering stage (n=6)

Potential Benefit [1=Strongly Disagree, 5= Strongly Agree	(1)	(2)	(3)	(4)	(5)
BIM reduces the time taken to prepare project bids	1	1	1	2	1
BIM allows opportunities for alternative solutions to be considered during the tender phase			1	1	4
Clash detection is a very important benefit of BIM for the main contractor					6
BIM improves communication and access to information within the project team		1		1	4
Large value projects are well suited to BIM			1	2	3
The amount [or value] of rework reduces on BIM projects			1	3	2
The 3D visualisation function of BIM improves decision-making and reduces inaccurate drawing interpretation			2	1	3

Time to bid

Participants did think that BIM made price checking easier during the bid phase, which aligns with Thurairajah and Goucher (2013). Some participants commented that much more effort was needed to prepare the bid, but that BIM results in a better quality bid, and also benefits the construction methodology and visualisation, which far outweighs the increased time and effort to bid using BIM. Their expectation is that as their company becomes more familiar with BIM, less time will be needed to prepare bids. Eadie et al. (2013, 2014) suggest that a contractor's estimator will spend valuable time having to recode, or at the least, spend time verifying that the BIM model objects are coded correctly, until designers improve their object coding practices with regard to cost information.

Alternatives and optioneering

Participants generally agreed that BIM allows opportunities for alternative solutions to be considered during tendering stage. One participant commented that BIM offered more flexibility in 'optioneering', allowing the bid-team to virtually construct the building and being able to play-out 'what-if' scenarios, benefitting the project as a whole. Observations in a BIM-enabled case study by Eastman et al. (2011) were that alternative solutions to problems were more easily generated and comprehended, when compared with traditional design methods, and that undertaking build simulations, including alternatives, in front of the client, was a definite benefit at tender stage.

Clash detection and rework

All participants strongly agreed that clash detection, or spatial coordination, is a significant benefit to main contractors. McGraw Hill Construction (2014) found that 38% of contractors receive a high benefit from reduced errors and omissions, and describes spatial coordination as a valuable activity provided by BIM. Furthermore, Eadie et al. (2013) found that clash detection was the single most significant driver for adopting BIM. However, one of the participants pointed out that clash detection is most often carried out once the contract has been awarded, due to time constraints. Participants agreed that reduced rework by using BIM is beneficial; the ability for main contractors to utilise BIM tools for coordination of subcontracting trades prior to construction, with a resultant reduction in rework, was commented upon. This aligns with McGraw Hill Construction (2014), who found that 28% of contractors benefitted highly from reduced rework, and Eadie et al. (2013) found that cost savings through reduced rework were a very strong driver for BIM implementation.

Communication and access to information

Most participants strongly agreed that BIM improves communication and access to information within the project team. One participant disagreed, saying they felt that if the team didn't communicate without BIM, adding

BIM to the mix would not all of a sudden make them communicate. Many contractors see the ability to work collaboratively with owners or design teams as being highly beneficial, and has been identified as one of the 'top 5' BIM benefits (McGraw Hill Construction, 2014).

3D visualization, decision-making and coordination

The 3D visualization function of BIM was felt to improve decision making and reduce inaccurate drawing interpretation. Participants highlighted that the ability to get subcontractors to have input at an earlier stage, to avoid costly clash detection and rework on-site, was hugely beneficial. A survey of New Zealand and Australian main contractors found that 57% of contractors consider the use of 3D models to convey design intent as being the top benefit of BIM (McGraw Hill Construction, 2014). Eastman et al. (2011) found that walk-through visualizations can assist clients in the decision-making process, and so can reduce 'preference' changes later on. In a survey of U.S. contractors, Ku and Taiebat (2011) found that clash detection and visualization were the most commonly used BIM functions implemented by contractors. Eadie et al. (2013) also found that the improvements in design quality enabled by 3D visualization were rated by BIM users as an important driver for BIM implementation.

Challenges for main contractors using BIM during tendering stage

Participants' ratings of main contractor challenges of using BIM during pre-construction are presented in Table 3.

Cultural resistance

Most participants agreed that there is a cultural resistance to the change from traditional tendering approaches to one incorporating BIM processes, which supports the findings of Eadie et al. (2014) (from a survey of the UK Top 100 contractors) that the scale of culture change required was a very significant barrier to BIM implementation.

Similarly, Bryde et al. (2012) assert that successful BIM projects need the commitment and buy-in from directors. Participants commented on this point at length, stating that senior staff were often not computer-savvy, and were consequently being overly risk-adverse, and completely unwilling to entertain the idea of something new. Several commented on design professionals' lack of willingness to work with new technologies, or reluctance to share the information (model/data). Kue and Taiebat (2011) found similarly, describing the change from traditional 2D to 3D BIM (and beyond) as being a leap in technology, as well as a cultural and organisational change.

In stark contrast to the above though, were comments from 2 participants who disagreed with the statement about cultural resistance. They were 'very excited' about the changes in the industry with the arrival of BIM, and they are embracing the change in order to not be left behind.

Table 3 Challenges for main contractors using BIM during tendering stage (n=6)

Challenges [1=Strongly Disagree, 5= Strongly Agree	(1)	(2)	(3)	(4)	(5)
There is a cultural resistance to the change from traditional tendering approaches to one incorporating BIM processes	1	1		2	2
The high cost associated with training staff in BIM is too great for businesses	2	2	1		1
The length of time it takes for staff to become competent in the use of BIM is too great for businesses	3	1	2		
Software programme upgrades associated with BIM are too expensive for businesses	1	4	1		
Hardware upgrades associated with BIM are too expensive for businesses	1	4	1		
Traditional forms of procurement, such as Design-Bid-Build, are difficult to work with in a BIM environment	2	1	1	2	
BIM requires a complete change to business systems and processes	1	4	1		
BIM is unattractive to businesses due to the higher initial costs incurred during pre-construction phase (eg: design fees)	1	2		3	
Not many clients are requiring BIM on projects, so the incentive for more widespread uptake of use is limited	2	1	1	1	1

All participants commented on the industry changing and the desire to become more efficient in all areas. A participant commented that the use of BIM on their projects gave them a definite competitive advantage, in particular areas of modelling to look at resources and programming; this reinforces other findings that many main contractors who use BIM during pre-construction derive an improvement in trade coordination; for all main contractors, a benefit of making the decision to adopt BIM technologies into their businesses was to promote themselves as an industry leader (McGraw Hill Construction, 2014).

Implementation costs of BIM

Generally, participants did not consider that the costs involved in getting set up with BIM were a barrier; the 'cost of BIM' is seen, by their respective companies, as being the cost of doing business.

When discussing whether or not cost implications hindered the more widespread use of BIM in the industry, one participant said "… [the]

downstream benefits are where the most importance lies, particularly as 80 percent of cost of a building is in its operation, so really, if a client can get value out of the design process and have that information that is developed at that time, that can be transferred to the operation process - why wouldn't you want that?". Similarly, Bryde et al. (2012) commented that the costs of implementation can be reduced if BIM is utilised from the outset, and that once the initial technology investment has been made, costs will not be such a negative factor. This lends some support to the findings of Eadie et al. (2014) that cost of software and cost of training were only 3rd and 4th respectively, when ranked out of 10 possible barriers.

Procurement methods

All participants expressed their desire, as a main contractor, to get on board early to maximise their input and to take advantage of the BIM-enabled tools on the project from the start. One participant commented that getting the client to understand the value of a BIM-enabled project before choosing a design consultant was a key way of making BIM's use more widespread. Similarly, McGraw Hill Construction (2014) found most contractors surveyed felt more use of contracts to support BIM and collaboration was the factor most likely to increase BIM benefits for users.

Changes in business systems and processes

BIM was not felt to require a complete change to business systems and processes, with one participant commenting that it is the same process, but more efficient. Similarly, Bryde et al. (2012) purported that some negative effects of the cost of BIM implementation are less relevant than the positive effects brought about by updates in processes because of the implementation. several comments were directed at design consultants who were reluctant to share models or work with the main contractors for project benefits; late and/or uncoordinated designs mitigated some BIM advantages – "irrespective of whether the project is BIM-enabled or not, if you have late information you can't do much with it".

Demand for BIM-enabled projects

Some participants commented that clients are specifically requiring BIM – particularly government projects. Also some private sector clients were asking for BIM, which is coming through in tender documents, with clients wanting to know of tenderers' BIM experience. However, the most BIM-experienced participants highlighted that education of the client, and getting them to have the right level of expectation, was a barrier; this aligns with much of the literature (Ku & Taiebat, 2011; McGraw Hill Construction, 2014). As has been done in Singapore, and more recently in the UK, clients' use of BIM can be enhanced by having a government mandate Hopefully, recent developments on this front will provide forward momentum for the development of BIM in New Zealand, with the NZ BIM Handbook (Building & Construction Productivity Partnership, 2014) and

NZ BIM Schedule (Building Research Association NZ [BRANZ], 2014) available for use by industry.

CONCLUSIONS

Main contractors' perspectives on BIM use during tendering have been presented; the benefits they have experienced by its use, as well as the challenges encountered. Significant perceived benefits in improved clash detection/coordination, and the ability to consider alternative solutions and 'optioneering' were highlighted. The benefits of 3D visualisation in order to grasp complicated construction detail and project scope was also identified, as were the efficiencies driven into business systems and processes by the collaborative nature of BIM, providing the platform for main contractors seeking more efficient construction methodologies, less waste and stronger pricing. All participants commented that BIM would work best when used on Early Contractor Involvement (ECI) projects, as they have more input into the BIM process from the outset.

Few challenges to BIM implementation were perceived as being significant barriers; however most participants agreed that there was that there is still some way to go before BIM is fully embraced in the construction industry. Varied responses as to the level of cultural resistance to BIM were expressed, and most participants identified resistance by risk-adverse and senior staff, who are not computer savvy, as being a hindrance to more widespread uptake of BIM. This position was no surprise as the challenges to implement this new technology are well documented in the literature. Nevertheless, one of the main drivers for more widespread BIM use was felt to be increasing client demand for BIM-enabled projects, perhaps indicating an increasing awareness and interest in the BIM-sphere.

Contrary to much of the literature, the training, software or hardware upgrade costs of implementing BIM were not considered to be a major challenge, being seen as the current-day cost of doing business in a BIM-enabled environment.

Participants were overwhelmingly positive and enthusiastic in their current and anticipated use of BIM, and they realise and embrace the enviable position they are in, of being at the cutting-edge of the technology in New Zealand’s construction industry, and are regularly extending their knowledge into the 4D (time) and 5D (cost) areas of BIM.

This study only represents a snapshot of the perceptions of main contractors who are currently using BIM during tender stage, and due to the small sample size, generalizations to the larger sample population of all New Zealand contractors cannot be made. The findings could inform the design of a larger, more international survey of medium to large contractors, to build upon and update these findings, and to reflect any changes in this fast moving sector of the industry.

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ENVIRONMENTAL, SOCIAL AND ECONOMICAL PARAMETERS OF SUSTAINABILITY IN GREEN BUILDING RATING TOOLS WORLDWIDE

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ABSTRACT

"*Sustainability*" has become one of the buzz words in the era especially in the construction industry. It has multiple interpretations and sometimes it means different things to different people. However, in commonly known terminology, the concept of sustainability is regarded to be three-fold; environmental, social and economic. This is usually identified as the triple bottom line of sustainability and often represented by three intervened circles and all core elements of sustainability can be related to these three pillars of sustainability. In terms of construction industry, numerous international green building rating tools have been developed providing a yardstick for measuring sustainable building performance. However, the extent to which the economical and social pillars of sustainability evaluated in these rating tools are questionable. Therefore, this research aims to analyse the effectiveness of eight green building rating tools worldwide in evaluating economical and social sustainability in buildings. The rating tools used in the study are: (1) Leadership in Energy Efficiency Design (LEED); (2) Building Research Establishment Environmental Assessment Method (BREEAM); (3) Green Star; (4) Green Mark; (5) Green Building Index (GBI); (6) Indian Green Building Council Rating System (IGBC); (7) Building Environmental Assessment Method (BEAM) Plus; and (8) Comprehensive Assessment System for Building Environmental Efficiency (CASBEE). The credit points of each rating tool is initially categorised based on the related category of sustainability, that is, economical, social or environmental sustainability.Then a comparison analysis is carried out based on a quantitative measure, namely, a normalised score. Finally, the comparison result is presented with radar diagrams. According to the findings, environmental sustainability is widely considered in green building rating tools while economical sustainability is rarely evaluated.

Keywords: Economical sustainability, Green buildings, Green building rating tools Social sustainability, Sustainability

INTRODUCTION

The concept of sustainable development evolved based on the availability of limited resources since its inception and it gained its momentum with the definition of "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" stated in Brudtland report (Brundtland, 1987). Ever since, sustainable development was adopted and defined by many researches. (Curran, 2009; Giddings et al., 2002; Kuhlman & Farrington, 2010). According to Grierson (2009), the initial definition meant that a balance can be achieved between human socioeconomic activities, natural resource availability, and environment preservation.

In more commonly known terminology, the concept of sustainability is regarded to be three-fold; environmental, social and economical (Elkington, 1994). In synthesizing all these definitions, Vos (2007) illustrated that nearly all shared core elements of sustainable development are related to economical, social and environmental considerations. According to Said and Berger (2013), sustainable development should be comprehensive and consider all triple bottom line aspects. These three domains are often identified as the three pillars of sustainable development or the triple bottom line (Carew & Mitchell, 2008; Kats et al., 2003) and it is thus illustrated as the intersection of three intertwined circles.

These three elements reciprocally reinforce each other, and economic growth and social well-being are underpinned by environmental concerns, and vice versa (Svensson & Wagner, 2015). However, according to Welsford (2014), in order to sustain the environmental and social practices, the options must remain economically viable. According to Young (1997), economical, environment and social sustainability are like a three legged stool. Therefore, if one leg is missing from the 'sustainability stool' it will cause instability because society, the economy and the ecosystem are intricately linked together (Young, 1997).

Environmental sustainability refers to the long-term viability of the natural environment maintained to support long-term development by supplying resources and taking up emissions and result in protection and efficient utilisation of environmental resources (Balkema et al., 2002). A much narrower explanation of this would be "not leading to the depletion of resources or the degradation of environment" (John et. al., 2014). Economical sustainability seeks to maximize the flow of income that could be generated while at least maintaining the stock of assets (or capital) which yield this income (Solow, 1992). Economic prosperity is concerned with the monetary gains from the project for the benefits of the clients, contractors, public and the government (Abidin, 2010). Further, growth, efficiency and stability are identified as elements of economical sustainability (Munasinghe, 2004). According to Balkema et al. (2002), economical sustainability should, in principle, include all resources: also those associated with social and environmental values but however, in practice most analyses include only the financial costs and benefits.

However, when considering the building sector, sustainable development through green buildings is a much discussed topic. According to Chan et al. (2009), green buildings bring together a vast array of practices and techniques to reduce the impacts of buildings on energy consumption, environment and human health and supports the triple bottom line in sustainable development. However, it is necessary to assess the extent to which these green buildings serve the purpose of sustainability. Therefore green building rating tools were developed to act as a solid yardstick in evaluating the building (Eichholtz et al., 2010).

There are many green building rating tools developed by many institutes and organizations in many countries reflecting the requirements of the relevant country. First and foremost green building rating tools were launched in 1990 in United Kingdom (UK), named Building Research Establishment Environmental Assessment Method (BREEAM) (Building Research Establishment Environment Assessment Method, 2015). Afterwards, the mostly discussed and widely used green building rating tool was launched by the United States Green Building Council (USGBC) named Leadership in Energy and Environmental Design (LEED) (United States Green Building Council, 2015a). LEED building rating system is accepted in many countries in the world with 1.85 million square feet of construction space certifying every day (United States Green Building Council, 2015b). Further, there are many rating tools such as Green Star in Australia, Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) in Japan, Green Mark in Singapore and all these are widely discussed and evaluated by many researchers (Crawley & Aho, 1999; Gowri, 2004; Haapio & Viitaniemi, 2008; Reed et al., 2011).

Each of these rating tools has developed credit points and certain standards to evaluate the extent to which the building is sustainable. However, it is necessary to identify as to what extent the pillars of sustainability is evaluated by these rating tools through these credit points. This is a significant requirement which is rarely addressed by the literature. Therefore, this research evaluated the credit points allocated by the selected green building rating tools to identify the extent of economic, social and environmental sustainability parameters considered in green building rating.

RESEARCH METHODOLOGIES

To evaluate the extent to which environmental, economical and social parameters of sustainable development is considered in green buildings; initially eight well established green building rating tools were selected representing different regions of the world. According to the World Green Building Council (2015), out of 71 green building council members, 27 councils were identified as established green building councils. Therefore, these 27 established green building councils were classified under the main geographic regions and based on the extent of usage; widely used green building rating tools were selected and reported in Table 1.

Table 1 Green Building Rating tools

Region	Assessment tool
America	LEED
Europe	BREEAM
Asia-Pacific	BEAM Plus[1], Green Mark, CASBEE[2], GBI[3], IGBC[4] , Green Star - Australia
Middle East and North Africa	LEED, BREEAM

[1] BEAM Plus – Building Environmental Assessment Method (from Hong Kong)
[2] CASBEE - Comprehensive Assessment System Built Environment Efficiency (from Japan)
[3] GBI – Green Building Index (from Malaysia)
[4] IGBC – Indian Green Building Council Rating (from India)

These tools identified in Table 1 were used for this research. There are many versions and types developed by each of these green building rating tools. In the selected eight green rating tools there are different schemes available. For certain tools such as BREEAM and LEED, there are different versions available for new construction, renovations and community development and so on. In such circumstances the latest version is selected for analysis. Further, in these rating tools, there are different schemes for different types of buildings such as schools, non-residential buildings and residential buildings. In such cases, the relevant rating tools related to non-residential buildings are considered for the study. The main reason for the selection of new construction of non-residential buildings is majority of projects certified are newly constructed non-residential buildings (Green Building Council Australia, 2015; United States Green Building Council, 2015a)

Credit points of each rating tool were evaluated and classified as to which pillar of sustainability is represented through the specific credit criteria. In each rating tool the final rating on the green building is given based on the final score obtained by each building evaluated. The final score is calculated based on the credit points which are identified by green building rating tool. Therefore, it is argued that to evaluate the extent to which the specific building is sustainable can be evaluated by the credit points each building can achieve. As an example if a building can obtain a higher score by getting higher number credit points can obtain a higher rating reflecting the higher standard of sustainability. Considering that fact, this research evaluates the effectiveness of each green rating tool in attaining the triple bottom line of sustainability in terms of the credit points allocated to each pillar.

All these rating tools had "Innovation" credit points which were given to reward the new innovative ideas of designers and professionals. Therefore, "Innovation" credit points were excluded from the study. These rating tools have published many versions of rating guidelines. Therefore, for this research the latest version of rating tools were used. Further, when there were different versions available for different types of buildings, versions related to new construction and non-residential buildings were taken for the study. The main reason for the selection of new construction of non-residential buildings is majority of projects certified were newly constructed non-residential buildings (Green Building Council Australia, 2015; United States Green Building Council, 2015a)

When allocating credit points to environmental, economical and social pillars separately, certain credit points represented one or more pillars of sustainability. In such cases it is allocated to the most suitable pillar after considering the intent of this credit. In most of the rating the reasoning or the intent of the credit point is given. In those uncertain instances the classification was done based on the aim or the intent given in the respective green building rating tool. As an example, credit points which were allocated to reduce the Volatile Organic Components (VOC) were usually categorized under social pillar of sustainability because in general the main aim of introducing such a credit was to provide the building occupants a healthy environment. However, it is possible to argue that reduction in VOCs to be categorised as environmental sustainability in the long run. In this instance credits pertaining reduction in VOC were allocated to social pillar of sustainability.

In allocating credit points, when there was a range of credits available for particular credit criteria, the maximum credit points were taken into consideration. In CASBEE rating tool, there are no points allocated for each credit point (CASBEE, 2014). The credit allocation of CABSEE is comparably different from other rating tools. In this tool, each credit point was evaluated based on a scale ranging from level 1 to level 5. For credit points to be evaluated on a scale, these credit points are to be equally important. Further, if there are no weighting factors given, all credit points are assumed to be of equal importance and there is no order of importance for credit points (Ding, 2008; Todd et al., 2001). Therefore, for the calculation purposes, each credit point evaluated on the scale is given the value of "1" when allocating points for each pillar of sustainability.

In certain rating tools such as BREEAM, Green Mark and IGBC, there were pre-requisites to be fulfilled which were not given credit points. Therefore, these were not reflected in the calculation for this study. Further, in these ratings there were certain credit points which were not categorised into any of these pillars. In such cases, these were allocated to a separate category called "other".

After allocating all the credit points to the relevant pillar of sustainability, the final scores were calculated. Once the scores were established, these were normalised on the basis of 100 to illustrate the importance each rating tool had given to each pillar of sustainability. Finally, based on the normalised scores, radar diagram was developed illustrating the extent to which each rating tool allocate credit points for the three pillars of sustainability.

ANALYSIS ON THE CREDIT POINT ALLOCATION ON PILLARS OF SUSTAINABILITY

As given on the research method, after developing the normalised scores the radar diagram was developed, as given on Table 2 and Figure 2 respectively.

Table 2 Normalised scores for green building rating tools on three pillars of sustainability

	Environmental Sustainability (%)	Social Sustainability (%)	Economical Sustainability (%)	Other (%)
Green Star	74.00	19.00	0.00	7.00
LEED	73.77	18.85	0.82	6.56
BREEAM	74.62	16.15	2.31	6.92
Green Mark	77.40	18.64	0.00	3.95
GBI	69.57	21.74	0.00	8.70
BEAM Plus	55.71	30.00	0.00	14.29
IGBC	78.41	15.91	0.00	5.68
CASBEE	25.00	17.95	0.00	57.05

Based on the comparison among green building rating tools, environmental sustainability is given the highest priority in all the rating tools except for CASBEE (Refer Figure 1). Further, majority of the rating tools except for GBI, BEAM Plus and CASBEE, had allocated approximately

74% to 78% of the credit points to ensure that the environmental sustainability is embedded in the green buildings. According to Table 1, GBI allocated 65.57%, BEAM Plus allocated 55.71% and CASBEE allocated the least of 25% of the credit points to environmental sustainability.

Social sustainability was addressed in almost all the green building rating tools worldwide to a considerable extent (Refer Figure 1). Further, according to Figure 1 it is clearly illustrated that, BEAM Plus has slightly higher consideration on social sustainability compared to other rating tools.

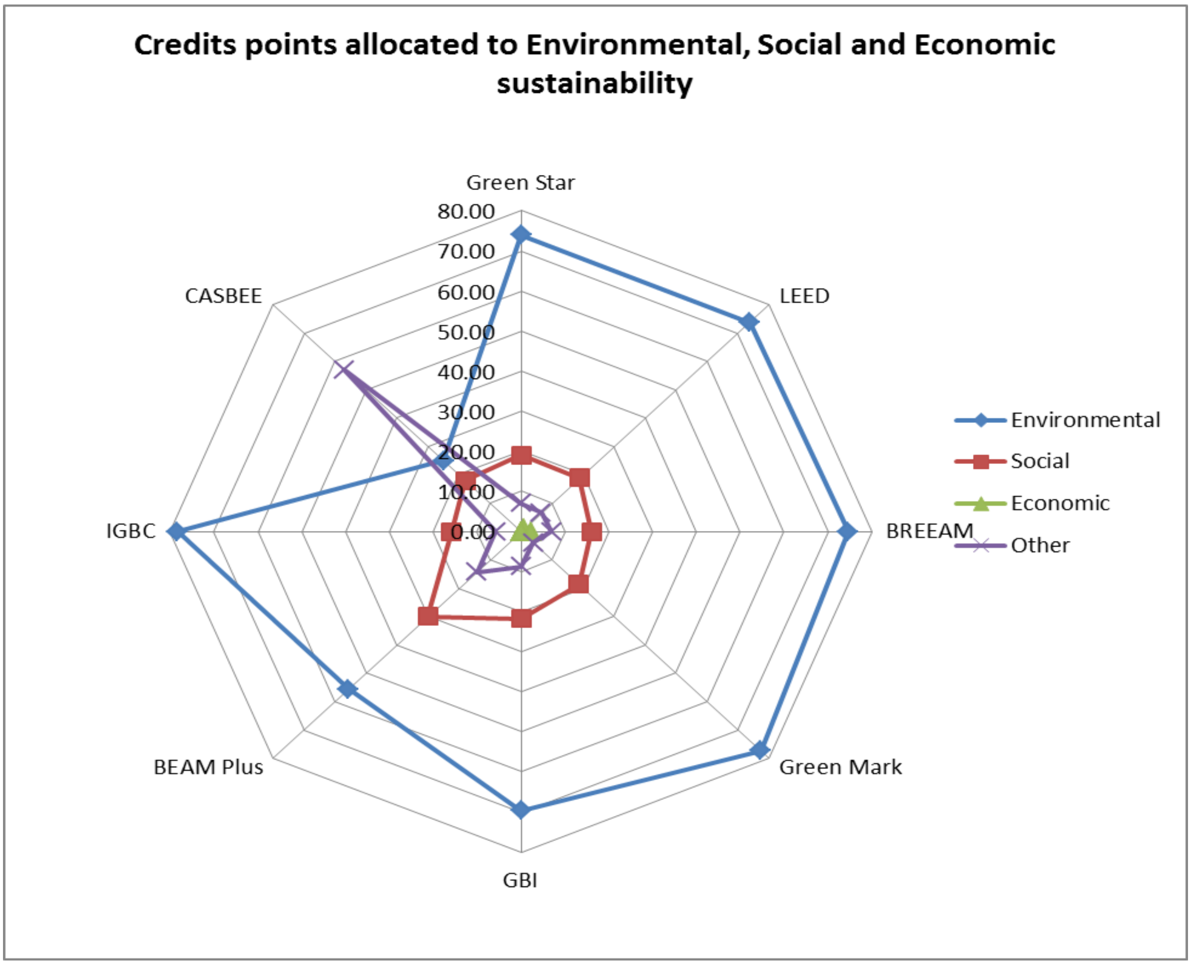

Figure 1 Credit points allocated to Environmental, Social and Economical sustainability

However, it is interesting to note that economical sustainability is almost not considered in most of the green building rating tools. According to Table 2, only LEED and BREEAM had allocations for economical sustainability of 0.82% and 2.31% respectively. In LEED rating system there was one credit point allocated to “integrative process” which focused on cost effective solutions. Similarly in BREEAM, there was a credit point allocating 3 credit points for “life cycle costing and service life planning” which directly related with the economical pillar of sustainability. However, in each of these rating tools, there was a main criteria for "Energy". This directly focused on reduction in energy usage which is strictly required due to the severe problems in fossil fuel combustion and many other environmental issues. Therefore, these credit points were allocated to environmental pillar of sustainability. However, with the reduction of energy usage, when the building life cycle is considered, there can be massive savings over the life span. This aspect was not reflected in here.

According to Figure 1, there were certain credit points which do not directly entertain any of these three pillars of sustainability. These points were significant in BEAM Plus and CASBEE. CASBEE is a green building rating tool which was developed to suit the specific requirements of the country (Suzer, 2015). Further, majority of the credit points which falls into the other category in CASBEE are directly related to earthquake resistance. In BEAM Plus these other credit points included design aspects such as "design appraisal', "modular and standardised construction" and "adaptability and deconstruction", which are not directly related to any of the three pillars of sustainability.

CONCLUSIONS

In this research, the credit points of the selected green building rating tools worldwide were analysed based on the extent to which those credit points reflect the three pillars of sustainability. Almost all the green building rating tools had given a significant focus on environmental sustainability except for CASBEE. Further, the least focus was given to economical sustainability, whereas only LEED and BREEAM allocated direct credit points to evaluate the economical sustainability. Therefore, significant attention must be given to include credit points to motivate the professionals to develop economical and cost effective solutions in green building construction especially in an era where the cost premium of green buildings are at a debate. Further, according to the literature, it is necessary to balance the triple bottom line in sustainable development. Therefore, economical sustainability must also be considered when further developing these rating tools in future.

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INVESTIGATING THE BARRIERS TO SUSTAINABLE HOUSING IN WESTERN AUSTRALIA: PERCEPTIONS OF KEY STAKEHOLDERS

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ABSTRACT

Sustainability in the built environment is becoming a more prominent issue that the construction industry needs to address, in order to achieve environmental and social benefits, and lower environmental impacts. Furthermore, mediating the implications of housing is crucial, as a response to major environmental issues such as global warming and climate change. The purpose of this study is to contribute a better understanding of sustainable housing in Western Australia, by identifying knowledge of, and attitudes towards, sustainability in the residential housing market by major stakeholders, including building professionals, householders and real estate agents. The research investigated the barriers associated with its uptake and ranked them in terms of their criticality. The study collected data from 72 participants using a quantitative survey. The results show that a range of political, economical, social and technical factors affects sustainable housing. The most critical barriers were identified as inadequate building regulations, a lack of or insufficient rebate programs and increase capital cost. Recommendations made in this report include, developing a cost/benefit research program, education and training, government providing rebates and incentives, and legislation making sustainable practice mandatory. The results of this report hope encourage behaviour change, and increase the uptake of sustainable housing.

Keywords: Sustainable housing, Western Australia, Drivers, Barriers

INTRODUCTION

Today sustainability in the built environment is becoming a more prominent issue that the construction industry needs to address, in order to achieve environmental and social benefits, and to lower environmental impacts. A rapidly increasing population has seen an increase in the level of construction activity across the globe. The housing sector has been identified to have a range of negative impacts on the natural environment including, global warming, climate change, ozone layer depletion, solid waste, air and water pollution, ecosystem destruction and natural resource depletion (Ahn et al., 2013). The consumption of energy in the residential sector is a major contributor to Australia's stationary energy greenhouse gas emissions (Department of Climate Change and Energy Efficiency, 2010). Henry (2012) believes focusing on the performance of existing housing is crucial to improve sustainability of the built environment. To act in a more sustainable manner, research is required to identify knowledge of, and attitudes towards sustainability in the residential housing market by major stakeholders (Yang and Yang, 2014).

The aim of this research is to minimise the residential construction industry's negative impacts on the natural environment. In order to achieve this aim, highlighting the importance of sustainability in the built environment will require a number of objectives to be met. The research will be required to: 1) identify the barriers associated with the uptake of a more sustainable housing market in Western Australia; 2) rank the barriers in terms of their criticality; and 3) develop an agenda with recommendations to promote sustainable housing and encourage behavioural change has been developed based on the data collected.

LITERATURE REVIEW

Promoting sustainable housing is a challenge concerning policy makers at many scales (Henry, 2012). Along with government, a number of stakeholders can strongly influence the housing sustainability market through the inclusion/exclusion of potential sustainability measures, and the emphasis or weighting placed on elements (Gething and Bordass 2006). Architects, property developers, interior designers, builders, and real estate agents are all said to be influential professionals who can help drive "the market". According to Henry (2012), government and corporate stakeholders are more aware about issues such as climate change, and have become increasingly concerned about potential solutions such as sustainable housing. Hayles (2012) investigated the relationship between sustainability and affordability, and questioned whether affordability, which is related to reducing the whole life cycle cost of owning a home, is going to be driven by the consumer, the market, or legislation. Research into existing literature found that both, consumer and developer awareness of the issues are equally important. A consumer needs to be educated how to best run their home for reduced operating costs and maximum comfort, while a developer needs to realise why they are required to build to a certain standard.

In consonance with the emerging benefits and definitions of sustainability, various factors can be identified as influential to the implementation of sustainable practice across stakeholders (Yang and Yang 2014). A factor can either have a pull or push effect depending on how it is applied. Sometimes a barrier may appear as a driver when used in another way. For example, economic cost at the construction stage is seen to be a barrier due to the perception of increased capital requirements, however it is also a driver as it reduces utility costs during the operation phase. Glass, Dainty and Gibb (2008), used the PEST model of analysis to determine the drivers and barriers associated with developing improved standards in the construction industry. The drivers and barriers were catergorised under the following categories; political, economical, social and technological. Yang and Yang (2014) conducted research into multi-dimensional issues preventing the uptake of sustainable housing in Australia. The research explored various factors that influence the decision making of key stakeholders towards sustainable housing implementation by means of drawing insights from combined interview and questionnaire studies. The top five most important factors drawn from the categorized data included economical, institutional/political, technical and design, and socio cultural factors.

Political factors refer to legislation set out by government, and external regulatory bodies and policies. According to Gan et al. (2015), government policies and regulations provide the main approach to mitigating the negative impact of construction activities on the environment and society. However the level of success driven by these regulations and policies is in accordance with not only their content, but also their enforcement. Ahn et al. (2013), believes a lack of rebate or incentive programs offered by government reduces the drive for individuals to be sustainable. According to Häkkinen and Belloni (2011), legal and administrative barriers such as problems attaining planning permission and receiving certification inhibit the uptake of sustainable practice (Reid, 2012). Economic factors are considered to be the associated costs, risks and benefits related to sustainable housing. It is understood economic factors are generally renowned to be the highest priority for owners when new technologies or norms are introduced into the construction industry (Gan et al., 2015). Compared to traditional construction methods, the fear of higher costs is perceived as a barrier inhibiting the uptake of sustainable dwellings (Henry, 2012). Bon and Hutchinson (2000), also claim that one of the largest barriers to residential sustainability is the misconception of inadequate market value alongside higher capital costs. Sustainable techniques and technologies can produce major cost benefits when in use; however this is not effectively communicated to a wide audience (Häkkinen and Belloni 2011). Zhou and Lowe (2003, p116) conform to these barriers stating, "Investors and developers hold the misconception that capital costs will raise when they apply the sustainable construction methods; they lack to understand the economic benefits of sustainable construction.

Furthermore, the challenge for investors includes the difficulties to obtain financial supports and a lack of visible market value." The social drivers of residential sustainability include increased user satisfaction, improved occupant productivity and health benefits. Social drivers compliment economic prospects as they improve the tenant's turnover rates, enhance selling and letting potential and reduce the risk of tenants vacating (Häkkinen and Belloni 2011). Vanegas and Pearce (2000) believe the increasingly noticeable impacts of the building environment on human health promote sustainability in accordance with the perceived health benefits. The health benefits improve quality of life for individuals, and society as a whole. The US Green Building Council (2011), conforms to these ideas stating, sustainable design and construction is driven by environmental and community benefits, and enhanced occupant health and well-being. The barriers identified in this paper are shown in Table 1.

Table 1. Barriers to implement sustainable housing in Western Australia

Barriers			
Category		**Description**	**Reference**
Economic			
BE1	Increased Capital Cost	Green technologies and building methods incur additional cost.	Henry (2012)
BE2	Perceived Risk	Fear of spending extra money and not receiving a better return to compensate	Zhou and Lowe (2003)
BE3	Lack of market demand	Lack of visible market value by consumers	Bon and Hutchison (2000),
BE4	Split Incentives between parties	Builders want to build a house for cheaper which is more expensive to run for householders and vice versa	Bond (2011)
Political			
BP1	Building Regulations	If building regulations are not formulated then individuals will not be forced to be sustainable	Gan et al. (2015)
BP2	Approval and Certification	Problems attaining planning permission and receiving certification inhibit the uptake of sustainable practice	Häkkinen and Belloni (2011)
BP3	Policy Enforcement	A well structured policy is ineffective without adequate enforcement	Gan et al. (2015)
BP4	Rebate programs	A lack of or insufficient rebates offered by government deters people from being sustainable	Ahn et al. (2013)
Social			
BS1	Lack of consumer information	The public is unaware of the initiatives to endorse sustainable such as grants and rebates.	O'Leary (2008)
BS2	Professional Motivation	Construction companies are not actively offering sustainable options of building refurbishments, as they cannot identify sufficient demand.	Rohracher (2001)
BS3	Lack of education and training	Professionals and consumers have little or no knowledge about sustainable homes	Sponge (2006)
BS4	Tendency to maintain current practices	Society is resistant to want to change our behaviour and attitudes towards sustainable living	Du Plessis (2007)
Technological			
BT1	Extension of project schedules	Possibility of project delay from higher risk foreseen with unfamiliar techniques including, additional testing and inspection, the lack of previous experience	Häkkinen and Belloni (2011)
BT2	Limited supply of sustainable materials/products	Sustainable practice is concerned with the availability of advanced technologies, which requires specialized human and material resources	Hill and Bowen (1997)
BT3	Methodologies and tools to measure sustainability	Unclear methodologies and tools create inconsistency in the way sustainability is defined and measured	Ang, Groosman and P. M. Scholten (2005)
BT4	Inadequate or untested sustainable technologies or materials	Limited availability to new technology, unreliable/unproven technology and poor access to information	Bond (2010)

RESEARCH METHOD

In order to deliver the research objectives, survey questionnaires were designed, developed and implemented to obtain quantitative data. The survey method is preferred. A cover letter describing the survey, the questionnaire, and a prepaid self-addressed envelope was then emailed/mailed to householders, building professionals, and real estate agents around the Perth metropolitan region. A web-based questionnaire was also available where interviewees were given the web link to participate instead of completing and returning a hardcopy. A total of 500 questionnaires were disseminated, and 73 valid responses collected. Questionnaires were returned anonymously, meaning no formal reminder strategy was used to target individual non-responders. The responses were separately coded, and entered into a computerised database in order to be analysed. The barriers were rated by three groups of stakeholders (builders, agents and industry professionals), using a 5-point Likert Scale (1 = significantly unimportant; 5 = significantly important).

The means and standard deviations of the drivers and barriers were calculated to determine their criticality. In addition, it is important to analyse the consistency of responses from the three different stakeholder groups that were involved. One method of assessing the variance was to adopt the ANOVA analysis, which is dependent on the normality of the data. The normality of the data was verified using a Kolmogorov-Smirnov test. The null hypothesis was that there was no significant difference between normal distribution and the data. The p values of all drivers and barriers were 0.000. Therefore the data was not normally distributed resulting in the null hypothesis being rejected. Variance was assessed using a Kruskal-Wallis one-way analysis. The null hypothesis proved that the difference between the mean ratings of different stakeholders was in insignificant. If the p value was below 0.05, the null hypothesis could be rejected, suggesting the difference amongst the mean ratings of the three stakeholder groups was significant. In order to effectively identify key factors from a non-normal distribution, the Fuzzy set theory was adopted in this study (Shen, Wu, and Zhang, 2011).

Results

Importance of barriers

The outcomes of participant's perceptions regarding the importance of barriers relating to sustainable housing are shown in Table 2. The means and standard deviations of the barriers highlight their criticality. As per the results seen in Table 2, the most critical barrier hindering sustainable housing is a lack of building regulations (BP1). Furthermore tendency to maintain current practices (BS4) was also rated as being a significant barrier, which validates the ranking of BP1 that building legislation is required to overcome this culture. The second most important barrier was rebate programs (BP4) that, suggests insufficient incentives by governments deters people from being sustainable Ahn et al. (2013). It must be understood that rebates and incentive programs will be at the benefit of the householders, and the data supports this claim as Table 2 shows the households have rated BP4 the highest. One interesting finding is that inadequate or untested sustainable technologies or materials are rated as the least critical barrier, possibly indicating that we do have sufficient access to these features.

Table 2. Means and standard deviations of barriers of sustainable housing

Code	All (N=73)		Households (N=30)		Builders (N=22)		Real Estate (N=21)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
BE1	3.81	0.828	3.7667	.97143	3.9091	.61016	3.7619	.83095
BE2	3.56	0.764	3.5000	.93772	3.6818	.56790	3.5238	.67964
BE3	3.33	0.783	3.2667	.86834	3.3182	.71623	3.4286	.74642
BE4	3.40	0.878	3.4333	.77385	3.0000	.92582	3.7619	.83095
BP1	3.85	0.794	3.8000	.76112	3.7727	.86914	4.0000	.77460
BP2	2.93	0.948	3.2000	.92476	2.4545	.59580	3.0476	1.11697
BP3	3.44	0.866	3.5333	.86037	3.2727	.88273	3.4762	.87287
BP4	3.84	1.000	4.0667	.82768	3.7273	.93513	3.6190	1.24403
BS1	3.62	0.700	3.8333	.74664	3.6364	.58109	3.2857	.64365
BS2	3.08	0.939	3.3667	.96431	3.1818	.95799	2.5714	.67612
BS3	3.38	0.922	3.7000	.91539	3.2273	.97257	3.0952	.76842
BS4	3.19	1.076	3.1667	.98553	3.4091	.90812	3.0000	1.34164
BT1	3.01	0.920	2.8333	.87428	3.1818	.90692	3.0952	.99523
BT2	2.96	0.920	3.0333	.85029	2.8636	.83355	2.9524	1.11697
BT3	3.03	0.928	3.0000	.90972	3.1818	.90692	2.9048	.99523
BT4	2.89	1.021	2.9000	1.12495	2.6818	.89370	3.0952	.99523

Group perceptions of barriers

The findings of the Kruskal-Wallis one-way analysis of variance are presented in Table 3. The P values of 12 barriers (BE1: increased capital cost; BE2: perceived risk; BE3: lack of market demand; BP1: building regulations; BP3: policy enforcement; BP4: rebate programs; BS3: lack of education and training; BS4: tendency to maintain current practices; BT1: extension of project schedules; BT2: limited supply of sustainable materials/products; BT3: methodologies and tools to measure sustainability; BT4: inadequate or untested sustainable technologies or materials) are larger than 0.05. Therefore no significant variance between the three groups of respondents exists. The P values of the remaining 4 barriers (BE4: split incentives between parties; BP2: approval and certification; BS1: lack of consumer information; BS2: professional motivation) are less than 0.05, which indicates homogeneity assumption is likely to be breached. There are significant differences in the rating of barriers by the three types of stakeholders. Therefore, it is important to treat the three groups separately in further analysis.

Table 3. The results of Kruskal- Wallis one-way analysis variance

Code	P-value	Code	P-value	Code	P-value	Code	P-value
BE1	0.828	BP1	0.690	BS1	0.028	BT1	0.348
BE2	0.612	BP2	0.009	BS2	0.010	BT2	0.864
BE3	0.867	BP3	0.490	BS3	0.066	BT3	0.441
BE4	0.031	BP4	0.359	BS4	0.406	BT4	0.379

Key Barriers

Based on the fuzzy set theory, the degree of membership were calculated. Meanwhile, the integrated degree of membership was also calculated. Following the benchmarking of o.85, nine key barriers were identified as shown in Table 4. Four of the key barriers were from the economic category including, BE1: increased capital cost; BE2 perceived risk; BE3: lack of market demand; and BE4: split incentives between parties. Three key barriers are related to political category including, BP1: building regulations; BP3: policy enforcement; and BP4: rebate programs. Two key barriers were from the social category including, BS1: lack of consumer information; and BS3: lack of education and training. No key barriers were found in the technological category.

Table 4. Key barriers identified by the fuzzy set theory

Code	Household	Builder	Real Estate	Integrated results
	$\mu_{A_G}(\chi_i)$	$\mu_{A_D}(\chi_i)$	$\mu_{A_P}(\chi_i)$	$\mu_A(\chi_i)$
BE1	0.900	1	0.952	1*
BE2	0.867	0.954	0.952	1*
BE3	0.867	0.909	0.952	0.984*
BE4	0.900	0.727	1	1*
BP1	0.933	0.909	1	1*
BP2	0.800	0.500	0.714	0.808
BP3	0.867	0.818	0.905	0.936*
BP4	0.966	0.864	0.714	0.976*
BS1	0.967	1	0.905	1*
BS2	0.800	0.773	0.572	0.823
BS3	0.933	0.819	0.762	0.942*
BS4	0.766	0.818	0.572	0.834
BT1	0.633	0.727	0.761	0.782
BT2	0.700	0.682	0.666	0.733
BT3	0.667	0.818	0.666	0.822
BT4	0.601	0.455	0.666	0.673

DISCUSSIONS

The economic category is the only group to have all of its four barriers considered as key hindrances. This is possibly due to the fact that economic factors are generally renowned to be the highest priority for owners when new technologies or norms are introduced into the construction industry (Gan et al. 2015). Increased capital cost (BE1) was ranked as the highest key barrier from the economic group, which highlights the fact green technologies and building methods incur additional cost. The second highest economic barrier was perceived risk (BE2), which indicates stakeholders have a fear of spending extra money and not receiving a better return to compensate (Zhou and Lowe 2003). Although the respondents held similar views on this barrier, with all groups mean rating = or >3.5, the builders rated this barrier the highest. This aligns with research conducted by Heffernan et al. (2015), who discovered contractors see a lack of market value for sustainable housing as a result of complex balance of build cost, land values, planning contributions and sales value. Perceived risk (BE2) also relates to the identification of lack of market demand (BE3), which suggests there is a lack of visible market value by consumers in Western Australia.

Three key barriers were identified from the political category, of which building regulations (BP1), was rated the most critical barrier overall with a mean of 3.85. This is due to political factors being seen as the joint most influential barriers for the delivery of sustainable housing alongside economic barriers (Heffernan et al. 2015). According to Gan et al. (2015), if building regulations are not formulated then individuals will not be forced to be sustainable. Only two key barriers identified relate to the social aspect of sustainability, including lack of consumer information (BS1) and lack of education and training (BS3). These two issues are considered as essential for the success of sustainable housing as social barriers are secondary to the theme of economic barriers. Furthermore if an individual is not educated or misinformed about sustainable housing, economic barriers such as increased capital cost (BE1) may become more of a hindrance through misconception or overestimation. A lack of consumer information (BS1) was rated the highest amongst the key social barriers. This supports the results of an Australian study conducted by Mcgee et al. (2008 pg3), which disproved the theory “A demand-lead market assumes that consumers know what their choices are, and that they have some experience of their options in order to make an informed decision”. In fact it was proved mandating drove the uptake of sustainability aspects which reinforces BP1 (building regulations). The Kruskal-Wallis one-way analysis of variance found no significant difference exists between the three groups of ratings in regards to a lack of education and training (BS3) being a key barrier. This result stipulates the professionals and consumers have little or no knowledge about sustainable housing (Sponge Sustainability Network 2006). A study by Heffernan (2013), also found knowledge gaps existed for all parties involved in the delivery of sustainable housing, and there was a need to provide adequate education and training.

CONCLUSIONS

With the increasing population in Australia, more and more pressure is being put on the natural environment and our ability provide a sustainable future. The overall aim of this study was to contribute a better understanding of sustainable housing in Western Australia. The groups of factors affecting the implementation of sustainable housing include economic, political, social and technical factors. Amongst these, economical and political factors were found to be the most influential. Stakeholders consistently rated building regulations as the most critical barrier. In order to formulate a response to the barriers hindering the adoption of sustainable housing, there is a strong sense that the adoption of sustainable features could be improved by developing a research program to outline costs and benefits of sustainable housing. At the same time, education and training of all stakeholders will highlight the importance of necessary change. Legislation may also be needed to offer incentives to reward people for reducing their environmental impacts.

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INVESTIGATING THE RELATIONSHIPS BETWEEN SAFETY CLIMATE AND SAFETY PERFORMANCE OF RETROFITTING WORKS

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ABSTRACT

Retrofitting work is becoming increasingly important to a sustainable built environment as it helps reduce the greenhouse gas emissions and energy consumptions. However, retrofitting works are mostly small projects and predominantly undertaken by small-medium sized contractors, thus prone to safety problems as these contractors do not have sufficient resources for safety measures. Moreover, despite that safety has been widely researched in the construction industry, research into the safety of retrofitting works has been limited in the literature. As safety climate is a widely recognised construct to explain and predict safety performance, this paper presents an on-going PhD study aiming to examine the safety climate factors of retrofitting works and investigate the relationships between safety climate and safety performance. After refining the research gap through a literature review, the data collection will be started by interviewing the retrofitting stakeholders to identify the related safety issues comprising safety attitudes and safe-unsafe behaviours, followed by distributing an online questionnaire targeting the crews of small-medium sized contractors for safety climate measurement due to the lack of breakdown quantitative data (e.g. accidents records/rate, lost work days). Finally, structural equation modelling (SEM) will be employed to examine the quantitative relationships between safety climate and safety performance. This paper will present the research framework of the study, report the initial findings, and give recommendations to improve safety performance of retrofitting works.

Keywords: retrofitting works, safety management systems, safety climate and safety performance

INTRODUCTION

Retrofitting work has become dramatically important in the Australian construction industry as well as in the United States (US), the United

Kingdom (UK), and several European Union countries (EU) (Aste and Del Pero 2013; Kok, Miller and Morris 2012). Retrofitting works has been utilised to optimise energy sources by reducing energy consumption and carbon dioxide emissions, water use, and waste material in an optimum consideration for environmental conservancy (Jin et al. 2014). Retrofitting types tend to rely on the building circumstances, namely: replacing and upgrading the building equipment/appliances, such as upgrading the lights, and optimising the building controls for the heating/cooling systems, and changing the traditional energy sources to renewable energy. Retrofitting the existing buildings for new uses may be cheaper than demolishing and rebuilding (Bullen, 2007). In Australia, the Melbourne City Council conducted a survey of 2256 buildings in 2013 to deliver the ultimate target of 4.5 Star National Australian Built Environment Rating System (NABERS) across the surveyed buildings by 2020. The survey found that more than 50% (1200) of the buildings had been retrofitted, or the retrofits were being undertaken, or were being planned within the next five years (1200BUILDINGS, 2013). So far, 541 buildings have undertaken retrofit work and 315 are planning a retrofit (City of Melbourne 2015).

Despite the vast bounties above, retrofitting works involved with several risky activities and work environment that endanger workers' safety, such as being at height or in confined spaces; dealing with electricity; and using mischievous chemical substance. Green roofs (vegetated and solar panel) are an example of the combination of hazardous activities that can lead to different types of accidents (Behm 2011). Four (4) insulation workers died by falling from height or electrocution through the Home Insulation Programme (HIP) in Queensland, Australia 2009-10 (CourierMail 2013; NationalAffairs 2014; TheAustralian 2013). Another three (3) workers died while installing solar panel by electrocution and heat exhaustion in California, US 2009-10 (Behm 2011). Retrofitting works are mostly minute and undertaken by small/medium sized companies (Jin et al. 2014). These companies have a lack of resources for technological developments in safety or insufficient understanding of legal requirements. By default, fewer resources are allocated for safety (Chen and Jin 2015; Hasle and Limborg 2006), and consequently intensifies inherent safety problems.

Traditionally, safety approaches were confined to analysing the injury-based data (Sparer et al. 2013). These metrics of occupational health and safety (OHS) are comprised of man-hours-lost, the direct cost of accidents, the number of accidents and severity rate (Coyle, Sleeman and Adams 1996). Whereas, many safety researchers have focused on identifying workers attributes that are implicated with susceptibility of accidents (e.g. Cooper and Phillips 2004; Alshahrani, Panuwatwanich and Mohamed 2015; Lingard and Rowlinson 1998). This is because large numbers of occupational injuries have been caused due to individuals' behaviours rather than mechanical/equipment failure or unsafe working environments (Mullen 2004).

As one of the safety approaches, safety climate has been widely utilised. Safety climate has been implemented in different fields to evaluate and predict organizational safety performance (Zohar 1980). Furthermore, it is normally considered to be an indicator of work safety behaviour changes (Meliá et al. 2008). However, the literature reveals a lack of safety climate studies in the retrofitting sector (Chan et al. 2005; Dedobbeleer and Béland 1991; Hon, Chan and Yam 2014; Lingard, Cooke and Blismas 2009; Mohamed 2002; Niskanen 1994; Sparer et al. 2013; Zhang, Lingard and Nevin 2015). It remains largely unknown on: 1) how to measure and evaluate the safety climate of the retrofitting workplace, given the uniqueness of the retrofitting works; and 2) how safety climate affects its safety performance.

Thus, this study aims to shed light on identifying the safety climate factors and investigating the relationship between safety climate and safety performance of retrofitting works in Australia. The specific objectives to be achieved are:

1. Identifying the safety problems in retrofitting works in Australia;
2. Identifying the safety climate factors of retrofitting works in Australia;
3. Investigating the relationship between safety climate and safety performance; and
4. Providing recommendations for safety improvement.

RESEARCH FRAMEWORK

Figure 1 shows the stages of the research framework.

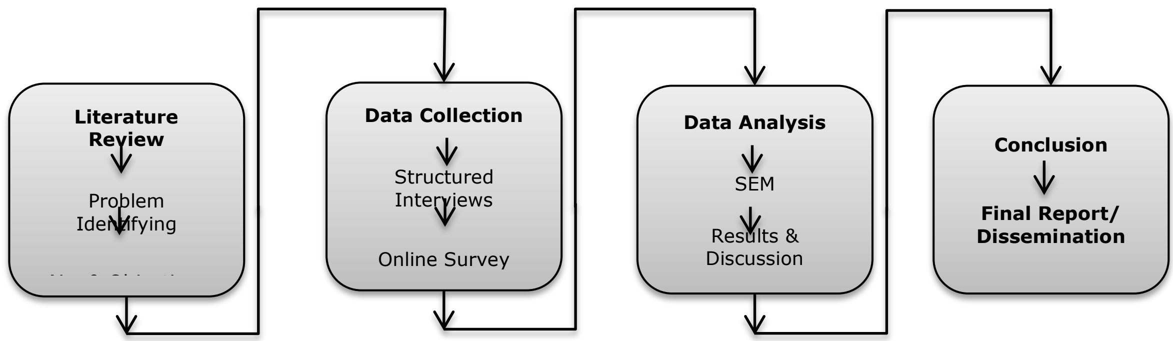

Figure 1 Research Framework

The current research has utilised a mixed qualitative and quantitative research approach. It consists of three phases. Firstly, a thorough literature review was conducted to enable addressing the knowledge gap and identify the aim and objectives. The literature review has concentrated on significance and safety issues of retrofitting works, safety management approaches, and measurement of safety climate and safety performance.

The second phase starts with data collection and has been divided into two main parts. The first part will adopt a qualitative method represented by a structured interview that will be conducted with the retrofitting stakeholders by asking open-ended questions, aiming to discover the safety issues of retrofitting workplace. To keep the stakeholders' privacy, the interview will be recorded and the transcript will be de-identified. The second part is to distribute anonymous online safety questionnaire (OSQ). The OSQ includes three sections namely: safety climate, safety performance and participants' demographic information.

Finally the data will be analysed for cross-interpretation. To deliver profound information in the specific context of the retrofitting works, analysing the textual data will assist in grasping the safety factors of human behaviours/actions (Carter and Little 2007). Interviews' data will be analysed by NVivo software (for classifying and clustering). Completed questionnaires received will be statistically analysed by Statistical Package for Social Sciences (SPSS). Exploratory factor analysis (EFA) will be used to examine the safety climate factors. By using the factor structure, structural equation modelling (SEM) method will be employed to analyse the relationship between safety climate and safety performance.

LITERATURE REVIEW

Retrofitting Works

Retrofitting works are becoming increasingly crucial to the construction industry in Australia, as well as in the United States and several European countries (Aste and Del Pero 2013; Bullen 2007; Kok, Miller and Morris 2012). Bullen (2007, p. 20) has defined retrofitting works as "*extending the useful life of existing buildings supports the key concepts of sustainability by lowering material, transport and energy consumption and pollution*". Retrofitting is frequently incorporated with adaptation, refurbishment, upgrade, conversion, and renovation (Wilkinson, et al., 2009). In many growing economies, the annual rate of new buildings corresponds to less than 2% of the existing building stock (Bullen 2007; GBCA 2013). Therefore, retrofitting works will play an important role to achieve the environmental sustainable standards.

Many retrofitting works are undertaken by contractors/subcontractors, which are defined as small/medium-sized companies (Jin et al. 2014). Such companies have fewer resources allocated for safety because of several reasons such as budget constraints, limited technological developments, and understanding of the legal necessities (Chen and Jin 2015; Hasle and Limborg 2006), consequently lower priority will be given to safety. Therefore, these companies may not have adequate safety awareness, resources or training, meanwhile most of the employed workers tend to be unskilled due to insufficient safety training programmes (Hon 2012; Chen and Jin 2015).

Retrofitting workers might underestimate the potential risks and neglected the safety responsibility involved in small and simple tasks. There is also a tendency for them to finish their tasks as quickly as possible so that they can move onto the next job (Hon, 2012; Lingard & Holmes, 2001). This is particularly the case when workers are paid by piece rate, or bonus, which is based on the number of completed tasks. At the worksite, duties and locations might be changed frequently, depending on resources and task positions. These changes and transitions can cause unexpected hazards (Zhang et al. 2013). For example, when retrofits are made, the rules might not be applied in the design tool or platform check.

Safety Management Approaches

Safety approaches have become drastically important and seriously required in various industries/fields to preserve the workers' lives and for continuous productivity. The safety management progression passed with three phases (Hudson 2007). Technological solutions, the first phase, have focused on providing safe physical techniques at worksite (e.g. guarding machinery and PPE). Afterwards, safety systems have emphasised on developing and implementing the systems of the safety management. In the recent phase, researchers have concentrated on investigating the cultural determinants due to the importance of recognising human behaviours inside organizations. Whereas human factors are dealt as a complement component to the technical solutions and safety management process towards a safe organisation (Zhang, Lingard and Nevin 2015).

Safety Climate

Safety climate, as a snapshot of safety culture, represents a single aspect of several interactions that form the safety culture. Moreover, safety culture is a product of multiple interaction objectives between people, their jobs, and the organisation (Lee and Harrison 2000). Safety climate and safety behaviour are the leading indicators towards a safe organization. Zohar (1980) observed that organization climate enhances organizational safety performance. Thus, the safety climate approach has become the focus of safety researchers and practitioners in terms of the workers' behaviours and safety attitudes (Cooper and Phillips 2004). Safety climate has been defined as the basic shared perceptions of the work environment by the employees, and these perceptions have psychological utility to adapt workers' behaviours (Zohar 1980).

Until now, the majority of safety climate studies are concentrating on analysing the safety climate factors (e.g. management commitment, worker' safety involvement, safety rules/regulations) which measure the safety perceptions of the workers and management through developing textual indicators by questionnaires (Fang, Chen and Wong 2006; Mohamed 2002; Hon, Chan and Yam 2012). However, analysing safety climate factors has become insufficient as hypothesised, in terms of the suggested accuracy for preventive actions (Zhang, Lingard and Nevin 2015). Besides investigating safety factors, some researchers are looking at safety agents (e.g. individual workers, co-workers, clients, contractors, managers and supervisor) because of the local group interactions regarding to the local rules and principles and their responsibility role (Meliá et al. 2008). Table 1 shows a summary of the recent safety climate studies that investigated the factors and agents in the construction industry. The measurement tools, which have been invented or developed by these studies, can assist the construction organizations in diagnosing the weak features in the safety practices. Accordingly, safety climate can reflect the organisational safety perceptions and contribute to a better safety performance and enhance workers' behaviour (Zhang, Lingard and Nevin 2015).

Table 1 Safety Climate studies in Construction Industry

Studies	Investigating	Analysed Level
Mohamed, 2002	Factors	Individual
Meliá, et al., 2008	Factors & agents	Individual, Group & Organisation
Lingard, et al., 2009	Factors & agents	Individual & Group
Zhou, et al., 2010	Factors	Individual
Hon, et al., 2012	Factors	Individual, Group & Organisation
Sparer, et al., 2013	Factors	Individual
KH Hon, et al., 2014	Factors	Individual, Group & Organisation
Wu, et al., 2015	Factors	Individual, Group & Organisation
Zhang, et al., 2015	Factors & agents	Individual, Group & Organisation

Safety Performance

Safety performance is defined as "*actions or behaviours that individuals exhibit in almost all jobs to promote the health and safety of workers, clients, the public, and the environment*" (Burke et al. 2002). Safety performance is measured directly and indirectly. Direct safety performance is measured by different types of information and it can be categorized into several groups such as statistical measures, behavioural measures, periodic safety audits, and balanced scorecard approach (Choudhry, Fang and Lingard 2009). Indirect safety performance measures can be explained through safety behaviuor including: personal characteristics, safety culture and safety climate (as leading indicators) (Seo et al. 2015).

DATA COLLECTION STRATEGY

Structured Interview

The data collection starts with structured interviews. The targeted interviewees will be managers, supervisors and contractors/ subcontractors. Undoubtedly, those people might have faced safety problems or have seen/heard about their crews' accidents. Interview questions have been quoted from the literature and concentrated on what are the most common accidents, causes and activities, applied safety practices and safety challenges of retrofitting works.

Online Safety Questionnaire (OSQ) Instrument

Measuring safety climate in retrofitting works will be acquired through anonymous online safety questionnaire (OSQ). OSQ has been divided into three parts including: safety climate, safety performance and personal attributes. The first part is the safety climate measurement that has been adopted from the reliable and validated NOSACQ-50 survey (Kines et al. 2011). Safety climate of retrofitting works will be measured from two levels: management/supervisors level and workers level in seven dimensions. Secondly, the safety performance is divided into three categories, i.e. accident/injury history, safety compliance and safety participation. Finally, the demographic background consists of 4 core areas comprising: safety training; work-related attributes; educational level and personal attributes.

INITIAL FINDINGS

Retrofitting works is becoming considerably important and growing up faster than expected. The initial findings of the recent Melbourne retrofit survey indicate a significant increase in retrofit activities. 37% of the surveyed buildings were undertaking a retrofit from 2010 to 2015, while quarter (25%) was from 2008 and 2013 (Melbourne 2015). Tuning up of retrofit activity has considerably changed. The current increase of the tune-up activity is from 21 to 26 per cent (Melbourne 2015), but in 2013 survey tune-up activity from 4 to 14 per cent (1200BUILDINGS 2013). In Queensland, the Queensland Government has established several retrofitting plans. For instance, a One Million Rooftops plan has put the target of one million rooftops or 3 gigawatts of solar photovoltaics (PV) to be accomplished by 2020. This plan will assist reducing electricity bills for families and businesses which will create jobs and protect the environment. Regarding to solar installations, Queensland is the highest amongst the Australian states, whereas around 40% of the plan (400,000 of the households and small businesses) installed solar (Queensland Government 2016). As massive works of retrofitting are still being conducted with active growing rate, the more risks are threatening the workers' safety.

Safety climate approaches are becoming a better measure of organisational safety culture. Various studies have been conducted in different fields including construction industry. Kines et al. (2011) have developed and validated a safety climate questionnaire (NOSACQ-50) in four different countries. The concepts and wording of the questionnaire items have contributed to sufficiently capture the unified safety perceptions among organizational workers. Another study, Wu et al. (2015) have attempted to identify a multilayered core dimensions of safety climate and their in between relationships. The resulting four core dimensions are comprised: 1) safety priority; 2) safety supervision, training, and communication; 3) safety rules and procedures; and 4) safety involvement. Two main benefits of core dimensions are directly applied in practice and can be transformed into specific contexts. More recently, Zhang et al. (2015) have evaluated the safety climate measurement tools and revealed a number of features including: 1) multilevel analysis; 2) agent analysis; 3) appreciation of co-workers' influence on group-level; and 4) recognition of the client's role. This measurement tool has been distinguished to include safety responsibilities of various important safety agents. These studies have revealed different aspects that assist to comprehend how to employ safety climate approach to measure the safety in construction enterprises. Until now, however, there are no studies conducted to measure the small-medium enterprises/companies, and especially in retrofitting works in Australian construction industry.

CONCLUSIONS

Despite that retrofitting works is becoming more and more important, the construction workers are alarmingly in critical safety situation. While there are ample safety climate studies in construction industry, none of these investigated the retrofitting sector, in which most retrofitting works are undertaken by small-medium sized companies. Studying the safety climate of the retrofitting workers will reveal the true priority of safety in workplace by using the mixed qualitative and quantitative approach. From the initial findings, there are no detailed statistics to evaluate and measure the safety performance in such businesses. This research will help to detect unsafe behaviours and hazardous activities which in turn could lead to accidents.

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A RADICAL OUTCOME-BASED APPROACH FOR ASSESSMENT OF CONSTRUCTION CONSULTANTS IN THE PUBLIC SECTOR

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ABSTRACT

Public-sector construction clients in the UK and Australia have a clear objective to maximise potential and value for construction and infrastructure projects. Carefully selected consultants can enhance a project in many ways and ensure that it meets the client's needs. The existing selection approach is often an input-based assessment relying on a range of task and contextual performance factors. This approach is applied at the tender stage but unfortunately cannot guarantee the strategic project objectives to be achieved. Outcome-based performance predictive models, which link performance influencing factors to project outcomes, were developed for the public-sector clients. A hierarchical regression analysis was conducted using data from 60 consultancies collected from a questionnaire survey sent to the estate offices of the UK universities, which form a unique public sector. The participants were asked to choose a construction consultancy recently completed upon which they could indicate the level of influencing factors used for selection of consultants at the tender phase and the average performance outcomes achieved by consultants during the consultancy period. Each performance project outcome was regressed against influencing factors. Individual performance outcomes (i.e. time, cost, quality and working relationship with the client) can be significantly predicted by the performance predictive models, using related management and economic factors including project staff, competence of firm, execution approach, consultant framework, competition level and size of firm. The sum of these performance outcomes' scores represents the consultant's quality. Such models are adaptable for building and construction disciplines within the wider public sector.

Keywords: Construction consultants, Outcome-based selection, Public sector

INTRODUCTION

Public-sector construction clients in the UK and Australia have a clear objective to maximise potential and value for construction and infrastructure projects (Department for Business, Innovation and Skills, 2013; Love *et al.*, 2010). Best value approach is now a predominant principle for procuring public services in the UK (OGC, 2008). Both quality and cost are considered but assessed separately, based on the technical quality and the fees proposals in the tender. Quality is assessed first to determine whether the consultant's services can meet the client's requirements. It is then weighted against cost (tendered fees) according to their importance in the project to arrive at a final value for money judgment. The final selection should be the tender which offers the best overall value for money. Consequently, quality assessment is important because it forms a key part of the selection process.

According to Morledge and Smith (2013), the existing selection approach is often an input-based assessment relying on a range of task and contextual performance factors. This approach is applied at the tender stage but unfortunately cannot guarantee the strategic project objectives to be achieved. Public-sector clients should concentrate on required performance outcomes instead of prescriptive input to measure project success (Cabinet Office, 2011). A radical change is necessary so that project outcomes can be objectively assessed based on performance influencing factors.

This research aims to develop performance predictive conceptual models to forecast performance outcomes of construction consultants within the UK university environment, covering consultancies for new build, refurbishment and maintenance projects. Empirical studies show that there is a causal relationship between output performance and input economic and management factors in production of services and that regression can serve as a tool to forecast the performance (Lee, *et al.*, 1999). Accordingly, it is possible to objectively and significantly predict the performance of construction consultants in relation to project outcomes, based on these influencing factors known at the procurement stage. The regression models developed are in the form of mathematical regression equations to calculate individual performance outcomes. With ratings assessed for individual factors, each model will calculate a performance score for each performance outcome. Performance scores for individual performance outcomes will then be added to provide a total quality score.

PERFORMANCE OUTCOMES

Project success outcomes should cover both design and construction phases (Ahadzie *et al.*, 2008). Yeung *et al.* (2008) developed a model to measure project success for civil engineering projects undertaken by the Hong Kong Government, which was based on the traditional criteria of price, time and quality. However, it did introduce four other critical success factors. Validation of the model was achieved through structured interviews with the public-sector clients in Hong Kong, resulting in seven critical success factors. Apart from time performance (variation in time against programme), cost performance (variation in cost against budget) and quality performance (cost of rectifying defects, number of defects or number of complaints) during the construction phase, innovations (cost and time savings expressed as a percentage of project totals) at the design phase were also considered to be crucial. The research also identified that management commitment (percentage of meetings attended by project managers and directors), trust and respect (speed of solving disputes) and communication (number of letters and emails sent between parties) significantly influenced the project outcomes.

Ling (2002) suggests that architectural and engineering consultants with potential for successful performance should be selected. Consultants must be able to produce a functional and satisfactory building that meets the client's needs, based on their proper design capability. If consultants are not properly selected, extra time and monitoring costs will be incurred (Russell and Jaselskis, 1992). Design quality is considered to be the most important factor when measuring the consultant's performance.

Apart from cost efficiency, reduced carbon emission in the government estate through the procurement of new construction is also one of the government strategic objectives in public-sector construction. This should be achieved by reduced energy consumption, water consumption and waste to landfill in accordance with agreed targets from the existing and emerging government policy, as stated by Cabinet Office (2011).

Through research into highways maintenance projects undertaken by a county council, Lam and Gale (2014) identified five critical success factors that measured the success of public-sector projects. These factors can be categorised into time: start on time (ratio of days late starting against contract period) and finish on time (ratio of day finished late against contract period); cost: accuracy of payment (interim payments, including claims, certified within 5% of contractor's application); quality: right first time (project completed without remedial works) and health and safety inspection (percentage of inspection passed). In terms of quality, Love and Heng (2006) point out that defects and failures can be caused by errors and omission in design, thus resulting in rework which involves repairing defects, replacement of waste materials and warranty repairs.

Performance requirements of quality, time and cost are explicitly specified in the public-sector contracts for appointment of construction consultants, including GC/Works/5 General Conditions for the Appointment of Consultants (PACE, 1998) and GC/Works/5 General Conditions for the Appointment of Consultants: Framework Agreement (PACE, 1999). Consultants are required by these contracts to carry out all necessary services and obligations to complete the project satisfactorily at or below the approved cost limit.

Based on the Customer Care Statement (Estate Management Office, 2014) and Hoxley (1998), 'working relationship with the client' should also be regarded as one of the performance outcomes. Such performance outcome can be measured by:

- Being fair, responsive and courteous in the delivery of quality services
- Being positive and providing a service which meets the customers' requirements
- Getting things right the first time
- Responding effectively to customers' complaints and using customer feedback to secure continuous improvement

In short, five generic performance outcomes, as required from construction consultants within the public-sector environment, were identified by project management and strategic management theories: time, cost, quality, innovations and working relationship with the client (dependent variables). Details are shown as follows:

Table 1 Performance Outcomes

Performance Outcomes	Measures
Time (POT)	- minimal variation in time against programme - start on time - completion on time
Cost (POC)	- at or below the approved cost limit - minimal variation in cost against budget - life cycle cost minimised
Quality (POQ)	- a functional building/refurbishment/maintenance that meets the client's needs; with minimal rework (making good defects and material waste) due to error made in the design, or a necessary item or component is omitted from the design) - health and safety design and inspections to minimise accidents - sustainable design (reduction of energy, carbon emission, water consumption and waste, improvement of air quality and other aspects, or BREEAM rating for higher education)
Innovations (POI)	- cost / time savings expressed as a percentage of project totals
Working relationship with the client (POR)	- fair, responsive and courteous in the delivery of quality services - positive and provide service which meet the customers' requirements - get things right first time - respond effectively to customers' complaints and use customer feedback to secure continuous improvement - willingness to engage with end users and flexibility in reacting to or accommodating changes

PERFORMANCE INFLUENCING FACTORS

In relation to the economic factor, Lam (2009) examines the impact of market competition on performance in housing maintenance consultancies. In an empirical study on the procurement of maintenance consultants at the Hong Kong Housing Authority, Lam found from a regression analysis of 50 maintenance consultancies that the performance outcomes were positively influenced by the number of direct competitors on the tender list. Consultants had to provide competitive quality and quantity of resources in order to win a contract.

The theory of job performance suggests that it consists of task performance (Van Scotter and Motowidlo, 1996) and contextual performance (Borman and Motowidlo, 1993). The former refers to the proficiency and skills in job-specific tasks related to the project and the relevant job experience. The latter refers to general communication and coordination skills as well as initiative and teamwork within an organisational setting. Both input factors can have a positive impact on the project outcomes.

Morledge and Smith (2013) suggest three generic ability factors for final selection of consultants, namely, capability of firm, competence of firm, and staff proposed for the project. In addition to these three task performance factors, CIRIA (1994) suggests that execution approach, i.e. the strategy chosen to execute a project, should be considered. Capability refers to the size of firm which is measured by the overall experience of firms in projects of similar function as well as the availability of sufficient staff, finance, facilities and quality management system for the firm to meet the demand of project programmes.

Competence refers to the performance of a firm in past projects. This can be ascertained by seeking references from previous clients if and when a new consultant is assessed. Past behaviour and performance is considered to be the best predictor of future behaviour performance according to the theory of selection psychology (Hogan *et al.*, 1996; Ling, 2000). Project staff refers to the relevant expertise and experience of the personnel directly employed for the project, including the project team leader and other nominated staff. Yeung *et al.* (2008) adds that management commitment, expressed as a percentage of meetings attended by project managers and directors, is one of the critical factors to guarantee project success. Lastly, the way to execute a project (execution approach) is a measure of the consultant's design and management methods to meet the client's needs. All of these literature findings indicate that those four task performance factors can positively influence the performance outcomes, as measured by time, cost, quality, innovations and working relationship with the client.

Conscientiousness, initiative, social skills, control and commitment should be considered when assessing contextual performance (Borman and Motowidlo, 1993). Ling (2002) confirms that conscientiousness, comprising the level of enthusiasm in tackling a difficult commission and the speed in producing design drawings, is a significant positive factor influencing the performance outcomes. According to Motowidlo and Van Scotter (1994), individuals who enthusiastically tackled difficult work performed better. According to Chen and Mead (1997), building owners, consultants and contractors contended that slow production of drawings would hinder team performance and compromise teamwork. Owners often want their projects to be completed speedily. Other factors, including initiative (offering suggestions to improve design), social skills (interpersonal and communication skills), controllability (respect for team work and collaboration, compliance with instructions and speed of response) and commitment (loyalty to employer, preparedness to revise design and interest in the commission), were found by Ling (2002) to not be significant in influencing how well architects and engineering consultants performed.

PACE (1998) requires that for construction consultancy services in the public sector, consultants should collaborate with other project team members at all stages including design, cost planning and control, procurement, tendering, construction and operation and maintenance. Yeung *et al.* (2008) find trust and respect, as measured by the speed of solving disputes, is one of the critical success factors for construction projects. When compared to the traditional discrete appointment approach, consultant frameworks provide longer and stronger relationships and hence enhance trust and collaboration and teamwork between the client and the supplier (Lam and Gale, 2014), which in turn improve the performance outcomes.

Based on the job performance theory, task and contextual performance influencing factors, along with their respective measures, are summarised in Tables 2 and 3.

Table 2: Task Performance Factors

Performance factors (Predictor variables)	Measures
Project staff, PST (relevant expertise & experience)	- qualifications, experience and time commitment of the project team leader - qualifications and experience of proposed staff - management arrangements for sub-contracted services
Execution approach, APP (design and management methods for the commission)	- quality of design to meet the client's strategic needs (potential value to student recruitment and learning, staff recruitment, carbon reduction) - quality of design to meet the client's practical needs (problem-solving ability to resolve functional requirements, operational efficiency, aesthetics, cost / time constraint) - managerial procedures (communication with clients; managing the programme and sub-consultants; working around existing occupiers; collaboration with other project team members)
Competence of firm, COP (past performance)	- performance on past projects or job references from previous clients
Size of firm / capability, SFM (overall experience & facilities)	- experience of similar previous university projects - suitable qualifications of senior partners / managers - availability of technical facilities - financially stability - quality management system

Table 3: Contextual Performance Factors

Performance factors (Predictor variables)	Measures
Conscientiousness, CON	- speed in producing design drawings or completing tasks - level of enthusiasm in tackling a difficult assignment
Trust and collaboration, CFW	- collaborative consultant frameworks - traditional discrete appointment of consultants

HYPOTHESES AND RESEARCH METHOD

Based on the competition and job performance theories, the following hypotheses were developed:

H1: Time performance outcome of construction consultants was positively correlated to the level of task and contextual performance inputs and the level of competition.

H2: Cost performance outcome of construction consultants was positively correlated to the level of task and contextual performance inputs and the level of competition.

H3: Quality performance outcome of construction consultants was positively correlated to the level of task and contextual performance inputs and the level of competition.

H4: Innovation performance outcome of construction consultants was positively correlated to the level of task and contextual performance inputs and the level of competition.

H5: Relationship with the client was positively correlated to the level of task and contextual performance inputs and the level of competition.

Positivist approach was adopted as the analytical framework to examine the causal relationship between the output performance and input management and economic factors. This rigorous scientific approach can produce robust results through generalisation. A hierarchical regression analysis was conducted using data collected from a questionnaire survey sent to the estates offices of the universities in the country. The informants were asked to choose a construction consultancy recently completed, upon which they could rate: firstly, the average performance level of individual performance outcomes achieved by the consultant over the consultancy period (dependent variables); secondly, the level of task and contextual performance inputs revealed in the quality assessment in all tender procedures including prequalification, interview and tender evaluation; and thirdly, the level of economic force (predictor variables). These three blocks of predictor variables (task performance, contextual performance and economic factors) were entered into the hierarchical regression equation one by one for analysis. For each performance outcome, an analysis was conducted to validate the relationship between the performance outcome and the influencing factors, to identify the relative contribution of each block to the performance, and to identify the significant performance predictors. Regression is a powerful tool for developing a forecast of the future based on the past (Schleirfer and Bell, 1995). It is one of the most efficient methods that can analyse the relationship between the result and various types of influencing factors.

The hypotheses were further developed into performance predictive models which set out the relationship between individual performance outcomes and influential management and economic factors, as shown by the below hierarchical regression equations. Each project performance outcome (POT, POC, POQ, POI or POR) was regressed against three blocks of influencing factors, namely, task performance factors (PST, APP, COP and SFM), contextual factors (CON and CFW) and the economic factor (competition level, CL)

$$POT = \alpha_t + (\beta_{1t}PST + \beta_{2t}APP + \beta_{3t}COP + \beta_{4t}SFM) + (\beta_{5t}CON + \beta_{6t}CFW) + (\beta_{7t}CL)$$
$$POC = \alpha_c + (\beta_{1c}PST + \beta_{2c}APP + \beta_{3c}COP + \beta_{4c}SFM) + (\beta_{5c}CON + \beta_{6c}CFW) + (\beta_{7c}CL)$$
$$POQ = \alpha_q + (\beta_{1q}PST + \beta_{2q}APP + \beta_{3q}COP + \beta_{4q}SFM) + (\beta_{5q}CON + \beta_{6q}CFW) + (\beta_{7q}CL)$$
$$POI = \alpha_i + (\beta_{1i}PST + \beta_{2i}APP + \beta_{3i}COP + \beta_{4i}SFM) + (\beta_{5i}CON + \beta_{6i}CFW) + (\beta_{7i}CL)$$
$$POR = \alpha_i + (\beta_{1r}PST + \beta_{2r}APP + \beta_{3r}COP + \beta_{4r}SFM) + (\beta_{5r}CON + \beta_{6r}CFW) + (\beta_{7r}CL)$$

Where
α = constant, or the Y-intercept of the regression line
β_n = regression coefficients for the predictor variables
PST, APP etc = values of the predictor variables
$_{c,\ t,\ q,\ i,\ r}$ = indices for cost, time, quality, innovations and relationship with the client

Generalising the quantitative study results requires having a sufficient number of cases for the regression analysis. Coakes and Steed (2007) stipulate that the minimum requirement is at least six times more cases than the number of predictor variables. As there were 7 possible predictor variables, the minimum number of cases required was 42. Questionnaires were sent to the university estate directors, deputy directors, senior engineers, senior project managers and consultancy managers of the university estates in the country through Association of University Directors of Estates, Association of University Engineers and direct contacts using the email addresses available on the university websites. These participants were specifically selected because of their senior position, expertise and experience in the selection and management of construction consultants. 60 questionnaires were duly completed and returned from 38 universities between May and September 2014. There were 161 universities in the UK in 2011/12 (HESA, 2012) so the sample constituted approximately 23.6% of the population. Although the sample size is relatively small, it is sufficient to meet the minimum number of cases required for regression analysis.

RESULTS AND DISCUSSION

Details of the regression results for the final models are shown in Table 4. All insignificant predictors including 'competition level' have been excluded from the models.

Table 4: Regression Analyses of the Performance Outcomes

Block / Predictor variable	B	Beta	sr^2	p-value	Tolerance	R	R^2	Adjusted R^2	R^2 Change (Sig. F Change)	ANOVA Sig.
Performance Outcome of Time										
Block 1						0.849	0.720	0.702		0.0005
Block 1 PST COP SFM	 0.676 1.035 -0.319	 0.865 0.416 -0.324	 0.580 0.118 0.058	 0.0005 0.0005 0.003	 0.776 0.683 0.553				0.720 (0.0005)	
Intercept	-6.432									
Performance Outcome of Cost										
Blocks 1 and 2						0.854	0.730	0.719		0.0005
Block 1 PST	 0.788	 0.935	 0.729	 0.0005	 0.835				0.599 (0.0005)	
Block 2 CFW	 1.796	 0.369	 0.131	 0.0005	 0.830				0.131 (0.0005)	
Intercept	-8.761									
Performance Outcome of Quality										
Blocks 1 and 2						0.695	0.483	0.462		0.0005
Block 1 APP	 0.475	 0.574	 0.320	 0.0005	 0.972				0.240 (0.0005)	
Block 2 CFW	 1.575	 0.500	 0.243	 0.0005	 0.970				0.243 (0.0005)	
Intercept	5.725									
Performance Outcome of Innovations										
Block 1						0.460	0.211	0.178 not significant		0.003

Block 1 COP	0.582	0.509	0.181	0.002	0.700				0.211 (0.003)	
Intercept	-0.881									
Performance Outcome of Relationship with the Client										
Blocks 1 and 2						0.775	0.600	0.574		0.0005
Block 1 PST COP	 0.842 0.905	 0.760 0.257	 0.477 0.065	 0.0005 0.008	 0.826 0.981				0.562 (0.0005)	
Block 2 CFW	 1.263	 0.212	 0.038	 0.041	 0.834				0.038 (0.041)	
Intercept	-6.642									

'Contextual task factors' was found to be the most significant positive predictor block for performance outcomes of time, cost, quality and working relationship with the client, as shown by the highest R^2 Change values and their Sig. F Change values (all <0.0005). The analysis also identifies significant positive predictors for four performance outcomes, all with p-values<0.05. Project staff (PST) is the most significant factor influencing time, cost and working relationship performance, with sr^2 values being 0.580, 0.729 and 0.477, respectively. This is consistent with the arguments of Yeung *et al.* (2008) and Morledge and Smith (2013). Skills in architectural, vibration and acoustic design are particularly relevant to construction works for teaching and laboratory facilities in the university environment. Management skills and arranging sub-contracted services are equally important with reference to appointments of multi-disciplinary firms that can provide the full range of services required (CIRIA, 1994; Mortledge and Smith, 2013).

Competence of firm (COP) also significantly affects time and working relationship performance. 'Competence of firm' is related to past performance. The causal relationships are supported by Kashiwagi (2004) and Lam (2009) who claimed that previous success is closely linked to future performance, especially when construction projects are completed in an already occupied environment.

Execution approach (APP) is the only significant predictor for quality performance. 'Execution approach' is a measure of the consultant's design and management methods to meet the client's strategic and practical needs as well as maintaining a close liaison with the client. The impact of this factor is supported by Church (1993), Bennett *et al.* (1996) and Hoxley (1998) who state that problem-solving ability and understanding project scope and brief, as shown in the project approach, are important requirements when selecting consultants. Furthermore, working in occupied environments requires special attention. The ways in which work and services are delivered and how communication is handled with the client and other stakeholders are now increasingly critical (Atkin and Adrian, 2009).

Consultant framework (CFW) is a significant predictor for cost, quality and working relationship performance. 'Trust and collaboration' is represented by the consultant framework appointment approach which encourages collaborative and integration within a project team. Construction, refurbishment and maintenance programmes in universities have high values but high risks due to the presence of existing occupiers and buildings. Using the framework appointment method can nurture longer and stronger relationships and collaboration, thus ensuring project success, as supported by Constructing Excellence (2005).

Size of firm (SFM) is negatively correlated to performance. Size of firm is measured by the overall experience of the firm in similar projects and the availability of sufficient staff and facilities. Rowbotham (1992) argues that large firms often allocate resources to major projects whilst small firms always use senior and experienced staff to provide better services in order to gain more business in the future. This argument explains the negative correlation.

Competition level (CL) is a not a significant predictor for all performance outcomes if it is below 10. 'Task performance factors' is the most significant predictor so dominates over the other influencing factors. Consequently the significant impact of 'project staff', 'execution approach' and 'competence of firm', along with the influence of 'consultant framework', masks the effect of 'competition level'.

Conscientiousness (CON) is found not to be a significant predictor for all performance outcomes. This factor was considered by Ling (2002) to be significant in influencing the performance of architects and engineers employed by design and build contractors in the private sector in Singapore. Speed in completing tasks is a key measure for this factor. It is important for private sector investment projects, but can be less critical in the public-sector university environment.

There was no significant correlation between innovation performance and the predictors. The UK government requires that time and cost issues must be improved through innovations (Department for Business, Innovation and Skills, 2013). However, it will take time for consultants to build such experience and the momentum required for innovations. Consequently no significant correlation can be detected between innovation performance and the predictors at this stage. Nonetheless it is expected that such a relationship can be established once a culture of innovation has developed in the future.

CONCLUSIONS

In the public-sector university environment, five performance outcomes are identified: time, cost, quality, working relationship with the client and innovations. Task performance, contextual performance and economic factors are also identified as generic influencing factors.

The regression analysis generalises the performance outcome predictive models as follows:

Performance outcome of time

$$POT = -6.432 + (0.676PST + 1.035COP - 0.319SFM)$$

Performance outcome of cost

$$POC = -8.761 + 0.788PST + 1.796CFW$$

Performance outcome of quality

$POQ = 5.725 + 0.475APP + 1.575CFW$

Performance outcome of working relationship
$POR = -6.642 + (0.842PST + 0.905COP) + 1.263CFW$

For each performance outcome, the predicted score should then be divided by the total score so that it can be converted into a weighted score (out of 100). It is necessary that the client and his professional estate team should decide the weightings for individual performance outcomes according to the organisation's needs so that a single performance score can be calculated for each consultant. This quality score can then be combined with the fee score to decide the best value consultant to be selected.

The results serve can be used for enhancing the professional practice of the building professionals involved in consultant management in the university sector. The client's professional team should focus on the significant performance influencing factors and take advantage of the performance predictive models to select quality consultants.

The performance predictive models developed should be regarded as 'conceptual'. Different university estate offices may have different requirements on performance outcomes and selection criteria, which may further vary according to various project situations. It is recommended that the conceptual models developed should be reaffirmed by comparing the predicted performance scores calculated by the models with the performance scores awarded by assessors. Adjustments can be made by using the quantitative research method adopted in this research, thus creating customised models. Similarly, it is recommended further models should be developed based on this principle for other public-sector organisations. The conceptual models will therefore benefit not only the university sector but the wider public sector.

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FAMILY SATSANG: A STRATEGY FOR ENRICHING REFLECTIVE PRACTICES IN LEARNERS

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ABSTRACT

The degree of self esteem and interpersonal trust that children develop begins in the family and through their relationship with the family members. Family is a forum where children can freely express their views, opinions and reflections without hindrance which in turn would help in building up self confidence and deep relationship with one another.The paper highlights the *family satsang* strategy adopted by Bethlehem Oratory: an experimental family based system of education (K-12) initiated by Bethlehem Educational Research Foundation (BERF) in India. BERF is a Non- Governmental Organization of a team of educational researchers and an institutional member of World Council for Curriculum and Instruction. Bethlehem Oratory functions as learning communities of families who share the view of cultivating spiritually intelligent culture in children by enabling them to realize the divinity in oneself, in nature and in others. Each family of Bethlehem Oratory follows the strategy of *family satsang* which is the gathering of the members of the family- grandparents, parents and children- for one hour daily in the evening to pray together, to discuss and express one's views on social and other life related issues etc. The *family satsang* strategy is conducted as a continuous, daily activity of a single family; as a weekly gathering of small number of families, and as monthly and annual gatherings of community of families where children are given opportunities to reflect, discuss and present their views on important life related issues. The paper depicts how *family satsang* enriches reflective practices in children.

Keywords: Family based system of education, Family Satsang, Parenting, Reflective Practices

INTRODUCTION

Most of us began our lives in families and spent thousands of hours during our childhood interacting with our parents, siblings and grandparents. Socialization between parents and children historically was viewed as a one way process. Today, however, we view parent child interaction as reciprocal (Hartup and Laursen, 1999; Parke, 2004). An important form of reciprocal socialization is *scaffolding*, in which parents time interactions in such a way that the infant experiences turn – taking with the parents. Scaffolding involves parental behavior that supports children's efforts, allowing them to be more skillful than they would be if they were to rely only on their own abilities. Scaffolding is not confined to parent-infant interaction but can be used by parents to support children's achievement–related efforts in school by adjusting and modifying the amount and type of support that best suits the child's level of development.

As a social system, the family can be thought of as a constellation of subsystems defined in terms of generation, gender and role (Kreppner, 2002; Minuchin, 2002; Parke, 2004). Divisions of labor among family members define particular subunits, and the attachments define others. Each family member is a participant in several subsystems. Jay Belsky(1981) proposed an organizational scheme that highlights the reciprocal influences of family members and family subsystems. Belsky believes that marital relations, parenting and the infant behavior and development can have both direct and indirect effects on each other.

The early relationships have potential lifelong effects. It is believed that sensitive, responsive parenting during the child's first year leads to a secure attachment. To the degree that parenting is lacking in sensitivity or responsiveness, insecure attachment develops. There is evidence that secure attachment is associated with later characteristics as positive affect, empathy, high self esteem, and unconflicted interactions with peers and with adults. The basic aspects of the self concept develop within the family through the social interactions that occur there. Who we are and what we think of ourselves result in large part from the perceptions and evaluations of our closest relatives.

Psychiatrist Robert Coles (1997) emphasizes the importance of mothers and fathers in shaping empathetic behavior in children. Coles suggest that the key is to teach children to be "good" or "kind" and to think about other people rather than just about themselves. Good children who are not self-centered are more likely to respond to the needs of others. This kind of moral intelligence is not based on memorizing rules and regulations or on learning abstract definitions. Instead, children learn by observing what their parents do and say in their everyday lives. Such experiences are important at any age, but Coles believes that the elementary school years are the crucial time during which a child develops or fails to develop a conscience. Without appropriate models and appropriate experiences, children can easily grow into selfish and rude adolescents and then into equally unpleasant adults.

Parents are important figures in the adolescent's development of identity. It is found that poor communication between mothers and adolescents and persistent conflicts with friends were linked to less positive identity development (Reis and Youniss, 2004). The presence of a family atmosphere that promotes both *individuality and connectedness* is important in the adolescent's identity development (Cooper and Grotevant, 1989). Research findings reveal that identity formation is enhanced by family relationships that are both individuated, which encourages adolescents to develop their own points of view, and connected, which provides a secure base from which to explore the widening social worlds of adolescence.

Good parenting takes a lot of time and a lot of effort (Hoghugi & Long, 2004; Waldfogel, 2004) Parental cooperation and warmth are linked with children's prosocial behavior and competence in peer relations. Most child psychologists recommend reasoning with the child, especially explaining the consequences of the child's actions for others, as the best way to handle children's misbehaviours. Time out, in which the child is removed from a setting where the child experiences positive reinforcement, can also be effective. Inductive discipline, which involves the use of reasoning and focuses children's attention on the consequences of their actions for others, positively influences moral development (Hoffman, 1970). Parents' moral values influence children's developing moral thoughts (Gibbs, 2003).

Sibling relationships are also important, primarily as a way to learn how to interact with peers. The sibling interactions provide a way to learn and to practice interpersonal skills (Dunn, 1992). The emotions aroused in response to siblings recur throughout one's life in other relationships, because friendships, love affairs and marriages tend to bring forth the kind of reactions originally associated with siblings (Klagsburn, 1992).

BETHLEHEM ORATORY: A FAMILY BASED SYSTEM OF EDUCATION

Bethlehem Oratory is a *family based system of education (K-12)* initiated by Bethlehem Educational Research Foundation (BERF**,** an institutional member of World Council for Curriculum and Instruction**;** a *Non-Governmental Organization of the United Nations in consultative status with the Economic and Social Council) in* 2006 at Bethlehem Centre, India. BERF is a non-Governmental, non profit Educational Organization of a team of educational researchers. The organization is an offshoot of the researchers' genuine desire to cultivate a 'spiritually intelligent culture' through education in the light of the 'spiritually dumb culture' exhibited by the modern society. Based on the researchers' experience of dealing with families and numerous problems faced by children, the need for greater parental involvement in the educative process of children was evident.

Bethlehem Oratory functions as learning communities of families who share the view of cultivating spiritually intelligent culture in children by enabling them to realize the divinity in oneself, in nature and others; by nurturing virtues in them; and by generating in them a feeling of sensitivity to nature and sensitivity to the feelings of others. They follow a way of life based on Christian principles characterized by firm belief in the divine presence and providence in every activity of their life.

At present, each community of families following this system of education has a minimum of three families staying nearby. After attending the Holy Mass together, they engage in the domestic works in their respective families after which they gather together at the respective centre for formal learning at 10 am upto 4 pm. The children are grouped according to their age levels. Each group is dealt with by their respective teachers/qualified parents. In the process of curriculum transaction, learning experiences are provided giving emphasis on the *Spiritual Domain* of learning (Mathew, 2008).

Each family of Bethlehem Oratory follows the strategy of ***family satsang*** (*Satsang* is a Sanskrit word. In Indian philosophy it means company with an assembly of persons who listen to, talk about, and assimilate the truth)which is the gathering of the members of a family- grandparents, parents and children- for one hour daily in the evening to pray together, to discuss and express ones' views on social and other life related issues etc. It is an educational strategy adopted by each family for developing interpersonal relationship, team spirit, cooperation, communication skills etc. in children. It functions on the principles of reciprocity, inductive discipline and authoritative parenting style.

FAMILY SATSANG

The phases of *family satsang* include - Phase1: Prayer; Phase 2: Satsang; Phase 3: Mediation; Phase 4: Blessing. Table 1 gives the description of the phases of *family satsang*.

Table : 1. Phases of Daily *Family Satsang*

Structure		The whole family members sit in circle.
Phases		
1	***Family Prayer***	Family satsang is initiated by the Family Prayer. Usually the elder member of the family leads the session. At times children are given the leadership to conduct the session.
2	***Satsang***	The family members sit in a circle and engage in sharing their experiences, reflections; engage in discussions, exposition of talents etc. After the family prayer, the members of the family engage in one or two of these activities each day.
	A- *Experience sharing*	The whole family shares their personal experiences of the day related to ▪ Personal responsibilities ▪ Personal relationships ▪ Personal difficulties ▪ God experiences
	B-*Reflection and interpretation of a thought*	Children choose a wise saying, a famous quotation or a proverb; express their views on it and give their interpretation of it in accordance to their age.
	C-*Discussion on current issues*	Children and parents involve in active discussion on current social, environmental and moral issues. (issues highlighted in news papers)
	D-*Relating anecdotes*	Parents narrate anecdotes of saints, great leaders, scientists etc. based on the significance of the day. At times children also narrate based on their readings
	E-*Exposition of talents*	Children expose their talents in singing , dancing , painting, role playing etc.
3	***Mediation***	Parents analyse the performance of children critically. Based on the analysis, they give necessary reinforcement and correction and offer suggestions for improvement.
4	***Blessing***	Children receive the blessings of the parents and grandparents. Children kneel down before the parents. Parents place their hands on them, pray for them and bless them.

Family satsang is carried out as daily gathering of a single family; as a weekly gathering of a community of families; and as monthly and annual gatherings of communities of families.

The weekly gathering of community of families is carried out once in a week (preferably on Sundays) at the respective centres. They spend two hours together. Each family takes an active role in sharing their experiences of the week; discuss their views on current issues, matters of moral dilemma etc.

As these learning communities of families stay at different parts of India, children from these families, along with their parents gather together occasionally at different centres, learn together, discuss their educational issues, arrange camps, retreats, workshops etc.

FAMILY SATSANG: AN INFORMAL MEANS TO CULTIVATE SPIRITUALLY INTELLIGENT CULTURE

Zohar and Marshall (2000) made the first attempt to find out the notion of Spiritual Intelligence (SQ) and defined it as "the intelligence with which we address and solve problems of meaning and value, the intelligence with which we can place our actions and our lives in a wider, richer, meaning giving context, the intelligence with which we can assess that one course of action or one life-path is more meaningful than another". SQ helps us to outgrow our immediate ego selves and to reach beyond to those deeper layers of potentiality that lie hidden within us. It helps us to live life at a deeper level of meaning. It gives us our moral sense, an ability to temper rigid rules with understanding and compassion and an equal ability to see when compassion and understanding have their limits. According to Zohar and Marshall (2004) Spiritual Intelligence's sense of meaning, values, and purpose generates Spiritual Capital. Spiritual capital's wealth of meaning, values, and higher motivation are necessary to sustainable capitalism and a sustainable society. We build Spiritual Capital by building ourselves. 'Building ourselves' means to grow as human beings; to engage in reflection and activities that put us in touch with the deeper core of our humanity. A critical mass of individuals using their Spiritual Intelligence to act from higher motivations, can shift the dominant features of a whole culture, be it that of a family, a community, an organization, or of a whole global culture.

The twelve *dynamic process* or *the qualities and principles of transformation* or *the behavioral and cultural indicators* of our spiritual intelligence viz. Self-awareness, Spontaneity, Being vision and value led, Holism, Compassion, Celebration of diversity, Field independence, Tendency to ask fundamental why questions, Ability to reframe, Positive use of adversity, Humility and Sense of vocation provide an energy input that enables us to shift our individual behavior. These qualities could be nurtured in learners as well if they are taken through a 'way of life' which offers training for genuine discovery of their own self – their potentialities, their drawbacks, their motivations and helping them to 'become' the 'real person' they are capable of becoming by enabling them to move up in the scale of motivations and by fostering their potentialities to reach the stage of self-actualization.

With this purpose, the researchers of Bethlehem Educational Research Foundation designed various formal and informal pedagogic means that nurture the qualities of SQ in learners. Most of these qualities can be nurtured through reflective practices. Family Satsang is an informal means adopted by BERF to develop reflective practices in learners. A few illustrations of the reflective practices that help to nurture qualities of SQ are given as follows:

I. Self-Awareness *is to know what I believe in and value and what deeply motivates me; awareness of my deepest life's purposes.*

Activity: Reflection and Analysis of daily life situations.

Learners review the events of each day and their responses to these events

A In terms of their ***relationship*** with others (parents, siblings, grandparents, neighbours, friends, relatives etc.).

B In terms of their ***responsibilities*** (personal, at home / school / community etc.)

C In terms of their ***feelings*** towards Negative / positive experiences in life; Failures/success of others;The pain of people whom they do not know/ know

D In terms of their ***motivations.***

What motivated them to do a good thing?
A reward in return; Appreciation of others; Fear of somebody; Love for God /the work/the person who entrusted; Personal contentment; as service
What prevented them from doing something good?
Laziness; dislike for the work; lack of confidence.
What motivated them to do something bad?
Basic instinct; rebelliousness/hatred/jealousy; lack of self control.
What prevented them from doing something bad?
Desire for a reward/ appreciation/praise; Fear of somebody; Love for somebody; Personal contentment

II. Spontaneity refers to ones capacity to be deeply responsive to the moment.

Reviewing instances of utilizing / missing good opportunities
At the end of each day pupils review 'the unfamiliar situations' yet good opportunities they missed/ utilized well.

Analysis of the causes for missing the opportunities (laziness, introvert nature, fear of taking risks, lack of confidence/motivation /

enthusiasm)

Decision to face and make use of unfamiliar situations

Noting their response/behavior in the respective situation
(able to respond in the appropriate way / not able to respond in the appropriate way)

If able, they analyse and note their qualities that made them respond well.

If not able, they analyse where they failed (lack of thought /confidence in oneself/openness; unable to comprehend the real nature of the situation etc.)

Making necessary corrections each time they face unfamiliar situations

III. Field Independence refers to one's capability to stand against the crowd or even against the previous dictates of one's own mind.

A **Reflection**

Pupils reflect on
The values that guide them
The extent to which they can stand for their values.
They check if they have the tendency to
Step back amidst criticism/move forward courageously

B **Analysis of the causes for stepping back**

Basic instinct to waver; desire for public approval; lack of courage; lack of faith in oneself/ in the spiritual strength of the value they stand for/in the ultimate triumph it offers

IV. Compassion or deep empathy is an ability to feel the feelings of others.

Step1. Reflection

Pupils reflect on what they feel when they see and hear of –

somebody in physical pain; somebody being humiliated/tortured

They check if they are: able to feel with/not able to feel with

Step 2: Analysis of the causes for not being able to feel with

A plentiful life; lack of personal experience of the miserable plight; etc.

Step 3: Personal experience of the miserable plight

Pupils imagine what they would feel if they were in such miserable conditions.

They are given opportunities to experience deprivation of certain needs and comforts of life.

Example: Remain hungry for some time.

They visit places of charity, hospitals, jails, orphanages etc.

CONCLUSION

The degree of self esteem and interpersonal trust that children develop begins in the family and through their relationship with the family members. *Family Satsang*, a strategy to develop a sense of freedom, a sense of the 'good will' behind advices and corrections, mutual understanding, team spirit, cooperation and communication skill in children paves way for the healthy development of the inner self and the social self. Reflective practices which help to build up qualities like self awareness, spontaneity, field independence, compassion,etc. form a major session of the family satsang strategy adopted by Bethlehem Oratory to create a 'spiritually intelligent culture' among children through education. The transformative principles of spiritual intelligence which enable the shift from a spiritually dumb culture to a spiritually intelligent culture is imperative for sustained excellence.

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ATTRACTING AND RETAINING YOUNG PROFESSIONAL WOMEN IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

Women are underutilised in the Construction Industry, making up only 11.8% of its employees in Australia. Online survey responses of young Australian female construction professionals were used to explore 1. what attracted them into the Construction Industry, 2. what challenges they experienced, and 3. what helped retain them in the Industry. Responses to the open-ended survey questions were coded and thematically analysed. Many of the young women were initially attracted to architecture and design, but later switched to construction. A quarter were temperamentally attracted to project work due to their skills in planning and organising; others were attracted to the nature of the Industry and the diversity of its roles and projects; while others were interested in the Industry at a very young age; or attracted due to family connections in the Construction Industry. The young women's main challenges were feeling like they had to continuously prove themselves to male co-workers; a lack of experience in the Construction Industry; and finding that long working hours placed demands on their personal lives. All the respondents planned to stay in the Construction Industry: most were excited by the opportunities for career advancement; were motivated by the training opportunities provided; and by changes in the Industry towards equal opportunity. These findings are encouraging: the young professional women displayed passion for their work and felt that despite its challenges, the Construction Industry offers them exciting future career prospects.

Keywords: attraction, retention, construction, young professional women

INTRODUCTION

The Construction Industry (CI) is a major employer of workers in Australia. Currently the Industry is short skilled, needing to recruit around 220,000 new workers by 2020 to keep up with growing demand (Hackett, 2014). Construction companies will struggle to find the staff they require if they do not change their culture and image to become an attractive employer for women. Hackett (2014) argues that the strong male emphasis is no longer valid: "the Construction Industry is changing; it relies less and less on brawn and more on brainpower".

Under-utilisation of women in the construction workforce

Although women have made great advances in the wider workforce over the past 40 years, in male-dominated industries like construction, their representation is still extremely low. Women make up only 11.8% of employees and 16% of managers in Australian construction companies (EOWA, 2011). These statistics indicate that women are underutilised and undervalued in an industry which is the third largest employer in Australia (Department of Employment, 2015).

Barriers to women's career advancement in Construction Industry

There are many barriers and day-to-day challenges that women experience working in the CI that contribute to the negative public image that deters young females from considering construction as a valid career path. One of the main barriers is the CI's male dominated image, which is perpetuated by gender biased vocabulary used on a daily basis e.g. tradesman or foreman. The Industry culture is portrayed as macho, with relationships characterised by conflicts, crisis and disagreements, which can be intimidating for the women working alongside them (Fielden et al., 2010). Another significant barrier is the family-unfriendly work practices. The Industry has a culture of working extremely long hours, with ten-hour days as standard, which can create conflict between work and life commitments (Turner and Lingard, 2008; Lingard et al., 2015). Whilst women and men both have to balance the weights and stresses of work and home life, women still maintain the primary responsibility for the domestic duties in most households (Fernando et al., 2014), so long working hours are likely to impact them more.

Sexist behaviour in the construction workplace is another deterrent to women working in construction. This extends to the recruitment process in the CI, which is thought to be one of the contributing reasons to limited female participation in the Industry. Traditional recruitment practices such as 'word of mouth' recruitment, advertisements displaying male images, discriminatory selection criteria and lack of part time roles are all contributing factors (Gurjao, 2006). A number of studies confirm that women in construction are subject to sexist behaviour and practices (Fielden et al., 2010). Women are often singled out by their male counterparts for tasks that are intended to 'test' their ability to work in a male environment. Women who experience these sorts of sexist behaviours may not receive adequate support from their managers as males hold most of the senior positions. Such sexist behaviour can undermine women's perceived professional status and may even lead some women to leaving the Industry (Fielden et al., 2010). In addition to the 'boy's club' mentality, other barriers include tokenism, and a lack of networks impact on the attraction, promotion and retention of women (Dainty et al., 2000; Bigelow et al., 2015). With the lack of women in senior positions and limited visibility of women on site, there are few female role models to suggest to young women that construction is a viable career opportunity (Moon, 2013).

Factors that attract and retain women in the Construction Industry

Although there has been substantial research about the difficulties that women face in the CI (e.g., Lingard and Lin, 2004; Fernando et al., 2014), less is known about what attracts women to the CI in the first place. Recent research has identified that having a parent working in the industry, awareness of career opportunities, and internship placements attract female undergraduates to the Industry (Bigelow et al., 2015). In addition, the fit between the nature of the CI and personal character traits (such as strong communication skills, eagerness to work extremely hard, and the ability to relate to different cultures and temperaments) is another factor which motivates women to believe they are suitable to work in a tough male dominated industry (Fernando et al., 2014). In order to attract and advance women within the Industry, companies need to provide more visible, strong female role models to inspire young women that they too can succeed in this exciting and challenging industry (Cherry, 2010).

Retention of women in the CI has been linked to the behaviours of senior managers through supporting, encouraging and enabling women to showcase their abilities (Cherry, 2010). Mentoring programs are also known to help women to progress in their careers (Lingard and Lin, 2004). Such mentoring programs assist women to tackle the negative barriers, and also help to increase personal and job satisfaction, and make it more likely for them to stay in the Industry (Moon, 2013). Further, the development of supportive networks and job shadowing opportunities are also seen as important (Worrall, 2012). Studies have shown that there is a link between flexible work patterns (including part time work, home based work, and job sharing) with lower employee turnover (Turner and Lingard, 2008). Companies which provide flexible working hours and locations increase job satisfaction, reduce stress levels and increase their employees' loyalty to the company and to the Construction Industry. However, despite what is already known, there still remains more to be discovered about what initially draws and subsequently holds young women in the Construction Industry.

RESEARCH AIM AND METHOD

This study aims to explore the thoughts, beliefs and opinions of the youngest generation of female entrants in the Construction Industry. Participants were young professional women with less than ten years work experience in the Industry. Three research questions were explored: 1. what initially attracted them into the Construction Industry, 2. what day-to-day challenges and barriers they experienced, and 3. what factors helped retain them in the Construction Industry.

This study used secondary data that was publicly available on the National Association of Women in Construction's (NAWIC) website. There were 80 female participants who voluntarily opted into the NAWIC (2013) online survey and gave their written consent for their responses to be published on the NAWIC website. All participants worked in the built environment and included architects, engineers, construction project managers, and trades. The criteria for inclusion in the present study were that the respondents were young professional women with less than ten years' experience in the Construction Industry, which resulted in seven useable surveys. The responses of these seven participants to the open-ended online survey questions were used for analysis in this study. The eligible participants all held roles involved in the everyday construction of infrastructure; most were project managers and one was a site foreman. The online survey consisted of a set of initial demographic questions about the participants' current position and organization, qualifications, and years of working in the CI (see Table 1 below for the participants' demographics). The written responses to NAWIC's (2013) open-ended survey questions provided qualitative data suitable for thematic analysis to gain rich insights into the topic of this exploratory study.

Thematic analysis is a qualitative technique which allows researchers to move beyond a broad reading of the written data to discovering patterns and developing themes. Thematic analysis involves five iterative steps: familiarization with data through reading the survey transcripts; generating initial classifying codes; searching for common themes among the codes; reviewing the different themes; and finally defining and naming these identified themes (Braun and Clarke, 2006). In this study, the coding was performed manually by highlighting key words relating to each research question and colour coding them. A large number of words were coded for this section, as it is important to identify as many potential codes and themes as possible, so that no potential emergent themes go unnoticed. Once all of the responses were coded, data that were identified by the same code were collated together and emergent themes were identified and named. The twelve themes that emerged from the analysis are shown below in Table 2.

Table 1 Participant Demographics

Participant	Name	Role	Organisation	Years in CI
1	Simone	Project Manager	Small Not-for-Profit	2
2	Jenny	Project Manager	Local property developer (SME)	5.5
3	Rachel	Project Manager	Large national project consultancy	2
4	Kylie	Project Coordinator	Large national commercial fit-outs	3
5	Amber	Project Engineer	Large engineering contractor	3
6	Michelle	Site Foreman	Large national commercial builder	5.5
7	Anika	Project Manager	Multi-national property group	6

THEMATIC ANALYSIS AND DISCUSSION

Initial codes were identified from the survey data and these codes were further analysed to identify 12 emergent themes, including 5 themes for what initially attracted women into the CI, 3 themes for the barriers and challenges they faced and 4 themes for what helped to retain them in the Industry. These themes are presented in Table 2.

Table 2 Emergent Themes for Young Female Professionals

Factors that attracted into the CI	Challenges and barriers experienced	Factors that retain young women
Initially attracted to architecture and design, but switched into construction (5)	Need to continuously prove themselves (4)	Potential career success (6)
Strong/organised temperament (3)	Little experience in construction (3)	Internal training (3)
Nature of industry/diversity of roles and projects (2)	Demanding work hours (2)	Male champions (2)
Interested at a young age (2)		Industry change/ equal opportunities (2)
Family construction background (1)		

1. Factors that initially attracted young professional women

Five themes emerged for this research question about what initially attracted them into the CI.

Attracted to design The most prevalent theme, for five out of the seven participants, was that these young female professionals were initially attracted to, or had a background in architecture and design, however, they were not satisfied in this industry and decided to make the switch into the CI. *"I had worked in an architecture firm for a year. I have always been fascinated with building and felt I needed to know more about construction"* (Anika, 6 years). The initial attraction to design stemmed from their interest in *"how the built form affects our everyday life"* (Rachel, 2 years) and the *"creative opportunities it offered"* (Jenny, 5.5 years). The Architecture and Design (A&D) Industry can also be appealing to women as the *"female presence is much more prevalent"* than it is in the CI. For these young women the initial attractions to A&D were not strong enough to hold them. One participant had been *"frustrated by the pace at which projects went through the office"* (Anika, 6 years). All five of these young women decided to make the switch into the male-dominated CI.

Strong, organised temperament The next theme that was identified for three of the seven participants was that they had a strong, organised temperament. They found that their confidence was a key: *"I am fortunate to be strong-minded, strong willed and confident in my capabilities in the Construction Industry"* (Michelle, 5.5 years). *"My strong points are communication, organization, problem solving and time management"* (Rachel, 2 years). Their confidence and organised nature led them to believe that they would be suitable for the tough male-dominated CI.

Nature of the CI The nature of the Industry and the diversity of roles and projects was a reason that attracted two of the participants. The fact that the Industry is very *"fast paced"* (Amber, 3 years), *"interesting"* and *"challenging"* (Kylie, 3 years) makes it suitable for individuals who enjoy exciting, stimulating and diverse work. The Industry boasts a *"wide range of jobs"* (Amber, 3 years), from residential to commercial to industrial, with every project comprising of an individual design, build and features. As every project is different it means that the industry is not repetitious, which makes it highly exciting. *"Potential projects are endless because there are always demands for new ideas and applications of technology in building and construction"* (Amber, 3 years).

Attracted from a young age For one participant, the Construction Industry was very attractive to her from a young age; *"I remember at a young age being fascinated as to how tall buildings stood so straight and didn't sway"* (Kylie, 3 years). Another participant was drawn to the

Industry from early childhood through her family's participation in the Construction Industry.

Family background in construction For Michelle (6 years' experience), her *"entire life has been involved in the Construction Industry, with my parents building their own homes as Owner Builders"*. This early childhood socialisation exerted a strong influence on her career choice. A common perception is that women who grow up in a construction family environment are attracted to the CI. However, in this study, only one of the seven participants became interested in the Industry due to their family background. The majority were attracted by the previously identified factors.

2. Challenges and barriers experienced

Three themes emerged from this research question about the nature of the challenges and barriers they experienced working in the CI.

Need to continuously prove themselves The first theme, for four out of the seven participants, was that these young women felt like they had to continuously prove themselves to the men working around them: *"My main challenge has been getting people to respect you and not look … at what you don't know. The guys will look you up & down and decide that you don't know anything before they even have a conversation with you"* (Kylie, 3 years). Many of the young women felt they were always being looked down upon and did not receive the respect that they felt they deserved. There is *"is still very much an attitude between the older contractors/trades that woman are not welcome on site"* (Jenny, 5.5 years). These male attitudes made it difficult for the women to work every day in that negative environment, and to have to continuously prove themselves. However, experiencing these negative responses made these young women even more determined to strive to achieve respect: *"being a woman in this industry has certainly provided challenges for me and has made me more determined to ensure that respect is gained, not only for myself, but for women generally"* (Jenny, 5.5 years).

Lack of experience in construction For three of the seven participants, their lack of experience in construction was one of the main barriers they faced when trying to enter the CI. One of the participants had *"no experience"* at all and found this to be an *"enormous challenge"* (Simone, 2 years). Many jobs require a minimum amount of experience in the Industry: *"I found that my lack of experience was a potential employer's main concern"* (Jenny, 5.5 years). Having no experience, meant that employers needed to be prepared to invest in the new employee. *"The biggest difficulty was convincing them to take a chance on me, with little construction experience and a degree in design"* (Rachel, 2 years). Those women with no prior experience were grateful to construction companies which were prepared to *"overcome the lack of experience"* (Anika, 6 years) and give them a chance.

Demanding work hours Another day-to-day challenge that two of the seven participants experienced, was that the nature of the work *"can be hard and very demanding"* (Kylie, 3 years). For some of the women distinguishing between home life and work was difficult; *"family and life is a hard one for me, as I don't think that I have identified that they are separate from work"* (Kylie, 3 years). Due to the demanding nature of the industry, the lines between home life and work can become blurred as their time is so consumed by the job, it becomes their whole life. For women without a demanding home life e.g. those living with their parents or not having any children, there is less difficulty in balancing the two: *"This job can be very demanding on my time however, due to my passion for it, it has never felt like a burden to work the additional hours required to ensure that the work is done. At this stage in my life, I don't have children and it is much easier for me to sacrifice my time for work when required"* (Jenny, 5.5 years). All the participants were at the early stage of their career. It is likely that work-life pressure may pose a problem later in their career if they start a family.

3. Factors that help retain young women in the CI

The third research question was what helps retain young women once they have entered into the CI. Four themes emerged.

Potential for career success The most prevalent theme, for six of the seven participants, was the potential success that can be achieved through working in the CI. Not only are there monetary successes, but also the ability to accomplish personal achievements. These achievements help to provide *"personal satisfaction"* (Simone, 2 years) and job satisfaction through the opportunity to *"gain more experience…and accomplishing greater projects"* (Michelle, 5.5 years). Potential career opportunities were an incentive to help retain women into the industry: *"I aspire to work my way up with experience and opportunity"* (Kylie, 3 years). Many of the young women held ambitious long-term goals, such as *"managing a full commercial development on my own"* (Anika, 6 years), *"doing some small property developments of my own"* (Jenny, 5.5 years), or becoming *"the Senior Manager responsible for a major division of a construction company"* (Amber, 3 years).

Internal training For three of the young women who participated in the survey, internal training and career development was one of the key factors that helped retain them in the Industry: *"I have developed a training plan for myself and luckily my employer … encourages development and learning"* (Amber, 3 years). Providing young women with the opportunity to complete training during their work hours offers them the chance to maintain a healthy work-life balance. It also provides them with the feeling that their company is investing in them, which in turn can make them more motivated and willing to stay with the company for the long term.

Male champions The third theme was the presence of encouraging male champions in the workplace. Two young women (one of whom worked in a large national company, the other in a multinational) paid tribute to the growing number of male champions. *"I have had a lot of support from males to be involved"* (Kylie, 3 years). They also expressed admiration and gratitude for their male champions and felt affirmed by these men's *"extreme respect for women who have the courage to understand what is typically a man's field"* (Anika, 6 years). This positive trend reflects the culture change recently demonstrated by the leadership in some of Australia's larger construction companies in joining the Property Male Champions for Change program (Property Council of Australia, 2016).

Perceived Industry change/equal opportunities The final emerging theme around retention was the young women's sense of a change in the Industry and growing equal opportunities for women: *"thankfully, times are changing"* (Amber, 3 years). Many of the young women attributed this change to the younger generation entering the Industry: *"this could be to do with the generation that I am and the acceptance of equal opportunities today"* (Kylie, 3 years). The younger generation of professionals, both males and females have started to peel back the negative image that the Industry holds and will hopefully be able make further progress in the future. While this generation was growing up, it became more accepted and normal for women to be in the workforce. Unlike older generations before them, the youngest generation in the workplace has been educated to value equal opportunities.

Conclusion

This study adopted a positive focus on what draws young professional women into the Construction Industry and what holds them there. Most of the research on women in construction focuses on negative issues such as what prevents women from entering and what causes them to leave the Industry. As well as identifying the challenges that young female professionals face, this current research identifies what initially attracted young professional women into the Industry and the factors that helped to retain them. The findings contribute new knowledge on how the Construction Industry can attract and retain women in this male-dominated industry. These findings may potentially help the Industry to diversify its workforce, fill its talent pipeline, create equal opportunities for women, and attract and retain more young women in the future.

Apart from confirming that women with a strong, organised temperament are attracted to construction, this study identified four new factors which attract young professional women. Many young women in this study were initially attracted to architecture and design (initially perceived as a more acceptable female career), but their dissatisfaction with this field led them to switch into the more hands-on work of the CI. The action-orientation and diverse nature of work/roles attracted the young women. Several were interested at a young age and one had a CI family background. These findings suggest that to attract more young female talent, construction companies need to more actively involve their young female employees to promote the Industry to young girls while still in school and at career fairs; providing information about the exciting action-oriented nature of the work and the diversity of available roles; promoting its suitability for assertive, organised young women; and offering opportunities for firsthand experience through site visits, work placements and internships.

The challenges that these young professional women experienced are consistent with those already noted in the extant literature: that is, having little experience in construction was a barrier to entry; feeling as though they had to continuously prove themselves to some male co-workers; and the extreme demands their work placed on their life and time. There are encouraging signs that some construction companies are supporting research on ways to improve the CI culture and working conditions (e.g., Lingard et al., 2015). Having little experience can be overcome by the targeted provision of work placements and internships for young female students. One positive finding was that none of these identified barriers deterred these young professional women from pursuing a satisfying career in the Construction Industry.

All participants planned to continue in the CI and were optimistic about the perceived opportunities for their future career development. A number of young women noted how much they valued their employers' provision of on-the-job training to enhance their knowledge and skills. None of the women mentioned female mentors, but several working in large national or multinational companies expressed gratitude to particular male champions who had encouraged and taught them at work. The young women had a sense that attitudes were changing in the CI and felt excited about their future prospects. Although this was only a small sample of young professional women who were recent entrants to the CI, the similarity of their reported experiences in both large and small companies is notable. The positive shift in the perception of the CI as a workplace of opportunity and career growth for women is a welcome development, especially since the fast aging workforce will necessitate the Construction Industry embracing greater gender diversity in the decades to come.

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UNDERSTANDING SENIOR COMMUNITY RESIDENTS FOR BETTER CONSTRUCTION OF RETIREMENT VILLAGES

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ABSTRACT

Housing for growing aging population has become a vital issue across Australia. A retirement village is regarded as a supportive home choice for senior people in response to the life transitions. However, only a small proportion of the Australian senior people choose to live in the retirement villages. Therefore, this study aims to identify the barriers against the senior community residents moving to the villages through a case study in Geelong. The empirical findings indicate that the two main categories of barriers are related to the living environment changes and economic pressure. Accordingly, the corresponding recommendations are proposed to overcome the barriers. While addressing the local senior housing issue, this study provides a direction for future research into the affordable and suitable construction of retirement village from a general perspective.

Keywords: barrier, retirement village, senior community residents

INTRODUCTION

The expanding society of ageing population has become a vital topic in Australia. The number of retirees will soar in the next decades as the "baby boomer" generation enters the older age in the nation. A number of life span transitions are faced by the people who are reaching old age. One of the most significant changes is retirement associated with a reduction in income. Moreover, as walking into their old age, people have to experience increasing likelihood of frailty, illness and disability, which may further lead to the widow and living alone. Those life span transitions will eventually lead to different needs of housing and services for the senior people, and thus producing appropriate housing that facilitates healthy and positive ageing has become a desirable priority for both the private and the public village operators. Retirement villages which prove more supportive housing environment can help the senior people respond to these transitions. Howe (1986) argued that moving to retirement villages can be regarded as one option for the senior people to maximize independence and security. A series of following research demonstrated that retirement villages are important housing alternative for the senior people, which can offer enhanced life style and social interaction while also providing care and community support (Bohle et al., 2014; Erickson et al., 2006; Miller and Buys, 2007). However, the majority of the senior people stay in their existing homes.

In order to maintain a sustainable construction of the retirement villages, recent research focuses on the demand for village living. K. M. Gibler and Taltavull (2010) developed a retirement housing demand model by identifying relationships between homeowner characteristics and housing preferences. Analogue to the life course model of older migration, a logistic regression model was developed to estimate the likelihood an senior people moves to retirement villages (Gibler and Clements-III, 2011; Wiseman, 1980). The developed model was subsequently applied to estimate the senior Americans' choice to move. The findings suggest that age has a positive relationship with the choice to move, while the other socioeconomic variables are not significant. Moreover, literature identifying the push and pull factors build up a base of the retirement village development model for the industry, especially from the subjective perspective of the retirees (Gardner et al., 2005; Kennedy and Coates, 2008; Stimson and McCrea, 2004). However, whether the retirees are willing to pay for their preferences of the retirement village attributes has not been confirmed by existing literature.

As retirees who live in the communities are prospective residents and this group is the target market of retirement village industry, it is important to gain knowledge of their thoughts of retirement villages to promote the industry. Only addressing the concerns of prospective residents, the retirement villages could be widespread through the senior people. The balance of this paper is organized as follows: next section presents a comprehensive literature review of the push and pull factors that affect the decisions of the senior people; the following section describes the research design and retirement village attributes; then it comes to survey delivery and data collection from senior community residents and the related findings and the final section gives discussion and conclusion.

LITERATURE REVIEW

There is large amount of literature investigating the push and pull factors that affect the senior people moving out from their home and into retirement villages. Gardner (1994) highlighted that the awareness of the differences between living in the village and living in homes is one major factor affecting senior people's decisions. However, the details relating to the differences were not disclosed. A following cross-sectional survey was conducted to three groups of senior people, who lived in two villages and homes in Melbourne respectively, in order to discover the pull and push factors (Gardner et al., 2005). By comparing the living life styles across the surveyed groups, the research confirmed the role of retirement villages in enhancing the senior people's quality of life. The research also identified that better living environment in the villages is a major push factor, while the major pull factor is their uncertain of the tenure value of the village units. Another case study into the retirement living in Queensland emphasised the reduction in contact with family is an important factor pulling the senior people away from moving to the retirement villages (Buys et al., 2006). Miller and Buys (2007) conducted a cross-sectional study into the leisure-time activity participations of the Australian senior people living in community and retirement villages respectively. Their findings confirm that the village residents involved more activities than the community residents. Bohle et al. (2014) emphasized the effects of separation and community on retirement housing choices, by conducting a comprehensive interview across the senior people in New South Wales and South Australia. The findings suggest that the needs of support play a role of push factor but the feeling of independence is a pull factor in affecting people moving to the villages. However, the research on senior people's perspectives of acceptable price for a home in Australia retirement villages is limited.

RESEARCH DESIGN

Questionnaires were used in some previous studies in the field of examining retirement village market, which mainly focused on senior people who were living in retirement villages. Buys et al. (2006) designed questionnaires for the senior people living in a Queensland retirement village who paid assistance or senior people who received instrumental support from family and examined relevant issues with those two groups of people. Xia et al. (2014) conducted questionnaires with senior people living in a Queensland for-profit retirement village and identified sustainable issues influenced their daily lives. Gardner et al. (2005) conducted questionnaires not only with the residents who were living in retirement villages, but also with the a group of senior people who considered moving but remained living in the community and tested their satisfaction levels with the quality of life. For this research, a semi-structured questionnaire was designed in order to identify whether senior community residents would move to retirement villages and relevant reasons.

The questionnaire mainly had two parts (Figure 1), including background information and opinions of respondents on current retirement village market in Geelong. The first part was designed to collect respondents' background information, including their gender, age, education, income range, current or previous occupation, health condition, and current living status. This information is important to understand whether their background would affect their views of moving to a retirement village. The second part was designed to ask the respondents whether they would move out from present home and move to a retirement village and relevant reasons. In the second part, a question was designed to collect the respondents' views of an acceptable price to pay for a home in the retirement villages, which helps to identify whether price significantly affects senior people's decisions of moving to a retirement village. Also it helps to identify whether current retirement village market price is higher than local senior residents' affordable prices. All the questions except the last one are provided with multiple choices, which not only help reducing the respondents' thinking and answering time, but also provide the researchers with advanced measurement scales. The last question which asks the respondents about their imagination of retirement village life style is an open-ended question rather than providing with multiple choices. The answers would not be restricted by choices that the researchers provided, and, it is beneficial for the researcher to receive true answers from the respondents. All respondents anonymously and voluntarily took part into this research, by doing questionnaire.

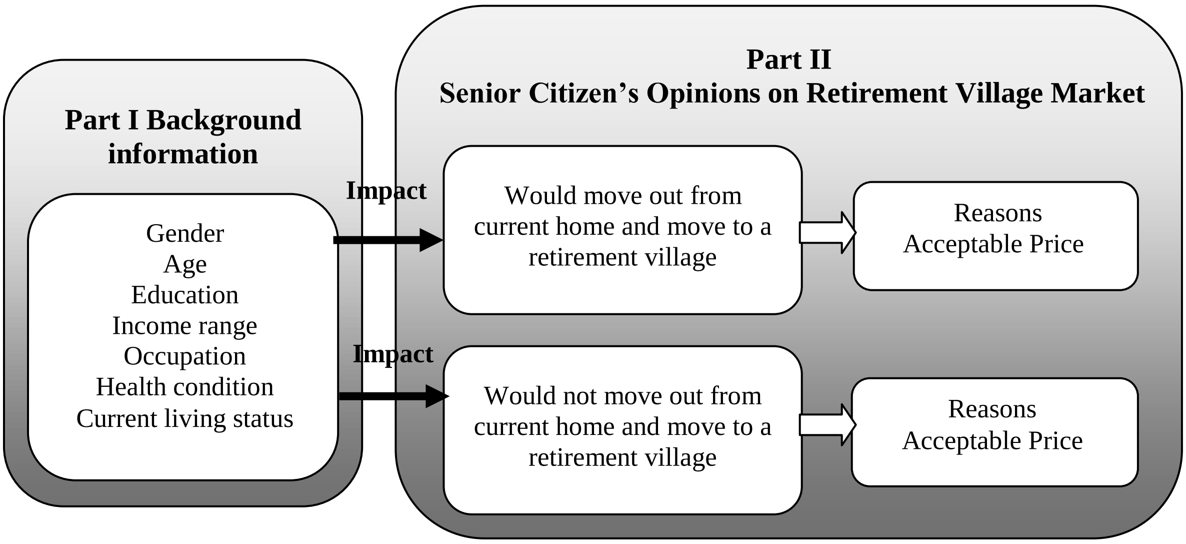

Figure 1 The Structure of Questionnaire

RETIREMENT VILLAGES IN AUSTRALIA

The retirement village industry has been developing rapidly across Australia. According to the Retirement Living Council of Australia (RLCA), there are 2,160 retirement villages by 2013, which provided over 110,000 independent living units accommodating more than 177,000 Australian senior people (RLCA, 2014). Majority of the retirement villages in Australia offer leasehold and license/loan contracts. RLCA (2014) reported that the for-profit retirement village industry was worth AU$50 billion in 2013 and contributed to the national economy with AU$4.7 billion. As a consequence, the emerging market of independent living units (ILU) in the retirement village becomes an important informative reference for industry practitioners, senior residents, and policy makers. According to the data report of the PwC/Property Council Retirement Census, the median price of a two-bedroom ILU is AU$385,000 in 2015, which raised by AU$10,000 from the median price in 2014. This research started with a case study in Geelong, Victoria to investigate the current demand for retirement villages among its senior age population. The research selects Geelong as a case study as Geelong is the second biggest city in Victoria where the population over 55 was around 28.8% by 2011 (City of Greater Geelong, 2015) and it is more convenient for the researcher to collect enough completed questionnaires if there were invalid figures collected from the first time fieldwork. Data collection was conducted in ten Geelong Senior Citizens Clubs from October to December 2015. Ethic applications were approved by the Deakin University Human Research Ethic Committee before conducting surveys. Before delivering questionnaire sheets, a "Notice of Participating in a Deakin Research Project on Retirement Villages in Geelong" had been delivered to each club, explaining the research aims and the procedure of doing questionnaires.

SURVEY FINDINGS

Demographic profile of the respondents

The survey provided a response rate of approximately 20% with 39 questionnaires returned. The majority of the respondents are female and had secondary school education or higher level, while one third of them are doing home duties now. Figure 2 summaries age and household income profile.

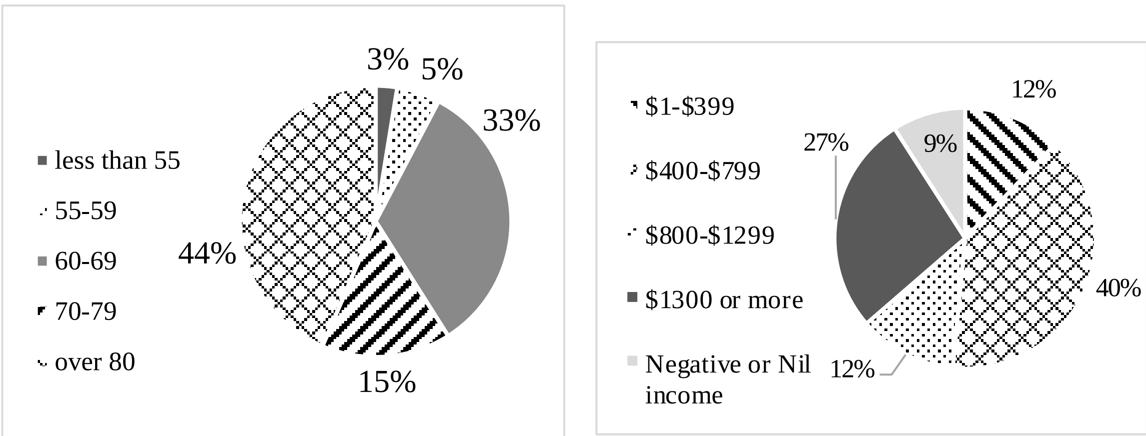

Figure 2 (a) Age bracket (b) Household income range of the respondents

Over nighty percent of the respondents are over 60 years old and the largest percentage belongs to those who are over 80. Even though the majority of the respondents are over 60, their health conditions are at or above the average level. Over 60% of the respondents' household incomes are less than $800 and 27% are over $1300. The respondents from 70-79 years old seem to obtain the least household income which is less than $400. Most of the respondents’ current income come from pension or superannuation, and those who had secondary school education hold the income less than $800. As regards to the living status, almost all the respondents live alone or with spouse/partner and live in the self-owned properties.

Barriers against moving to retirement villages

Most respondents have a strong negative perspective on moving to a retirement village. Table 1 shows discourage factors selected by the respondents, which the top 3 are ‘Too expensive to buy’, ‘Not want to change current community contact’ and ‘Ownership of the land and the unit is unclear’, following by lack of privacy and independence. Most of the respondents who choose expensive purchasing price as the first discourage factor also concern about unclear ownership and future price decrease of the unit. Loss of independence and lack of privacy seem to appear as twins choices. Concluded from the results above, economic pressure and living environment changes (including physical and social) are two main barrier categories hinder the relocation consideration.

Table 1 Concerns of senior people on retirement villages

Major concerns	**Number**
Too expensive to buy	13
Not want to change current community contact	12
Ownership of the land and the unit is unclear for me	12
Lack of privacy	11
Loss of independence	10
Afraid of future decrease in the price of the unit in retirement	6
Located far from CBD	4
Just for older people	3
Unfriendly staff and residents	1
Other	1

Economic pressure is the most significant barrier, especially the affordability. For the senior community residents, the most important factor influencing their decisions commonly about the retirement age is 'financial security’ (Australian Bureau of Statistics, 2014). From the report of Organisation for Economic Co-operation and Development (OECD), compared to median household incomes, basic Australian pension rate is low and one-third of the pensioners are living below the poverty line (OECD, 2015). Moreover, as mentioned before, the median price of a two-bedroom ILU is AU$385,000, which equals to almost 9-10 years’ incomes of most respondents who earn less than $800, and that purchasing cost excludes management fee of the unit. As a result, not surprisingly, the seniors think retirement villages are too expensive to buy. Most of the respondents who answered the question for the percentage paying for the retirement home prefer to pay only less than 50% of their wealth. Besides, some respondents worry about the unclear ownership and decreasing price in the future. The majority of respondents who choose these two items are less than 80 years old and have good or excellent health condition and they take a retirement village unit as another choice of investment. This part of seniors will face uncertain risk as the units are not their own properties and they cannot calculate the returns. Therefore they prefer stability by staying at current self-owned houses.

Living environment changes have stronger impacts on respondents over 80 years old. Since their health conditions are at average, they prefer more independence and privacy and they feel more comfortable with current familiar contact. So most of them choose ‘loss of independence’ and ‘lack of privacy’ as discourage factors. Also, the location of the retirement villages is another negative factor for them as respondents who choose ‘located far from CBD’ are all over 80 years old. Although most of the respondents do not want to move to retirement villages, some of them still give reasons to move out of home, such as current garden is too big, house is expensive and difficult to maintain, and decreasing driving ability. The results are consistent with previous research. Previous research indicate that delivery of services and facilities environment was an important factor influencing the decision of relocation. Requirements of medical services and home maintenance services contribute to the decisions of the senior people (Crisp et al., 2013; Kennedy and Coates, 2008; Nathan et al., 2012; Stimson and McCrea, 2004).

DISCUSSION

Living environment

With age growing, the senior people may hope for more privacy, therefore the government could cooperate with the industry and social organizations to improve the living environment such as outdoor living space and unit security design. To keep the community contact but not change the characters of retirement villages, the industry may lead the transition of the villages from independent units to part of a mixed-use residential community. Meanwhile, the government needs to lead a collaboration with Retirement Village Association and other industry institutions, such as developers, to deliver enough information to the senior community residents to make them realize the benefits of the retirement villages so that they are attracted to the market.

Economic pressure

Retirement villages are less attractable than traditional communities on account of additional costs and lower returns. Providing the senior people a wide affordable product and a considerable level of return to make a retirement village a desirable and feasible choice is a challenge faced by the industry (Stimson and McCrea, 2004). On one hand, to improve the affordability of retirement villages, the industry could review the facilities and services in the existing villages and develop simple villages that can meet basic needs of the residents to reduce the construction and operation costs. The government could make vacant land available (especially suburban area), find an acceptable partnership with the industry and reduce regulation constraints such as appraisal time. Part of the project could become social housing for aged care with the remainder for the developer to lease or sell. On the other hand, to help the senior people meet living costs, the government could contribute higher percentage of Gross Domestic Product (GDP) to the pension and similarly the employers to the superannuation.

CONCLUSION

From the data of Retirement Village Association, only 5% of the senior people who are over 65 years old live in retirement villages. A case study has been conducted in Geelong to investigate the willingness of senior community residents to move into retirement villages and to identify the barriers against not moving. The barriers are concentrated on two main categories which are living environment changes and economic pressure. In particular, the high price proves to be the most significant factor. The study provides practical implications for the public sectors and the industry. It is essential to gain an acceptable partnership between the government and the industry to meet the needs of the senior people. Absorbing retirement villages into mixed-use residential communities, delivering enough information to the senior people, improving the level of pension and reducing the development costs of retirement villages are feasible actions to overcome the barriers and attract more senior people as prospective residents. The limitations of the research include the number of respondents is relatively small and the questionnaire design excludes exogenous factors. Further study could take into account these determinants such as economic status and industry competition and find more accurate quantitative methods to evaluate the barriers, especially the economic ones.

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CHALLENGES AND OPPORTUNITIES OF SOCIAL MEDIA IN HIGHER EDUCATION

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ABSTRACT

In the 21st century, opportunities in education are available like never before. Use of social media in education has opened up many opportunities in education such as distance learning, blended learning, use of video and images in classrooms which was not possible using traditional classroom ways of education. Social media is playing a vital role in our everyday life. Social media is easy and quick in terms of accessing, reviewing, updating, and editing teaching and learning resources. The resources can be accessed at any time and from any place. Education has moved out of geographical boundaries of classroom teaching. Social media has made the world a smaller place. Educators and students have more information, more knowledge, and have better opportunities to use it. Social media helps to reduce stress and increase satisfaction among students. It allows each student (slow or quick) to study at their own pace and speed. We have reached more than 2 billion active social media users worldwide. The majority of the social media users globally range from age 14-29. This means a large proportion of social media users are either school students or University going students. Social media has improved our ability to absorb information. Teachers and students are pushing learning beyond the borders of classroom through social media. There are benefits such as flexibility, convenience, extra information, information when required, etc. for use of social media in education for both students and educators. However, there are many challenges facing the use of social media in education such as privacy, time wasting, incorrect communication, attention to detail, people skills to communicate, overloaded information, etc... We have done a study of how social media can be used in higher education and our paper discusses the challenges and opportunities of using social media in higher education.

Keywords: Higher Education, Opportunities in Education, Social Media in Education

INTRODUCTION

The pursuit of knowledge in a variety of fields is critical to human development. Around the world higher education is under pressure to change because of changing technology. Technology is changing fast and its contribution to higher education success is seen as vital (Garcia, Seglem & Share, 2013). In recent years, there has been a shift from using technology to convey individual ideas and expressions to the leveraging of individual strengths through technology to create community involvement (Jenkins, Clinton, Purushotma, Robison, & Weigel, 2006). Jenkins and his colleagues (2006) describe the community involvement as participatory culture, explaining, "Participatory culture is emerging as the culture absorbs and responds to the explosion of new media technologies that make it possible for average people to archive, annotate, appropriate, and recirculate media content in powerful new ways". Users share information and knowledge using social media. The technologies are transforming the ways students and teachers communicate, collaborate, and learn. Students at schools, universities, and colleges can enhance their knowledge using the educational literature, encyclopaedia, references, dictionaries, databases, which are freely accessed, participating in distance educational courses, in collaborative projects with students from other schools, universities, countries, discussing different problems with them.

Social media is also referred as Web 2.0 technologies (Gruzd, Staves, & Wilk, 2011; Hemmi, Bayne, & Land, 2009; Kaplan & Haenline, 2010) and it emphasizes user-generated content, usability, and interoperability. The growth of social media and other Web 2.0 technologies have impacted our day-to-day life (Lenhart, Purcell, Smith, & Zickuhr, 2010; (Joosten, 2012). Social media are web-based services that allow users to make personal profiles, create content, and share messages by connecting with other users in the community (Boyd & Ellison, 2007).

Websites and applications dedicated to forums, micro blogging, social networking, social bookmarking, social curation, and wikis are among some of the different examples of social media which are used in education. Social media's much publicised applications are Facebook, Twitter, YouTube and Wikipedia. The key characteristic of all social media practices is that of 'mass socialization'— i.e. harnessing the power of the collective actions of online user communities rather than individual users (Shirky, 2008).

The opportunities, such as distance education, blended learning, videos to demonstrate in the classroom, forums, chats etc., that social media can offer in the sphere of education are really unique. However, it is very important neither to overestimate the role of social media in education nor to underestimate it, in defining its role and place in the educational process. There are many challenges and opportunities of social media in education. This paper outlines a study undertaken to show challenges and opportunities of social media in higher education. It further discusses social media use in higher education, social media technologies used in education, challenges of social media in education, opportunities of social media in education, and finally conclusion.

BACKGROUND OF THE STUDY

Social media technologies are now regularly employed by a majority of internet users. Among younger users, the use of these technologies are nearing universal, such as 86% of 18–29 year olds using social media everyday (Madden, 2010). Similarly, 72% of adults and 87% of teens use text messages every day (Lenhart, 2010). In July 2010, Facebook announced that it had over 500 million users. As the number of users has increased there has been a growing interest in applying social media toward addressing national priorities (Pirolli, Preece, & Shneiderman, 2010), not just using them for entertainment or corporate purposes.

Students communicate between themselves and are included in social networks such as Facebook or Twitter. Facebook and Twitter could be used in educational purposes by creating virtual communities, groups of students with common interests or needs. Social media in education is becoming very important. One of the important reasons to integrate social media into the education is to improve communication among students and educators. Social media provides opportunity to communicate real time information in seconds. Sometime vital information needs to be sent out to students without delay. Social media is impacting the way education is done in our classrooms and outside as distance learning. Social media helps in engaging education community within and outside classroom. Social media has an impact on pedagogical approaches, learning and teaching and staff professional development (Griesemer, 2014). The key characteristics of social media are:

- Social media challenges traditional models.
- Social media allows people to communicate.
- Social media allows people to collaborate.
- Social media gives people an audience.
- Social media is open and transparent.

Yang & Liu (2008) have suggested that there are two major types of e-learning applications where social media can be used. The first one is online education applications, where all learning is conducted by using online computer mediated communications, and the second one is mixed education application systems, where learning activities take place in traditional classrooms and as blended learning through the use of online computer mediated communications. Li & Pitts (2009) have identified that technology has enhanced learning, networking, communication and resource sharing among learners and educators.

The table below shows some of the most popular types of social media and their main functions.

Table 1 List of most popular types of social media

Name	**Function**
Facebook	Registered users can create a personal profile, add other users as friends, and exchange messgaes and photos.
Twitter	A micro-blogging platform where users send 140 character messges to each other.
Google+	Real-time sharing through the web including messages, video conferencing and photographs.
Wikipedia	It is a free, open content online encyclopedia created through the collaborative effort of a community of users.
Linkedln	This allows registered members to establish and document networks of people they know and trust professionally.
YouTube	This is a video sharing website.
Flickr	This is a photo sharing website.
SlideShare	This is a presentation sharing website
WordPress	This is an Open source blogging platform.
Del.isio.us	This is a social bookmarking website.
Reddit	This is a social news website and forum where stories are socially curated and promoted by site members.
Pinterest	This is a social curation website for sharing and categorizing images found online.

SOCIAL MEDIA TECHNOLOGIES USED IN EDUCATION

Social media should be used as a tool to engage students in teaching, in order to provide them more work satisfaction and mutual communication, motivation and creativity (Tulaboev & Oxley, 2012). Social media is redefining the way students and educators engage with each other, the way they share information, the way assessments are done, and the way feedback on assessments are given. Social networks represent places where students could gain social and communication skills, and simultaneously become a part of social media culture. With social media, anyone can have a voice in a global conversation. The task of knowledge construction is being shared among the educators, students, and other individuals who share an interest for the subject (Grover & Steward, 2010).

Facebook in teaching

Today the most popular and most used social network is Facebook (FB). FB can serve educators as a place for publishing educational materials (i.e. PPT presentations, scripts, assignments, various multimedia contents etc.) Besides, Facebook can be used in creating quizzes for knowledge tests and discussions referring teaching subjects. Hence, from the educational aspect, Facebook can be observed as a social network aimed at connection and cooperation between students and educators that helps to solve communication problems.

YouTube in teaching

A typical way that Youtube can be qualitatively used in teaching is when educators record video sections with classes relevant to the educational content which is then uploaded. In this way students can search the content whenever they want it, and watch it repeatedly until they are familiar with the content.

SlideShare in Teaching

Students looking for inspiration for an upcoming presentation or hoping to learn more about a particular topic can browse SlideShare's site for ideas and content. It is also possible to mine the site for other people's presentations that could be used in class. Teachers can also connect to and follow their students' activity to keep track of what they're uploading and viewing.

Twitter

Any school or classroom can begin using Twitter as an important part of the learning process. A list of educational hashtags can be used by teachers and students who are looking to connect beyond the classroom. With a classroom account anyone in the class can tweet out questions requesting resources or sharing the learning that is taking place in that class. The appropriate hashtags should accompany each message. These messages might look like this: “We are looking for new approaches to software development. What are some unique models, tools and techniques you use? #softwaredev”.

CHALLENGES OF SOCIAL MEDIA IN EDUCATION

Traditional classroom teaching employed passive learning practices whereas social media has enabled active learning. Teachers using social media technologies are enabling students to be actively involved in learning (Jalal, 2012). Teacher’s role evolved from primarily a presenter of knowledge to more of a facilitator and mentor. However, there are many challenges facing the use of social media in education such as ability of a user to work with information, culture of communication on social media, teachers integrating social media resources, privacy, taking up time and writing skills.

Ability of a user to work with information

This implies that a student should be able to analyse the information he/she deals with, to select the facts, data adequate to the problem he/she investigates. Students need to find arguments to prove his/her own point of view. It is quite obvious that the information the student comes across on social media is not always helpful. More than that, it can start arguments and can have unappealing content; it can be not up to the required scientific level, etc. A lot of educational materials do not undergo any examination. This fact produces a lot of difficulties even for a teacher to select the material for educational purposes. Their mutual understanding or misunderstanding, sympathies or antipathies depend not on the technologies but on the students respect for each other.

Culture of communication on social media

Many people do not possess the culture of communication in terms of using the adequate forms of greetings, using the literary language, avoiding abbreviations, etc. As for the intercultural, transnational communication the problem is particularly acute. The lack of knowledge of a strange culture, national traditions, etc. promotes misunderstanding between students and educators and can be a cause of a conflict. Social media technologies are only means for communication among different people and do not train educators and students to be social media savvy.

Teachers integrating social media resources

In many higher education institutes teachers are not trained for the specific activity of handling social media resources in their curriculum. Teachers and educators consider this as a self-dependent activity in terms of using social media technologies, finding some materials for the projects, reports, essays, using forums if necessary, etc. But in fact education is a mutual, interactive activity, which should be controlled and directed. Even if the students are supposed to study some course or material located in social media they should be provided with the necessary instructions on how to do it, what additional information is to be used or other resources. Teachers have recognised that although they are comfortable in using technologies, they would need guidance as how to implement its effective use in the classroom (Tess, 2013).

Privacy

The challenge of social media posting is privacy. How private is the information that users place on social media? Who has access to the information and what is it used for? Whose role is it - parent, student, educator or website developer to ensure an individual understands his/her right to privacy and exercises it accordingly? Everyone asks himself/herself these questions. So, the privacy is one of the obstacles that have impacted the use of social media in education.

Impact of Social Media

The impact of social media environment on children and youth may not be healthy (O'Keeffe & Clarke-Pearson, 2011). Students using social media may get potential problems with cyberbullying such as online harassment, Facebook depression, sexting, and exposure to inappropriate content. The use of social media in education can cause lack of motivation towards learning if cyberbullying happens. It can also be boring sitting in front of computer for a long time without interaction, especially if the scientific material presented is free of audio and visual effects that will attract learner towards learning.

Writing Skills

Learners face some difficulty through social media technologies in expressing their views and ideas in writing. Many learners prefer to express their ideas orally which is the approach they have used for many years through their study. Social media users need to acquire writing skills to express their ideas and opinions freely. Face-to-face allows individuals to perceive physical clues like tone, inflection, body language, in an online environment, these are lacking.

OPPORTUNITIES OF SOCIAL MEDIA IN EDUCATION

Social media technologies have been admired for their capability to attract motivate and engage students in meaningful communicative practice, content exchange, and collaboration (Mills, 2011). Some of the opportunities of social media in education are discussed below.

Inspiring and engaging students

Social media technologies have increased student motivation, enhanced learning experience, increased passing rate, enhanced deeper learning of the subject, enhanced development of learner autonomy, enhanced team working and communication skills, and learning resources for future cohorts to use (Griesemer, 2014). Allam (2006) observes that the creative challenge of using moving images and sound to communicate a topic indeed is engaging and insightful. Willmot, et al. (2012) show that there is strong evidence that digital video reporting can inspire and engage students when incorporated into student-centered learning activities.

Flexibility

Flexibility is one of the most attractive elements of online learning in social media. Blended approaches that combine face-to-face and online learning are preferable to an online pedagogy alone. Face-to-face classes are likely to enable high levels of emotional understanding, while the convenience and flexibility of online components can motivate students to complete educational tasks on their own time. Social media provides participation through virtual classrooms, chat rooms and meetings by video.

Repeatable

The traditional education system does not cater for repeatable lectures or tutorials. Social media technologies make all teaching and learning resources available online. Students can revisit all required learning resources whenever they want to. Social media offers and gives opportunity for learners to retrieve the information immediately or later.

Convenience and accessibility

Social media helps to reduce stress and increase satisfaction among students. It allows each student (slow or quick) to study at their own pace and speed (self-pacing). Furthermore, it is easy to join bulletin board discussions at any time, or visiting classmates and instructors remotely in chat rooms. As a result, it helps resolve timetable conflicts. Students can choose to work full-time and study as a distance education student. Social media can provide stronger understanding and increase retention on the subject.

CONCLUSION

There are many challenges and opportunities in using social media technologies as an educational tool. Social media technologies have value in our classrooms. However, we need to use them wisely and assess their impact carefully. There is a substantial need to provide training to teachers and students so that these technologies can be used in an effective way in education. There are benefits of successful use of social media in education for both students and teachers. The ability of a user to work with information, culture of communication on social media, teachers integrating social media resources, privacy, cyberbullying, and writing skills are the some of the most important challenges facing education's use of social media. On the other hand, inspiring and engaging students, flexibility, repeatable and convenience and accessibility have a vital influence in the use of social media for education.

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SERVICE QUALITY MANAGEMENT FOR CONTRACTORS- THEORETICAL LENS FROM SUBCONTRACTORS

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ABSTRACT

Construction contractors have long been criticised of their poor administration and quality performance that often lead to time and cost overrun, disputes and litigation in projects. It is argued that higher level of contractors' service quality will bring about better project outcome and increased client satisfaction, and that contractors' service quality could be associated with the behavioural commitment of their subcontractors While a considerable amount of research has documented the perception of clients about contractor service quality performance, conceptually, the relationships between contractors' service quality and the behaviours of subcontractors remain unexplored. To address this deficiency, this study aims to develop a conceptual framework for contractors' service quality management. Based on a literature survey, we found that contractors' service quality could be categorised along five dimensions: tangibility; reliability; responsiveness; assurance; and empathy. A systematic criteria has been developed from these five dimensions based on the resource-based view. From the social exchange perspective, it postulates that subcontractors could define their working relationships with contractors as forms of social and economic exchange and that if they judge the relationships as more social than economic in nature, then the quality of those relationships will influence their organizational citizenship behaviours and hence project outcomes. However, as postulated by complexity theory, those relationships could be further moderated by the external environments in which the subcontractors operate in. Overall, this proposed framework presents an integral picture as to how contractors could manage their service quality in a socially connected but yet complex and uncertain, business environment. The hypothesized relationships will be tested and validated in the next stage of a research project.

Keywords: construction Firms, organisational citizenship behaviour, service quality, social exchange theory

INTRODUCTION

The construction industry has long been criticized for its poor quality performance (e.g. Lai et al. 2004). Over the past two decades, a considerable amount of research, across the world, has documented the effect of poor quality performance on the overall project outcome. For example, Alrcón et al. (2001) revealed that 20% of Chilean construction projects were cost overrun rate. In the Indian construction industry, Iyer and Jha (2006) pointed out that the rate of time overrun was 40%. Ahsan and Gunawan (2010) uncovered that there were 13.6% of the Chinese construction projects failed to meet the deadline and 5.4% of projects failed to achieve the budget goal. This scenario is no exception to construction industries in developed countries. Shrestha et al. (2013) revealed that, in Florida State, 17 % of construction project failed to meet the deadline and the total cost overrun was as high as US $ 200 million from 1999 to 2001. Similarly, in the context of Australian construction industry, Love et al. (2013) revealed that the rate of cost overrun was about 12.22%. Besides these time and cost overruns, Zhang and Bai (2013) also highlighted the huge numbers of disputes on project scope is another consequence of poor quality performance.

In addressing the aforementioned problems, many studies had been undertaken looking for means to improve the overall quality performance of the construction industry (e.g. Larson and Gary, 1995; love et al., 2000). For example, Pheng and Teo (2004) applied to the total quality management concept, investigating how construction firms could achieve an improved quality performance. Dikmen et al. (2005) applied quality function deployment as a strategic decision-making tool to increase client satisfaction. Derived from lean production, the concept of lean construction can improve quality performance by significantly reducing warranty costs (Andersen et al., 2012). As a result, the construction practitioners are having a systematic way to manage and improve their product quality (Harris and McCaffer, 2013). With the minimisation of the gaps of different product quality levels offered by contractors, Al-Momani (2000) however differentiated project quality into product and service quality, and pointing to the importance for contractors to gaining competitiveness by offering a higher and more effective service quality.

Hitherto, many studies have been conducted to investigate the service quality of construction firms. For example, Al-Momani (2000) and Hoxley (2000) developed evaluation system in assessing service quality. Love et al.

(2000) integrated service quality with quality function deployment. Forsythe (2007, 2008) identified different dimensions of service quality and revealed the process of how service quality theoretically occurs in the Australian housing construction industry. Most of these studies mainly attempted to classify and evaluate contractors' service quality. These evaluation systems, development strategies and different dimensions are based on the assumption that 'client satisfaction' is the key indicator of quality performance. Interestingly, it appears that no or little focus has been placed to examine subcontractors' perception about main contractors' service quality and how their perception could affect their contractual and pro-social behaviours and hence the project outcome. This could be seen as an oversight considering that 90 percent of construction works are usually undertaken by subcontractors (Eom et al., 2008). In addressing this gap, this study aims to develop a conceptual framework to explaining the relationships between main contractors' service quality and subcontractors' behaviours and project outcome. In fulfilling this aim, this study started with a comparative review of the concept of service quality and its dimensions, and the methodological approaches adopted by researchers in both service and construction domains. This is followed by the discussions of the gaps in knowledge and the conceptual framework and relevant theories underpinning contractors' service quality management.

Concept of Service Quality

Over the past decades, the concept of service quality has attracted much attention from researchers in the service and construction domains. A common perception of service quality is that it is the difference between service receivers' expectations and service providers' delivery.

In the service domain, Parasuraman et al. (1985, p.16) defined perceived service quality as 'a global judgment, or attitude relating to the superiority of a service' and noted that 'the judgment on perceived service quality is a reflection of the degree and direction of discrepancy between consumers' perceptions and expectations'. Similarly, Bitner and Hubbert (1994) related service quality to 'the consumer's overall impression of the relative inferiority or superiority of the organization and its services' (p.77). In accepting these definitions, authors (e.g. Taylor and Baker, 1994; Cronin et al., 2000) commonly see customer satisfaction as one of the key performance measures for service quality.

In construction, many studies regarded service quality as a process quality. For example, Arditi and Gunaydin (1998) described service quality as the quality of the overall supports from service providers during the entire service delivery processes through from the project initiation to the operation and maintenance stage. Ling and Chong (2005) described service quality as the extent of discrepancy between customers' expectations or desires and their perceptions. It is in line with Love (2000) who highlighted that service quality is a key component of value that enhances an organisation's capability towards maximising benefits and minimising non-price burdens for customers.

Dimension of Service Quality

Since the 1980s, a considerable amount of research has been done to develop and refine methodologies to assessing firms' services quality (e.g. Schvaneveldt and Enkawa, 1991; Akhtar and Zaheer, 2014). Many authors had developed their methodologies based on the five primitive dimensions of service quality coined by Freeman (1987). The 'reliability' dimension refers to the ability of parties to perform the promised service dependably and accurately. The 'responsiveness' dimension relates to the willingness of a firm to help and offer prompt services to customers. The 'tangible' dimension refers to the appearance of physical facilities, equipment, personnel, and communication material. As for the 'assurance' and 'empathy' dimensions, they represent 'the knowledge and courtesy of employees and their ability to inspire trust and confidence' and 'the caring, individualised attention that a firm provides to its customers', respectively. Subsequently, Zeithamal et al. (2002) expanded these five dimensions into efficiency, reliability; fulfilment; privacy; responsiveness; compensation; and contact. Similarly, Yang and Jun (2002) reclassified and operationalised Freeman's (1987) dimensions of service quality into: reliability; access; ease of use; personalization; security; and credibility.

Turning into construction, researchers have operationalised service quality into various dimensions. Hoxley (2000) utilised the same five dimensions from Freeman (1987) to measure service quality in the UK construction industry from the previous works done by contractors. In US, both Yasamis et al. (2002) and Arditi and Lee (2004) proposed models to assess contractors' service quality in construction. However, they were looking at different types of contractors. Yasamis et al. (2002) utilised eight dimensions to evaluate the pavement contractors' service quality, namely: time; timeliness; completeness; courtesy; consistency; accessibility and convenience; accuracy; and responsiveness. Integrating with quality function deployment, Arditi and Lee (2004) added three dimensions into Yasamis et al. (2002)'s eight dimensions to assess D-B contractors' service quality performance. They are: dependability; communication; and understanding the customers. Ling and Chong (2005) adopted the five dimensions from Freeman (1987) and found that the perceived service quality provided by the Singapore D-B contractors was below client expectations. They believed that the service quality can be improved by: 1) appointing a competent senior project manager; 2) building up expertise and project management capability; and 3) achieving a higher degree of cooperation. Targeting the house maintenance services in Australia, Forsythe (2007) added three new dimensions to Freeman (1987)'s original five dimensions to investigate customer satisfaction in the Australian residential housing industry. These three new dimensions are: 1) communication; 2) Care in execution of work; and 3) Work out put.

Methodological approaches adopted in Service Quality

In the service domain, it is notable that researchers are increasingly moving away from the customer-centric to the stakeholder approach when investigating means of delivering effective and high service quality. For instance, Burke et al. (1992) utilised a multiple-stakeholder perspective in reconceptualising psychological climate and found that besides customers' concern, organisations should also focus on their employees. LeBlanc and Nguyen (1997) found that in educational sectors, service providers should take the perceptions of various stakeholder groups (e.g. faculty and administrative personnel) into consideration instead of over-emphasising customer satisfaction, for their perceptions also have a considerable impact on service quality via a harmony working environment. More recently, organisational researchers have also looked at the relationships between employee attitude and behaviour, working relationship, organisational supports and service quality performance. For example, Snipes et al. (2005) highlighted that the intrinsic motivation of employees towards their job has a high positive impact on organisational service quality in the higher education sectors. These findings are shared by Husin et al. (2012) who further pointed out that increased support at work, reward system, and supervisory assistance can help developing employees' organisational citizenship behaviours (OCBs) and hence improving overall organisational service quality performance. Organ (1988) defined OCBs as a person's voluntary commitment within an entity that is not part of his or her contractual tasks, and classified OCBs into five dimensions, namely: altruism; courtesy; conscientiousness; civic virtue; and sportsmanship. More recently, the findings of Lee et al. (2012) and Singh et al. (2015) also point to the conclusion that employee reactions, customer satisfaction and customer loyalty are strongly associated with service quality. Jaiswal and Dhar (2016) further found that the effect of employee-employer relationship on organisational service quality is significantly mediated by their commitment.

In construction, studies had documented the importance of subcontracting in construction and the association between subcontractors' behaviours and overall project outcome. For example, Dainty et al. (2001) highlighted that subcontracting is critical in surviving the volatility of the construction business cycle for its function of increasing proportion of total construction work-load. This is in line with Hsieh (1998), who revealed that subcontracting is a key in improving contractors' site productivity. Both Ng and Wang (2005) and Mbachu (2008) examined the effect of subcontractors' behaviours on overall project outcome. They found that a project is likely to be successful and achieves its goals, when subcontractors are committed by conducting the following behaviours: 1) providing adequate resources in finishing tasks; 2) utilising suitable construction methods, 3) making feasible and flexible planning and closely monitoring and implementing them; 4) providing regular and close site supervision in projects which can detect potential errors; 5) taking constant actions to remedy non-compliances; and 6) requesting for time extension and order of changes in a reasonable manner. However, Shore et al. (2006) pointed out that if subcontractors become too contractually focussed, they will: 1) only care about payment; 2) do not care about nurturing a long-term relationship with their main contractors; and 3) do not perform in a proactive manner. In accepting these, authors have pointed to the importance of relationship building and management between main contractors and subcontractors towards gaining the emotional attachment and behavioural commitment of parties (e.g. Dainty, et al. 2001; Rahman et al., 2013). For example, in investigating the role of emotional attachment in UK construction projects, Dainty et al. (2005) related the notions of project affinity and chemistry to OCBs, and claimed that a connection and commitment of participants to the project outcomes influenced the way in which the participants worked and their OCBs.

In construction, Identifying key determinants of service quality has long been a priority of researchers in construction (e.g. Malonely, 2002; Arditi and Lee, 2004; Forsythe, 2008; Lim et al. 2011). The following factors have been identified as key determinants towards service quality: contractor-subcontractor relationship; project management capability; safety performance; skilled workforce; quality management system; supply chain capability; flexibility; organisational culture; and information. Some studies also attempted to develop approaches for improving service quality performance. For instance, Winch et al. (1998) tested a gap analysis approach in the Glaxo project in UK and highlighted the benefits of gap analysis approach in improving service quality. Similar efforts have been made by Forsythe (2008) by proposing a model in integrating QFD to achieve an enhanced service quality performance. Like QFD, Just-In-Time method has also been employed into the construction industry to improve service quality (e.g. Pheng and Hui, 1999). Forsythe (2007) also proposed a BUILDSERV instrument to replace SERVQUAL in assessing service quality in construction. Most of these studies treated client satisfaction as the final goal of service delivery.

Gaps in Knowledge

From the review above, it appears that little or no work has been done to explore service quality performance of main contractors from a multi-stakeholder's perspective. Most studies mainly focus on how satisfied clients are with regard to contractors' service quality performance. It is therefore not known how subcontractors perceive about, and respond and behave to the service quality delivery of main contractors. This could be a critical oversight in the area of service quality considering that each construction project team can be regarded as a 'temporary multi-organisation' and that subcontractors could be regarded as temporary or contractual employees of main contractors in their service delivery. It follows that subcontractors' behaviour could significantly affect the overall service quality delivery performance of main contractors. Another gap in knowledge revealed here is that little or no work has been done to map and examine the associations between main contractors' service quality, subcontractors' contractual behaviours and OCBs and overall project outcomes.

Underpinning Theories and Conceptual Framework

In addressing the gaps above, this study focuses on the perception of subcontractors about main contractors' service delivery, looking at how the service delivery could affect the subcontractors' contractual behaviours and organisational citizenship behaviours; and thereafter shaping the overall project outcomes. Figure 1 shows the proposed conceptual framework. Those hypothesised relationships are underpinned by the theories of resource-based, social exchange and complexity.

From a resource-based perspective, a firm is an entity that possesses unique collections of resources and capabilities bounded together in its administrative framework, and that 'ownerships' of these collections of resources and capabilities provide the basis for its operation and competitiveness (Penrose 1959; 1995). As such, in this study, the main contractors' resources and capabilities forms the basis of their service quality delivery which could be categorised along the five dimensions originally proposed by Freeman (1987). Of which, in the context of a 'temporary multi-organisation', subcontractors could be also seen as one of the main contractors' resources.

The relationship between main contractors and subcontractors could be explained by the social exchange theory, which postulates that the relationships could exist in the forms of economic exchange and social exchange (as described by Organ, 1988). According to Organ (1988), if people judge their relationships as more of a social exchange relationship, they will be motivated and committed to undertaking their tasks, and go beyond their contractual responsibilities. To the other end, they will be reward and contractually focussed if they perceive their relationships as more of the economic nature; hence the performance will be affected.

According to Tetenbaum (1998), the complexity theory assumes that an organisation can be regarded as an entity which comprises a complex linkage of elements that behave in line with its environment. Hence, the moderating effects on the exchanges between contractors and subcontractors can be explained by the complexity theory. Based on the complexity theory, the interactions between contractors and subcontractors during the service delivery are collectively influenced by several factors from the external environment (Baccarini, 1996).

Under circumstance of the Chinese traditional culture, Farh et al. (1997) integrated the concept of organizational citizenship behaviour with the Chinese society. They identified five dimensions of organizational citizenship behaviour from a slightly different perspective: 1) identification with the company (discretionary behaviours illustrating the deep concerns and active interest in the life of organisations); 2) altruism toward colleagues (discretionary behaviours of helping colleagues with their works); 3) conscientiousness (discretionary behaviours that go well beyond the minimum role requirements); 4) interpersonal harmony (discretionary behaviours by an employee to avoid pursuing personal power and gain detrimental effects on others and the organization); 5) protecting company resources (discretionary behaviour by an employee to avoid negative behaviours that abuse company policies and resources for personal use).

Reflected on the joint efforts of, five aspects of subcontractors' project outcomes will be led: 1) low defects and low rework occurrence rate (Ko et al., 2007; Mbachu, 2008); 2) accurate and flexible planning (Ng et al., 2003; Eom et al., 2008; Mbachu, 2008); 3) financial stability (Mbachu, 2008, Rahman et al., 2013); 4) systematic on-site health and safety management (Ng et al., 2003); 5) effective communication (Mbachu, 2008; Rahman et al., 2013); and 6) sustainability (Sarkis et al., 2008).

In this framework, the perceived service quality of contractors is evaluated on five dimensions. Each dimension stands for one aspect of contractors' utilisation of its own both tangible and intangible resources. According to Hartmann and Caerteling (2010) and Manu et al. (2015), during the service delivery, contractors and subcontractors are connected by two factors: 'price' and 'trust'. This point of view supports the hypotheses of this framework, as reinforced by the social exchange theory, that there are two kinds of exchanges between contractors and subcontractors during service delivery: economic exchanges and social exchange exchanges. Generated from the perceived service quality, perceptions on the differences of contractors' service quality may affect the exchanges between them, hence influence their corresponding behaviours (Macneil, 1977; Konovsky and Pugh, 1994). However, subcontractors' bidding decisions can determine the existence of these exchanges. These bidding decisions are affected by several factors from the external environment which is in line with the complexity theory (Shash, 1998).

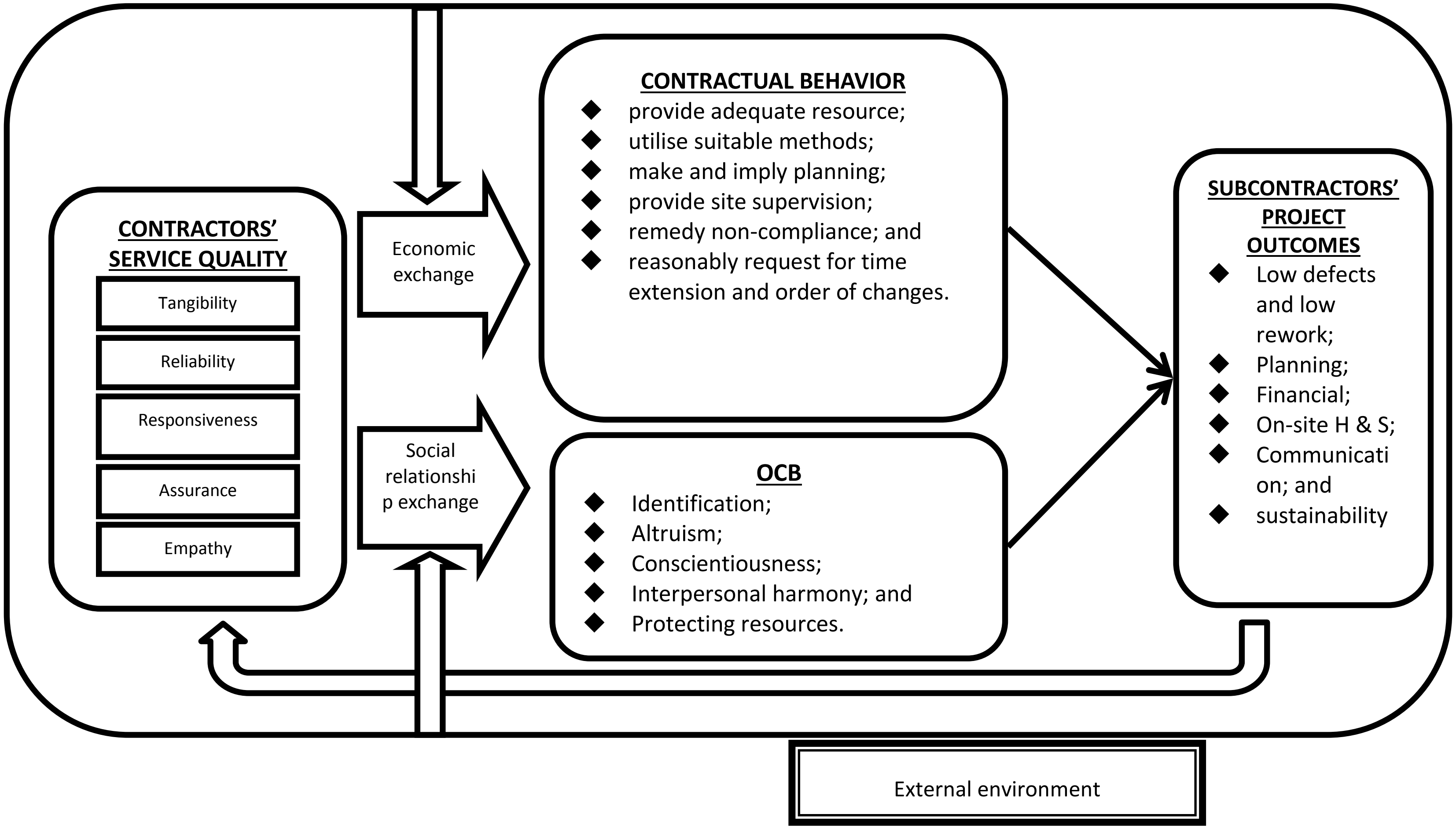

Figure 1 conceptual framework

CONCLUSION

This study investigated the service quality of construction firms, and developed a conceptual framework. This framework is underpinned by the social exchange theory; resource-based view; and complexity theory. Based on the literature review, it is postulated that the subcontractors will behave differently according to contractors' service quality; these corresponding behaviours (both contractual behaviour and organisational citizenship behaviours) can influence on subcontractors' project outcomes and ultimately affect contractors' service quality in turn.

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IS RADICAL INNOVATION A NEW VALUE-ADDING PARADIGM FOR CONSTRUCTION ORGANISATIONS OR JUST A CURRENT FAD? – A CRITIQUE –

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ABSTRACT

The Construction Industry, globally, has long been accused of low levels of productivity and innovation and arguably cannot be as readily measured using mechanisms common to other industries. Innovation is described and defined differently according to the particular context of discourse. This research investigated a process known as ‘radical innovation’ from a published and funding perspective longitudinally over time in a range of industries, including how it may or could be interpreted, applied and add value in the construction context. A systematic and in-depth literature review was undertaken involving sources from longstanding and credible journal data bases. The findings were analysed using an interpretative methodology that incorporated a multi-dimensional measurement approach. The findings, and the subsequent critique, were broken into two components – ‘radical innovation’ persé, and ‘radical innovation’ in construction. The resultants established that ‘radical innovation’ has been explored by researchers from the 1930’s in the context of many industries, but not within the Construction Industry context – where only a handful of journal articles having been published. In addition, enablers and obstacles have been identified, with only minimal evidence of previously proven methods within the Construction Industry. A poor track record of investing in research and development, the nature of the industry being adversarial and fragmented, with many micro organisations, suggested that an action research project will be the next step to test and potentially embody ‘radical innovation’ and increase productivity.

Keywords: collaboration, construction industry, knowledge management, organisational culture, radical innovation

INTRODUCTION

Government and industry organisations that promote research and development (R&D) in New Zealand, set strict criteria and guidelines for the research projects that will or might be funded. How do these organisations view radical innovation /what are their key research funding criteria:

1. MBIE – The investment mechanism is intended to support ambitious, excellent, and well-defined research ideas which have credible and high potential to positively transform New Zealand's future in areas of future value, growth or critical need. Radical innovation tends to be implicit not explicit, in criteria descriptors.
2. Callaghan Innovation seeks to assist businesses take innovation to the next level through technology, and collaborative partnerships between CI and businesses to lift productivity in the Built Environment Sector, for example.
3. BRANZ - The Building Research Levy, (1969) is used by BRANZ to offering grants for construction industry-related and scientific research. Of note, Lincoln University has been conducting research into cultural aspects of innovation, since 2008 in New Zealand and overseas, including building. The Ministry of Science and Innovation are the main funders, with BRANZ a co-funder. A paper published by Lincoln in 2010 looked at the potential need for a dedicated innovation centre in New Zealand focused on the building sector.
4. Building and Construction Sector Productivity Partnership. In 2011 this partnership reported that 45% of companies with 6+ employees were reporting levels of increased innovation.

Innovation can be divided into incremental and 'radical innovation' (RI) (Norman and Verganti, 2012), or even more specific divisions (Slaughter, 1998). Within these are different descriptors of innovation: product, process, organisational, input and marketing (Schumpeter, 1934). What differentiates RI from the incremental innovation is that it does not just significantly improve the existing patterns, but breaks existing patterns, and produces something new and unique (Dahling and Behrens, 2005).

There has been some discussion on RI in the published literature since the 1930s', when Schumpeter (1934) introduced the concept of creative destruction and disruption, but the concept has become popular during the last couple of decades. It can be argued that RI in construction has existed for a long time in the form of new materials, tools, engineering and architecture inventions. Examples would be Portland cement in the 1700s', steel construction in the 1800s', and the engineering and construction techniques needed to build the pyramids over four and half thousand years ago and the Megalithic Temples of Malta 4^{th} millennium BC (Unesco, 2015).

However, evidence of proven methods for RI within the Construction Industry is lacking in published literature. A poor track record of investing in R&D, and the nature of the industry being adversarial, and fragmented with many micro organisations has had a serious impact on innovation levels in construction (Abbot et al., 2006; Barlow, 2000; Blayse and Manley, 2004; Sexton and Barrett, 2003a).

RESEARCH METHODS

The research method was primarily exploratory, and involved looking for patterns of activity, similarities, and changes that have occurred over time in terms of the descriptor 'radical innovation'. A systematic and in-depth literature review was undertaken, including historical archives, journal articles and case studies from 189 longstanding and credible journal data bases. Peer reviewed published literature was investigated, analysed and compared longitudinally over time across a range of industries, with the main focus being, how 'radical innovation' may, or could be interpreted, applied and add value in the construction context. To commence the process, an historical archival journal article literature review, and quantitative analysis, was undertaken to confirm when the process of 'radical innovation' was first introduced, and published in quality assured academic literature, and how widely it has been investigated and evidenced to date. This literature review involved all disciplines e.g. art, literature, education, social sciences, business and construction, using the descriptor 'radical innovation' in the title of articles, and in the text of the articles. One hundred and eighty nine data bases were selected and included the following key data bases: Academic One File; Academic Search Complete; Business Source Complete; Ebsco Journal Service; Emerald Management Xtra 200; Engineering Source; Sage Premier; Science Direct.

The process was then systematically repeated by using the search descriptors 'radical innovation' AND 'construction', to try and identify if, and how the process has been explored, investigated, or applied over time in the Construction Industry. Only a small number of published references were found that involved the Construction Industry, so the search descriptors - 'discontinuous innovation', 'breakthrough innovation', 'disruptive change', 'fundamental change", 'revolutionary change', and 'paradigm shift', were individually added to the search involving 'construction'. For example, 'discontinuous innovation AND construction'.
Resultant published case studies provided a variety of relevant sources, and data that included quantitative and qualitative research methods. A few of the reference articles were exploratory case studies that could provide a starting point for ongoing research. The Findings in the selected literature were then collectively critiqued under the key headings: Definition and types of innovation and radical innovation; Radical innovation persé in peer reviewed published literature; Value, enablers

and obstacles of innovation and radical innovation persé; Radical innovation in construction in peer reviewed published literature; Value, enablers and obstacles of innovation in construction; and Construction industry vs. other industries. Conclusions and recommendations were then drawn from the findings.

FINDINGS AND DISCUSSION

Definition and types of innovation and radical innovation

To understand the context of the research it is important to define what is meant by 'radical innovation' (RI). Even though some innovations are clearly incremental and some clearly radical, it is not always easy to make the distinction, the line between the two is somewhat blurry.

Crossan and Apaydin (2010), defined innovation as production or adoption, assimilation, and exploitation of a value-added novelty in economics and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome. Crossan and Apaydin also noted that novelty is relative, what is common practice for one, can be innovative for others. RI, was also considered as revolutionary, disruptive, discontinuous or breakthrough (Crossan and Apaydin, 2010). Dahlin and Behrens (2005) defined RI as something novel, unique and having impact on future products and processes, when incremental innovation is a significant improvement to the existing products or process, but not totally novel or unique (Martinez-Ros and Orfila-Sintes, 2009). Ettlie et al. (1984) argued that RI can be distinguished from incremental, continuous innovation by looking at if the innovation is a clear, risky departure from existing practice. Leifer (2000), added into this by stating that RI either introduces totally new performance features, improves things by at least 5 times, or there is at least 30% reduction in cost. Norman and Verganti (2012), explored the differences between incremental and radical product innovation distinguishing them by the differing processes. They state that incremental innovation is a result of a deliberate design research strategy whereas RI in contrast is related either to the introduction of new technology or finding new meanings for a product. Story et al., (2014), came to the same conclusion noting that in order to achieve RI one has to depart from current design trajectories. In conclusion, RI breaks the existing patterns, whereas incremental innovation simply improves them, albeit significantly.

Keeley et al. (2013) created a framework of ten types of innovation by looking at over 2000 successful innovations including Google, Lego and McDonalds. Their framework consists of three areas, which are further broken down to innovation types:

- Configuration: profit model, network, structure, process
- Offering: product performance, product system
- Experience: service, channel, brand, customer engagement

This framework puts more emphasis on the experience, service and customer as part of innovation.

Radical innovation persé in peer reviewed published literature

When investigating peer reviewed journal articles, the term RI was rare before 1980s' (Table 1), although Schumpeter (1934), who is considered the godfather of innovation studies (Sledzik, 2013), discussed creative destruction and disruption in the 1930s'. Schumpeter was an economist and political scientist, but the first quality assured journal articles mentioning radical or disruptive innovation in early and mid-1900s' were related to other disciplines, such as art, literature, theology and education. From the 1980s', several disciplines joined the discussion including social sciences, medicine and business. New themes of innovation started to emerge such as intern-organisation innovation and innovation management (Stringer, 2000). In 2000, the discussion expanded to introduce open innovation, and the relationship of knowledge management and innovation (Chesbrough, 2003; Berchicci, 2013; De Wit et al., 2007).

Table 1. Frequency of the term 'radical innovation' in quality assured journal articles from 1950 to 2015.

Timeline	Included in the title	Included in the text	Disciplines
1950-1959	0	3	Art, literature and theology
1960-1969	0	37	Art, literature, theology and education
1970-1979	0	16	Art, literature, theology and education
1980-1989	5	100	Wide variety of disciplines including art, literature, theology, education, social sciences, medicine, business etc. but excluding construction
1990-1999	12	>500	Wide variety of disciplines including art, literature, theology, education, social sciences, medicine, business etc. but excluding construction
2000-2009	>70	>2000	Wide variety of disciplines including art, literature, theology, education, social sciences, medicine, business etc. but excluding construction
2010-2015	>100	>3000	Wide variety of disciplines including art, literature, theology, education, social sciences, medicine, business etc. but excluding construction

Value, enablers and obstacles of innovation and radical innovation persé

Considering that the line between incremental and RI is sometimes blurry. Value, enablers and obstacles are similar for incremental and 'radical innovation'. Whyte (2003) surmised that innovation was important for the long-term economic success of organisations, by offering market growth or a stabilised position in the market. In some cases, incremental innovation is enough to create competitive advantage, but in many cases RI is required in extremely competitive markets just to maintain the market position with competitive advantage, (Kim and Maubourgne, 2005; Rosenbusch et al., 2011). RI is considered to be a driver for technological, industrial and societal change, as well as growth and wealth of organisations (Schoenmakers and Duysters, 2010; Tellis et al., 2009).

Incremental innovation is enabled by organisational learning, which allows the development, acquisition, transformation and exploitation of new knowledge (Jiménez-Jiménez and Sanz-Valle, 2011). RI on the other hand requires more than this by combining internal knowledge base with external sources (Forês and Camisón, 2015), but preferably with unbiased external sources, (Schoenmakers and Duysters, 2010). Existing knowledge needs to be connected in new ways, (Keupp and Gassmann, 2013). Alliances and open innovation are offered as solutions to enable external knowledge acquisition, transformation and exploitation, (Besant et al. 2014; Schoenmakers and Duysters, 2010). Tellis et al. (2009) listed five main enablers for RI: educated and skilled workforce, capital, supportive government policies including intellectual property policy, support for academia-industry collaboration, tax credits for R&D, government's own procurement, and corporate culture. Corporate culture, attitude and practice, had the biggest impact on RI; companies need to be willing to cannibalise, be orientated to future markets, have a good risk tolerance, and empower and provide incentives to champions (Tellis et al., 2009). Ability to unlearn (Yang et al., 2014), adapt and reconfigure routines (Bessant et al., 2014; Starbuck, 2014) are core to RI.

The list of enablers for RI can also be turned into obstacles of RI: lack of skilled and educated workforce; lack of capital; restricting government policies; no support for academia-industry collaboration; no monetary incentives from the government, and an unsupportive organisational culture. There were some contradicting views though, for example when Tellis et al. (2009), listed capital as one of the main enablers, Keupp and Gassmann (2013) argued that restricted resources can actually be a driver for RI. Exploring more deeply, no tolerance for risk and no future vision hinder RI according to Tellis et al. (2009). Green and Cluley (2014), Sandberg and Aarikka-Steenroos (2014), added hierarchical, bureaucratic and unsupportive organisational structure, to the list of obstacles for RI.

Radical innovation in construction in peer reviewed published literature

Only a handful of peer reviewed journal articles discussing RI in construction context was discovered. Slaughter (1998) with the article 'Models of Construction Innovation', was the first published researcher to mention RI in construction context. Slaughter (1998) divided innovation in construction to incremental, modular, architectural, system and radical. To assist the construction companies to innovate she further specified activities for implementation by type of innovation. The main difference between the implementation activities for RI compared to the others is that the activities involve higher organisation level (top level) and require more specialised resources and links. Boland et al. (2007), studied Frank O. Gehry's adoption of digital three-dimensional representations, and the wakes of innovation it created in projects. The disestablishment of old practices by creating collaborative project networks, and the use of disruptive technology by adopting aviation industry software to be used in a construction project, was described. Yu et al. (2012), created a model for the automated generation of innovative alternatives (MAGIA), which used published specifications and patent databases to generate innovative technology solutions. The roles of the supplier and the end-customer in RI processes were highlighted by Mlecnik (2013) and Sivunen et al. (2013). Sivunen et al. (2013) argued that the RI process in construction is affected by external factors such as economic, social and political factors, competition and infrastructure, but also internal factors such as resources, organisational structure and organisational culture.

When the combination of descriptors, 'radical innovation' and 'construction', resulted in only a handful of articles, the search was expanded to include 'discontinuous innovation', 'breakthrough innovation', 'disruptive change', 'fundamental change', 'revolutionary change', and 'paradigm shift'. An additional small number of articles were found that introduced RI from the areas of product and process development, and digital technologies. In addition, a number of articles discussed the need for RI, but did not offer any proven examples.

Value, enablers and obstacles of innovation in construction

Abbott (2006), Barrett (2006), Davey (2004), Hardie (2010, 2011), Manley (2008), Sexton (2003a, 2003b, 2004) and Whyte (2003), all published literature on innovation in construction, focusing on the specific fragmented and project-based nature of Construction Industry, and on small and medium sized construction organisations/enterprises (SMEs). The need for SMEs to network and collaborate both with other organisations and academia to innovate, was highlighted.

Gann and Salter (2000) argued that project and business processes should be better integrated to enable innovation in project-based organisations. Keegan and Turner (2002), favoured more organic project management. Knowledge management and organisational learning were seen as a key for innovation creation in construction (Barlow, 2000; Davey, 2004; Eqbu, 2004; Issa and Haddad, 2008; Maqsood and Finegan, 2009).

Xue et al. (2014) implemented a systematic literature review of construction innovation. This identified collaboration, inter-organisational cooperation, academia-industry cooperation, complex product systems, culture, innovation climate, champions and leadership as the main categories of discussion in published literature. Blayse and Manley (2004) listed clients, manufacturers; structure of production; relationships between individuals and organisations; procurement systems; regulations, nature and quality of organisational resources as primary drivers of innovation.

Construction Industry vs. other industries

Construction is a project-based industry with two main types of organisations: temporary project organisations, and permanent company organisations. The Construction Industry is very fragmented with many small and micro organisations, being described as adversarial in nature, due to the dominating forms of contracting, which enable exploitation and development of a hostile and litigious environment, with a strong blame culture (Egan, 1998; Egbu, 2004; Latham, 1994).

Investment on R&D in construction, has been historically poor, (Winch, 2003). In the European Union, the Construction Industry invests less than 1% of its net sales in R&D, leaving the industry in the lowest category among all industries, (Hernandez et al., 2014). The figures are even lower in Australia, and in New Zealand, (Barlow, 2012; Morrison, 2001). Although innovation is often measured by the amount of R&D investments, it has been argued that R&D should not be used to measure innovation in construction, particularly if innovation levels are low in construction, compared to other disciplines (Bygballe and Ingemansson, 2014; Winch, 2003).

The nature of the Construction Industry tends to have a negative impact on RI, and innovation in general. The often fragmented and hostile environment does not support the development of an open, collaborative learning environment. Competition between organisations to win projects is often the main or only driver. Hierarchical and rigid organisational management structures do not allow full integration of project and business processes, nor more organic management methods, to enable innovation. Learning at project level is often not exploited at company or industry level, and company-level learning is not always shared at the project level. Internal networks are valued more highly than external networks, and there is a lack of integration in the supply chain across projects (Bygballe and Ingemansson, 2014). Adversarial procurement systems hinder collaboration, and a blame culture, and litigious environment lowers tolerance for risk, discourages creativity and reduces innovative initiatives. However, there are increasing examples of better integration across the supply chain (Bygballe and Ingemansson, 2014), and more collaborative ways for procurement are emerging (Blayse and Manley, 2004). Construction organisations have finally started to understand the importance of collaboration at the early stages of the project, and that the value added to the client is the key driver and goal of the project (Sivunen et al., 2013).

CONCLUSIONS AND RECOMMENDATIONS

It is evident that the term RI is new to construction and construction is more prone to other types of innovation: incremental, modular, architectural and system innovation. Nevertheless, considering the relatively extensive and representative historical references and the journal articles reviewed, it can be argued that RI definitely exists in the construction sector.

Whether RI adds value to construction, and identifies the proven methods, cannot be drawn from the limited published literature on RI in construction. However, when looking at innovation in general, its value, enabling, and hindering factors in the wider industry context, could and do apply in the Construction Industry context. Therefore it could also be argued that most of the factors for RI in the wider industry context apply in the construction context.

RI requires adaptation of new routines, and reconfigurement of existing processes and habits. Organisational structure and management need to allow this to happen. Due to the project-based nature of construction, project and business processes need to be better integrated, and project management needs to be more organic. Construction organisations still have a long way to go to become innovative organisational cultures, which provide incentives for innovative champions.

Knowledge management and organisational learning were seen as important enablers for RI in the wider industry context. Innovation in construction tends to happen at the project level. However, construction requires methods which suit temporary project-based organisations, when it involves development, acquisition, transformation and exploitation of new knowledge, in order to transfer that new knowledge to the next project.

Project-based practice needs ways to collaborate and to form external networks, which include the whole supply chain from the manufacturer to the client. This can be enabled by procurement systems, which allow true collaboration across the supply chain. In these networks, restricted resources, especially in the SME sector, can become drivers of innovation instead of being an obstacle, and the client becomes an important initiator of innovation.

This literature review has provided some insights into 'radical innovation' in construction, but to further explore the process an interventional 'radical innovation' action research project in conjunction with a construction organisation is the proposed next step, and will be commenced in mid-2016.

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STRATEGIES FOR SUCCESSFUL STAKEHOLDER ANALYSIS AND STAKEHOLDER ENGAGEMENT IN PPP PROJECTS

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ABSTRACT

Many countries around the world are in search of new means to engage the private sector in managing and financing infrastructure through Public Private Partnerships (PPPs). However, most of the PPPs have faced issues during design and concession periods. When considering these issues stakeholder management (SM) related issues can be considered as one of the main reasons for failure. PPPs involve many stakeholders whose interests might not be in agreement, leading to conflicting objectives. In such situations SM has a high level of importance to avoid the conflicts and to achieve the success of projects. Therefore, this paper concentrates on identifying the most critical strategies for successful stakeholder analysis (SA) and stakeholder engagement (SE) in PPP projects. Initially, the strategies for successful SA and SE were investigated via extensive review of literature. As most of the identified strategies were for general construction projects, 19 semi structured interviews were conducted to further validate the strategies. After the validation exercise the 341 participants in the questionnaire survey findings confirmed that all the strategies are critical in PPP project success. "Have a good understanding of each other's objectives" and "Clear and timely information distribution to general community" have become the most critical strategies. Further, the comparative study highlighted that most of the strategies have become critical for the economic infrastructure projects when compared with the social infrastructure. As such, this study highlighted the necessity of paying more attention to the SM concerns in economic infrastructure projects.

Keywords: Public Private Partnerships, Stakeholders Management, Strategies, Australia

INTRODUCTION

Public private partnerships (PPPs) are a relatively popular form of project delivery methods in procuring capital intensive economic and social infrastructure. According to Grimsey and Lewis (2002), achieving value for money in the services delivered and allowing the private sector entities to meet their contractual obligations are the primary objectives of using PPPs. However, many implementation issues associated in PPPs have led to PPP project failure in many instances. Some of the issues highlighted in the wider PPP literature can be viewed as: a lack of disclosure and transparency in the PPP arrangements (Regan et al. 2011), the political agenda towards PPP project decisions (Johnston and Kouzmin 2010, Siddiquee 2011), interests of the general public are not well addressed (Johnston 2010), a lack of staff capability in the PPP project delivery (Siddiquee 2011, Regan et al. 2011) and conflicts are not well managed (Johnston and Kouzmin 2010, De Schepper et al. 2014). All these issues can be directly associated with stakeholder management (SM) related concerns in a project.

Chinyio and Akintoye (2008) confirm the importance of SM in the modern forms of construction procurement such as partnering and private finance initiative. Accordingly many stakeholders are involved in this process whose interests are not always in agreement. According to a report published by the World Bank, the first factor out of seven major points that are holding up private investment in infrastructure is the wider gap between the government and the private sector interests (De Schepper et al. 2014). However, according to De Schepper et al. (2014), stakeholder issues do not merely emerge because of this gap but due to the concerns related to ineffective SM approaches. Despite the literature has suggested a proper SM is key to attain PPP project success, there is a lack in studies in this area. PPP procurement structure is different from a traditional contract where by definition PPP gives shared finances, risks and responsibilities in different stages of the PPP life cycle. As such, it can be expected that more complex internal and external stakeholder structure in a PPP as opposed to traditional procurement systems. Further, having two SM systems for the private contractor and the public initiator work fine in a traditional procurement since the responsibility is fairly set and clearly defined within the contract. However, in a PPP contract the shared concept will move towards a more integrated system to manage the stakeholders in one framework considering the main parties to the partnership. As such, this research seeks to identify the strategies for a successful SM with an aim of developing an integrated SM framework for PPP project. The next section will discuss the SM strategies identified from the literature review.

STRATEGIES FOR SUCCESSFUL STAKEHOLDER MANAGEMENT

Strategies contributing to the success of SM in construction projects have received the interest of many researchers in the construction management field (Reed et al. 2009, Yang et al. 2009). This research defines a strategy as a best practice leading to successful SM when implementing PPP policy in infrastructure development. These strategies were categorised into the main stages of SM process as stakeholder analysis (SA) and stakeholder engagement (SE) as shown in Table 1. SA is defined as "The identification of a project's key stakeholders, an assessment of their interests, and the ways in which those interests affect project riskiness and viability (Allen and Kilvington 2002)". As such, this is a very important stage in SM as if anyone undertook a poor SA it will lead to many issues when the project progresses. Yang (2014) propose two key steps for SA in urban development projects as stakeholder identification and prioritization. Reed et al. (2009) separate the SA process into three steps, namely, (1) identifying stakeholders; (2) differentiating between and categorising stakeholders; and (3) investigating relationships between stakeholders. Further, a variety of strategies related to successful SA were explored by the previous researchers as shown in Table 1.

Table 1: Strategies for successful SM

Strategies for successful SM	Yang et al. (2009)	Yuan et al. (2009)	Zou et al. (2014)	Tang and Shen (2013)	Reed et al. (2009)	Lim et al. (2005)	Olander and Landin (2008)	Byrson (2004)	De Schepper et al. (2014)	Mouraviev and Kakabadse (2013)
Stakeholder Analysis										
Have a good understanding of each other's (Government and private consortium) objectives	x	x	x	x	x					
Identify the stakeholders	x	x			x					
Classify stakeholders					x	x				
Identify relationships between stakeholders	x					x	x			
Identify concerns of each stakeholder	x			x				x		
Rank stakeholders	x			x				x		
Identify longer-term stakeholder issues								x		
Identify relationships among stakeholder issues								x		
An in-depth analysis of the political opportunity structure									x	
An in-depth analysis of the opposition within stakeholders									x	
Stakeholder Engagement										
Identify the suitable strategies to engage with the stakeholders	x			x						
Communicate and interact with all stakeholders	x		x	x						
Be honest				x						
Engaging with the opposition party during the bidding stage									x	
Engaging with stakeholders in the design of the bids' assessment criteria										x
Agreement of brief by all relevant parties				x						

The second major component in construction SM is the SE. SE is defined as "Communicate, involve and develop relationships with stakeholders (Chinyio and Akintoye 2008). SE can contribute to the sense ownership among the stakeholders, and it will improve the stakeholder trust towards the project. Yang et al. (2011) develop a typology of SE tools for construction projects together with their limitations and strengths and their level of engagement. And at the same time literature has highlighted certain strategies for successful SE in construction projects as in Table 1.

RESEARCH METHODS

A questionnaire survey was conducted to collect data to evaluate the criticality of the identified strategies. The scale intervals can be interpreted as follows: (1) not critical at all; (2) not critical; (3) Neutral; (4) critical; (5) extremely critical. Prior to conducting the survey, the strategies identified from the literature were validated using 19 semi structured interviews. This will allow for any errors in the questionnaire survey and also will make the strategies more PPP specific. Respondents were selected randomly by contacting the Government Departments and the private companies which have dealt with a variety of Australian PPPs. The interview results were analysed using the content analysis via NVIVO software. After validating the strategies, the online survey tool 'Qualtrics' was used to distribute the survey. Random sampling was again used. The sample was selected from the managers who are registered with the Australian Institute of Project Management (AIPM), the Australian Institute of Building (AIB) and LinkedIn professional networking website and has involved with SM related tasks in PPP projects. Overall, 357 responses were received of which 341 were valid and used for further analysis. The questionnaire data were analysed using the IBM statistical package SPSS22 soft-ware. Initially descriptive statistics such as mean and standard deviation were used. Subsequently, Mann–Whitney U-test was undertaken to investigate the differences in the views of different groups. The Mann–Whitney U-test can examine the level of agreement between stakeholders in the rating of the significances in each strategy to determine whether the mean significance of each strategy is equal between two groups (Zhang, 2006b).

The interview participants were all senior managers involved in the bidding, construction and operational phases of PPP projects. All of the interviewees had more than 5 years' experience in any type of PPP project with SM experiences. 10 Panel members represented the private sector and 5 of them represented the public sector. 4 have involved in both the sectors. 37% of the questionnaire survey respondents had more than 10 years of professional experience and 32% had more than 5 years of experience. Also nearly 50% of the respondents had the exposure to 2-5 number of PPP projects. Therefore, the respondents can be considered as well experienced in this field. There were representations covering both the private and the public sector views. Figure 1 shows the sample structure for both the interviews and the questionnaire survey.

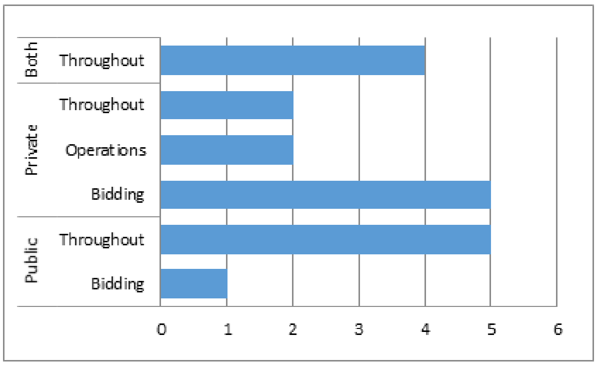

Figure 1a: Sample structure (interviews)

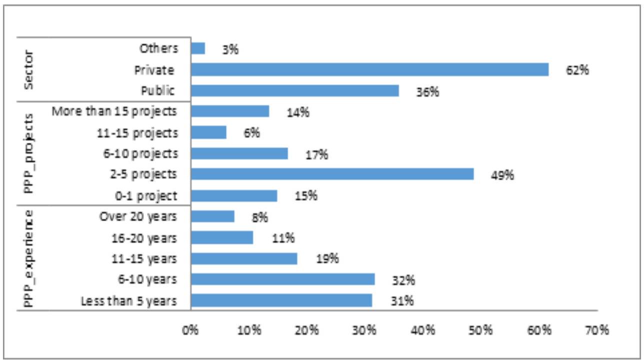

Figure 1b: Sample structure (survey)

Figure 1: Sample structure

RESEARCH FINDINGS

The strategies identified from the literature review were further validated using semi structure interviews. These interviews helped to adjust the strategies identified from the literature more PPP specific and allow for any errors in the questionnaire survey. The interviewees were asked to express their current SM practice in PPP projects and then highlight some of the critical issues related SM. Finally the interviewees proposed improvement measures for the highlighted issues. These narratives from the interviewees helped to explore a variety of novel strategies for successful SA and SE. Further, the strategies identified from the literature review were provided to the interviewees to validate them and to make them more PPP specific. This exercise made the questionnaire survey more comprehensive. The Table 2 shows the novel strategies identified from the interview findings.

Table 2: Strategies identified from the interviews

Strategy	Explanation
Maintain a register of all commitments made to stakeholders before bidding	Any infrastructure project in Australia usually does have a long history related to the Government before they come into the market. As such, it is important to record these milestones specially the promises made by the Government as a register and share it with the bidders.
Share the register with private consortium	
Private consortium participates in early information sessions conducted by Government	The interviewees from the private sector highlighted the need in participating early information sessions conducted by the Government. It will help the private consortium to get a clear idea about the origination of a project.
Early involvement of the financial institutions to understand the potential economic risks	Due to the current conditions in Victoria (the fact that the Government could change at any point in time) there is a lot of nervousness around the financiers. Hence, early involvement with the financiers was proposed.

Table 2: Strategies identified from the interviews (Cont'd)

Strategy	Explanation
Government engages an independent party to review the bids	Reviewing the bids by an independent party was proposed to improve the biasness and transparency in the bid in PPP point of view.
Government releases the independent reviewer's opinion to community	Making the independent reviewer's opinion available to the general community was proposed to enhance the transparency.
Establish an issue escalation process to address stakeholder issues	Establishing a proper issue escalation process was proposed to efficiently address the stakeholder issues in stakeholder meetings.
Easy channels for general public to understand the potential social impacts	Improving the Government websites allowing the people to access the information easily was proposed which may lead to lesser issues during the latter stages.
Establish community advisory groups	This is a novel method for SE as proposed by the interviewees. The group will be chaired with one professional whom was elected for two years and then rotated through every two years to help to ensure impartiality and consistency throughout the process.
Government develops a clear charter on how community advisory groups work	
Project value evaluation through SE	The need for assessing the public interest together with project value evaluation through regular SE was proposed.
Clear and timely information distribution to general community	Communicating clear information to the general community at the correct time was proposed for lesser issues related to general public concerns.
Private consortium engages with all political parties during bidding	Engaging with all political parties during the bidding was proposed to get a better indication about the political agenda of different parties towards an infrastructure.

After the validation process via semi structured interviews the questionnaire was developed. Table 3 shows the results of the questionnaire survey. Accordingly the mean response rating values ranging from 4.49 down to 3.44 in SA strategies and 4.42 down to 2.90 in SE strategies. No mean value scores fell into the 'not critical' (2.5) categories, which indicates that all of these strategies are critical. These strategies were ranked using the mean values. And then the Mann Whitney U test was undertaken to investigate the differences in the views in relation to the public vs the private sector and economic infrastructure (the private party bears market (demand) risk and revenues are often derived from third parties) vs social infrastructure (Government retains demand risk, traditionally through an availability based payment mechanism) projects. The last two columns in Table 3 shows the significance levels derived from the Mann Whitney U test which indicates that there are different opinions. After deriving these values mean ranking was used to investigate to which sector/project a strategy has become important. Accordingly, many strategies have shown a difference in the criticality in relation to economic and social infrastructure projects. All the strategies which indicated a difference have become critical for economic infrastructure projects. On the other hand, few strategies have shown a difference in public and private sector views.

Table 3: Survey results on SM strategies in PPPs

SM strategy	Mean	SD	Rank	Asymp. Sig. Economic vs Social	Asymp. Sig. Private vs Public
Stakeholder Analysis					
Have a good understanding of each other's (Government and private consortium) objectives	4.49	0.64	1	0.44	0.75
Early communication with stakeholders on their concerns	4.41	0.59	2	0.00	0.28
Identify longer-term stakeholder issues across the project life cycle	4.31	0.66	3	0.03	0.68
Maintain a register of all commitments made to stakeholders before bidding	4.18	0.81	4	0.05	0.56
Project value evaluation through SE	4.11	0.78	5	0.11	0.05
Identify relationships among stakeholder issues	4.06	0.63	6	0.86	0.50
Map stakeholders with the project time line	3.98	0.69	7	0.94	0.92
Share the register of all commitments with the private consortium	3.98	0.93	8	0.00	0.04
Identify relationships between stakeholders	3.96	0.72	9	0.16	0.24
Classify stakeholders into categories	3.85	0.75	10	0.04	0.92
An in-depth analysis of the opposite & aligned views within stakeholder groups	3.82	0.78	11	0.04	0.82
Rank stakeholders according to their importance	3.50	1.05	12	0.05	0.66
An in-depth analysis of the political expectations in the public sector	3.44	0.78	13	0.01	0.90
Stakeholder Engagement					
Clear and timely information distribution to public	4.42	0.60	1	0.01	0.19
Honest communication with general community	4.37	0.65	2	0.01	0.14
Establish an issue escalation process to address stakeholder issues	4.2	0.70	3	0.74	0.90
Private consortium participates in early information sessions conducted by Government	4.07	0.82	4	0.83	0.01
Easy channels for general public to understand the potential social impacts on them	4.01	0.74	5	0.05	0.29
Government engages with general community when developing the project brief and design	4.01	0.87	6	0.59	0.92
Identify the most suitable method to engage the stakeholders	3.99	0.73	7	0.50	0.29
Establish community advisory groups	3.95	0.79	8	0.02	0.09
Government develops a clear charter on how community advisory groups work	3.84	0.74	9	0.17	0.91
Early involvement of the financial institutions to understand the potential economic risks	3.82	0.95	10	0.63	0.22
Government engages an independent party to review the bids	3.58	1.14	11	0.01	0.00
Government makes the independent reviewer's opinion available to general community	3.31	1.10	12	0.08	0.08
Public participation mechanisms in shaping bids assessment criteria (by the Government)	3.14	1.06	13	0.74	0.02
Private consortium engages with all political parties during bidding	2.9	1.13	14	0.81	0.00

DISCUSSIONS

The top ranked strategies under SA and SE were directly related to the effective communication. "Have a good understanding of each other's objectives", "Clear and timely information distribution to general community", "Early communication with stakeholders on their concerns" and "Honest communication with general community" have become the most critical strategies under SA and SE. As such, it is clear that all the respondents have seen that effective communication as the paramount important factor in SM for PPP project. Olander and Landin (2008) confirmed this point for general construction projects in relation to external SM and accordingly stakeholder communication to be open; trustworthy; cooperative; respectful; and informative. Tang and Shen (2013)'s study on the factors affecting effectiveness and efficiency during the briefing stage of a PPP project also found that "open and effective communication" is the most important factor. According to Zou et al. (2014) most of the practitioners are looking at relationship management as a process of communication. Their results indicated that relationship management is perceived mainly about communicating with clients and stakeholders and maintaining strong relationship with clients. As such, the findings go in line with the findings of the previous literature.

A variety of studies in relation to risk management in PPP projects has compared the views of risk allocation to a specific party. For example Roumboutsos and Anagnostopoulos (2008) compared the risk allocation preferences between the public, the private and the financial institutes. Further, Chan et al. (2010) have compared the private vs. public sectors and academics vs. industrial practitioners views. These comparative studies have evident differences between different parties in relation to various aspects of PPP projects. Similarly the results of the Mann–Whitney U-test indicated differences in the views of the public and the private sector parties towards the SM related strategies. Sharing the register of all commitments prepared by the Government with the private consortium has become critical for the private sector side of the partnership. Most of the issues in the past PPP projects have occurred due to not disclosing the very early history of these projects with the private consortium. As such, it is very important to maintain a register of commitments and at the same time to share it with the private consortium. Further, participating in the very early information sessions conducted by the Government has become very critical for the private sector side of the partnership. This will enable the private consortium to get a clear idea about the project which will also facilitate the decision-making procedure in their tender. Further, "Government agency engages an independent party to review the bids" and "Public participation mechanisms in shaping bids assessment criteria (by the Government agency)" have also become critical for the private sector side of the partnership as they search for more transparency in these projects. All the strategies evidencing a difference have become critical for the private sector parties. As such, this research highlighted the necessity of a strong Government sector with robust SM activities in the attainment of an integrated SM framework for PPP projects.

Studies have been undertaken in relation to economic infrastructure (Wu and Zhang 2013) and social infrastructure (De Marco et al. 2012) discretely. However, there are limited comparative studies undertaken in these two types of PPP projects. Henjewele et al. (2014) did a comparison in relation to cost and time performance in healthcare and transport PPP projects. Their study indicated that healthcare projects are better compared to toll road projects in terms of cost and time performance. The survey results also indicated that there are differences in these two types of projects in terms of SM strategies (Refer Table 3). All the strategies, which indicated a difference, have become critical for the economic infrastructure projects. This might be due to the fact that the payment structure for service relationships is different which lead to variation in the interest towards the stakeholders. In social infrastructure projects the private company has only one customer which is the Government. Therefore, lesser the customers better it is for the project company as they have less maintenance work. Therefore, less marketing activities are undertaken by the project company to promote the social infrastructure projects. In contrast, in economic infrastructure the project company has a thousand of customers. Thus, the project company is undertaking a whole lot of strategies to attract more customers and to get the general public acceptance. For example "Early communication with stakeholders on their concerns" and "Easy channels for general public to understand the potential social impacts on them" have become critical for the economic infrastructure projects. When considering the Government sector perspective the people seek for more information in economic infrastructure due the usage fee leading to more measures to improve the transparency. For example "Government engages an independent party to review the bids" and "Government makes the independent reviewer's opinion available to general community" have become critical for the economic infrastructure projects with the aim of attaining transparency. As such, the results highlighted the need for paying more attention to SM in economic infrastructure compared with social infrastructure.

CONCLUSIONS

The importance of SM to PPPs has been recognized by many scholars and professionals in the construction management field. PPPs projects are expected be more complex and dynamic which make the SM more difficult. Therefore, it is crucial to develop a comprehensive set of strategies for successful SM for PPP projects. However, most of the strategies identified from the literature review were for general construction. As such this research reports on the critical SA and SE strategies for successful PPP projects. "Have a good understanding of each other's objectives" and "Clear and timely information distribution to general community" have become the most critical strategies. All these strategies are related to stakeholder communication aspects which go in line with the studies in general construction projects. The comparative study between the economic and social infrastructure projects highlighted a clear difference in the views on the criticality for most of the strategies. All the strategies have become critical for the economic infrastructure when compared with social infrastructure. As such, the findings insisted the importance of paying more attention to SM concerns in economic infrastructure projects. The results of this empirical study will help in developing a framework for effective SM for PPPs and it will act as a means of guiding the project team leaders in decision making. And at the same time this study emphasised the importance of a strong Government sector with robust SM activities in the attainment of an integrated SM framework for PPP projects. However, the findings are limited in Australian context as the survey was conducted in Australia. Further, it is limited to the strategies for SA and SE which are only two of the main stages of SM in projects. This research is part of a larger research project which aimed at developing a SM framework for PPP projects in Australian context.

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OFF-SITE MANUFACTURING OF BUILDINGS (OSM) IN AUSTRALIA: TOWARDS MEASURING STAKEHOLDERS' PERCEIVED VALUES

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ABSTRACT

Offsite manufacturing of buildings (OSM) is defined as a construction technique, whereby standardised modules are manufactured in a factory, transported to, and assembled on the site. OSM is an alternative to the traditional method of construction. Much has been written on the barriers and drivers of OSM in Australia and other developed countries. However, there is still a major gap on the measurement of stakeholders' perceived values in OSM. Stakeholders' perceived value is important in project planning and design of OSM due to their influence in project execution. In construction industry, value is defined as the ratio of function to cost or waste minimisation. Nevertheless, the concept of value is wider in meaning depending on the stakeholders' value perception. Value engineering, value based management and total quality management are methods employed in the construction industry to measure value in OSM projects. However, these methods failed to capture the stakeholders' perceived value in order to meet their expectations. The purpose of this paper is to propose the use of "value tree analysis" as a suitable method for capturing stakeholders' perceived values. The method would assist the OSM industries in decision making when developing OSM projects. This paper compares different value measuring techniques with value tree analysis based on their advantages and disadvantages in relation to OSM. It will also reveal the expected output from the adoption of the value tree analysis for the measurement of stakeholder perceived value.

Keywords: Australia, barriers, drivers, offsite manufacturing of building, stakeholders, value tree analysis

INTRODUCTION

The significance of measuring stakeholders' perceived values cannot be realised without understanding the present state of OSM, including its barriers and drivers. At present, there is a limited uptake of OSM in Australia due to barriers that prevent the stakeholders to perceive its benefits (Blismas & Wakefield, 2009). These barriers have been reported by different researchers in Australia and other developed countries. Blismas & Wakefield (2009) and Li et al (2014) identified OSM barriers as design inflexibility, transport and logistics problem, lack of expertise in off-site manufacturing, limited market demand and regulatory fragmentation. The drivers of OSM are identified as waste reduction, speedier erection of building, high quality building, environmental sustainable building and lower health and safety risks (Blismas & Wakefield, 2009; Rahman, 2014).

The report by Hampson and Bradon (2004) stated that OSM is the key vision for improving Australian construction industry in the next decade. Researchers and construction professionals have made a greater effort on how to increase the adoption of OSM in Australia and other developed countries. Various approaches employed are identification of barriers, constraints and current state of OSM. Despite all these approaches, the adoption of OSM has not increased as expected by OSM industry. There is no doubt that previous research have contributed to the knowledge of OSM. However, further research is still needed in order to encourage the adoption of OSM in Australia given its benefits to construction's stakeholders.

Further research to improve wider uptake of OSM should focus on capturing of stakeholders' perceived values. This is due to the impact each stakeholder has on the project decision making process (Olander, 2007). There is an argument on factors that drive stakeholders' desire towards the selection of a construction project. Today, stakeholders' desire is driven also by value in addition to the traditional time, cost and quality due to the clamour for value for money that is crucial in construct project delivery (Barima, 2010).

The concept of value has occupied a major role in project development process in the construction industry (Jahani & El-Gohary, 2012). It is the major driver of stakeholders towards the selection of a construction project. Discovering and analysing stakeholders' perceived values are requirement for facilitating value decision-making towards maximising the value of built infrastructure (Zhang & El-Gohary, 2014). In construction and market industry domain, a number of approaches for measuring value (e.g value engineering, customer value hierarchy, analytic hierarchy process and value tree analysis) have been implemented as methods for improving "objects and processes value" (Kelly,2007). However, these approaches define value as ratio of function to cost and customer value

(Jahani and El-Gohary, 2012; Cengiz & Kirkbir, 2007). Holistically, value is beyond the ratio of function and cost rather it is the value perceived by stakeholders (Barima, 2010). Therefore, it is important to employ a suitable method for capturing stakeholders' perceived values. Through this method, the perceived value can be measured, which would help OSM industry to meet stakeholders' expectations.

The purpose of this paper is to propose the value tree analysis as a suitable method for capturing stakeholders' perceived values in OSM.

LITERATURE REVIEW

OSM barriers and drivers

There are a number of barriers and drivers associated with the adoption of OSM in Australia. Barriers of OSM are factors that prevent the wider adoption of OSM and the drivers are parameters that encourage the use of OSM. Researchers classified the barriers and drivers of OSM as shown in table 1 below.

Table 1: Barriers and drivers of OSM

Barriers	Drivers	Sources
Logistic issue: This is the problem related to the transportation of OSM modules within the country due to its weight and size.	**Cost and time**: These are enablers that pertain to speeder erection, cost certainty and lower construction cost	Blismas & Wakefield, 2009; Gibb,1999; Li et al,2014.
Process: This refers to the design inflexibility for late design changes.	**Quality:** OSM offers high quality building and enhanced quality predictability.	Blismas & Wakefield, 2009;Goodier & Gibb, 2007;Li et al, 2014; Jaillon and Poon, 2009.
Industrial Knowledge: This barrier is associated with limited or lack of expertise in OSM.	**Occupational health and safety risks**: It is the moderate driver of OSM. It reduces accident on construction site due to its manufacture from factory environment.	Blismas & Wakefield, 2009; Li et al,2014;
Cultural barriers: This refers to poor public perception about OSM meeting quality expectation and limited market demand.	**Sustainability**: This is one of the drivers of OSM. It minimise construction waste and improve energy efficiency of a building.	Li et al,2014;Pan & Sidwell, 2011;Rahman,2014;
Regulatory: There is no specific regulation or codes for OSM. This constraint contributed to the low level use of OSM.	**Whole life performance**: This refers to the total cost of manufacturing, maintaining and disposing of OSM. It has a reduce whole life cost	Blismas & Wakefield, 2009; Pan & Sidwell, 2011

Values

The concept of value has a rich history in literature. It has been researched in various disciplines, such as, psychology, philosophy, marketing, construction and economics (Oliver, 1999).

Value, as a concept, has numerous definitions in different industries. There is no single definition for the concept due to the perception of stakeholders and industries in regard to value. For instance, in economics, it is defined as the utility of an item (De valence & Best,1999). In psychology, it is defined as things that are important to humans in their lives (Schwartz, 2006).

Furthermore, in construction industry, value definition is beyond the set of properties of a building; rather it is the driving force for stakeholders' decision making and the end of all construction projects (Emmit, et al, 2005; Keeney, 1996). Value plays a crucial role in construction project delivery. In a recent study, the focus on lower cost rather than value in project delivery has been cited as one of the reasons behind poor project delivery of construction products; therefore, construction industry needs to focus more on value delivery (Barima, 2010).

Values are motivational constructs and decision making concept for stakeholders. Motivational constructs are set of parameters that motivate humans towards the selection of a particular product, for example cost and environmental value (Schwartz, 2006; Cheng & Fleishmann, 2010). It is also known as predictive and explanatory factors in studying decision-making (Cheng & Fleishmann, 2010; Jahani & El-Gohary, 2012). Thus, to measure stakeholder perceived value in OSM, it is imperative to capture different stakeholder value perceptions and their system of value priorities (Cheng & Fleishmann, 2010)

Value metrics

Value metrics are set of parameters used for determining the level of value in a particular project. The broad knowledge of value has made it difficult to have a specific value metrics for construction projects. Metrics are determined by construction product, construction process and sustainability modality (Cuperus & Napolitano, 2005; Jahani & El-Gohary, 2012) as described below.

Construction product value is the combination of utility value and market value (Wandahl & Bejder, 2003). The parameters for product values are usability, flexibility, quality and market demand. Process value is the value associated with the management of the construction project. It is the values created during the development of project, examples of process value are customer satisfaction and profitability (Cuperus & Napolitano, 2005). Lastly, sustainable value is the classification of value as environmental, social and economic.

Out of the three value classifications mentioned above, sustainable value is adopted for this paper as there is an increase in demands for sustainability in built environment (Levitt, 2007). In addition, it also provides a robust metrics capable of meeting stakeholders' expectation compared to process and product value metrics. The author compiles the reported metrics in table 2 below.

Table 2: Classification of value and their metrics

Value	Metrics
Product value	**Usability**: it is the function of the building and how users' needs are fulfilled. **Flexibility:** It is the ability of the building to adapt to change in design due to climate variation or professional's advice **Quality**: This is the aspect of building value that focus on standard and condition of the building **Market demand**: it is the rate of demand of building from end users or mortgagees.
Process value	**Customer satisfaction**: It is the satisfaction the stakeholders derive during the development stage of building. **Profitability**: is the return on capital investment
Sustainable value	**Environmental value**: This is the value pertaining to the protection of the environment. Examples are water consumption of building, energy emission from building and air pollution. **Social Value**: This refers to the value that is associated to the quality of life of people in the community, such as wellbeing of end users, building safety, accessibility and indoor environmental quality **Economic value:** This is the type of value associated with the production cost, savings and transfer of wealth. Examples of this value are project cost savings, real estate value, building maintenance cost.

Value measurement

There are seven methods used in construction and marketing industry for measuring value. In construction industry, three methods are common for capturing the value of a construction project namely; Value engineering, value base management and total quality management. On the other hand, customer value hierarchy, customer value typology, analytic hierarchy process and value tree analysis are methods employed in marketing industry (Cengiz & Kirkbir, 2007; Martin & Petty, 2001; Kelly,2007).

In this paper, none of the value measurement techniques used in construction industry would be consider because they measure value as function to cost, waste minimization and quality improvement. Multi-dimensional value measurements are discussed in this paper because the core problem in OSM adoption is the inability to meet the stakeholders' needs, who influence the decision in OSM adoption. In addition, the value measurement methods in construction industry are incapable of guiding a decision process in OSM industry.

Multi-dimensional value measurements

Customer value hierarchy, customer value typology, analytic hierarchy process (AHP) and value tree analysis are the types of value measurement techniques used for capturing stakeholder perceived value. These methods have different systems for measuring stakeholder perceived value.

Customer value hierarchy

It is a multi-dimensional value measurement that measures the customer perceived value as objective layer, consequence layer and attribute layer (Jiayinet et al, N.D). This system ranks and maps stakeholder perceived value in order to understand the relationship between the objective consequence and attribute layer. It launches a way to identify customer demands based on their purchase attributes. Woodruff & Gardial (1996) stated that customer value hierarchy does not measure customer value relative to competition rather it measures it as a trade-off between positive and negative consequences of product as perceived value by the stakeholders (Cengiz & Kirkbir, 2007). Customer value hierarchy can identify the potential customer demand of product and service with high level accuracy. The system requires high numbers of questionnaires and interviews to capture the customer perceived value.

Customer value typology

This is another multi-dimensional value measurement for capturing customer perceived value. It measures customer perceived value based on three dimensions namely (Cengiz & Kirkbir, 2007).

- extrinsic value versus intrinsic value,
- self-oriented value versus other oriented value
- active value versus reactive value

Holbrook (1999) developed a matrix representing eight types of customer value; excellence, efficiency, status, esteem, play, aesthetic, ethics and spirituality through the three dimensions.

This matrix entails the co-existence of different types of customer value. Customer value typology treats customer perceived value as cost free benefit, which means that only the benefit side and not the sacrifice side is included in the method (Holbrook 1999).

Analytic hierarchy process (AHP)

AHP method of value measurement was introduced by Saaty (1990) as an excellent multi criteria decision making tool. It measures the stakeholder perceived value in hierarchical with goals, sub goals or factors and alternatives (Syamsuddin & Hwanag, 2009). The structure is translated into different questions of the general form. The input variables to AHP model are the decision makers to pairwise comparisons. The advantages of AHP is its simplicity in capturing stakeholder perceived value against other method of value measurement and enables qualitative and quantitative into the same decision making methodology (Syamsuddin and Hwanag, 2009). Also, it is useful in accommodating conflictual, multidimensional and incomparable objectives (Prabhu and Mendoza, 2009).

Value tree analysis

Value tree analysis is a multi-criteria analysis for capturing the stakeholders' perceived value; hence it reflects the values of the stakeholders (Prabhu & Mendoza, 2009). It is a method of structuring objectives by focusing first on stakeholders' perceived values and preferences rather than means of achieving them. Keeney (1992) stated that values are more fundamental than alternatives; hence he proposed to start the process of value focus thinking by capturing stakeholders' objectives or value and move to the alternatives of achieving them.

The benefits of value tree analysis are the identification of stakeholders' objectives or value and the alternatives for achieving the stakeholders perceived value. It also assists in identifying and structuring the appropriate value for decision making (Keeney, 1996).

Comparison of the multi-dimensional value measurements

The adoption of any value measurement technique should base on critical comparison of the value measurement techniques against the certain factors that. The author compiles the factors used as yard stick for the selection of value tree analysis among other value measuring techniques.

These factors were chosen because of the sources of the barriers of OSM, importance of in-cooperating stakeholders needs in OSM development and the understanding of the relationship between the values.

Table 3: Comparison of four value measurement techniques

Factors for effective value measurement in OSM	Customer value typology	Analytic hierarchy process	Customer value typology	Value tree analysis
Measure entire stakeholders value		x		x
Assist in decision guidance	x	x	x	x
Capture means of achieving stakeholders' perceived value		x		x
It shows the relationship between stakeholder's perceived value				x

Based on the above table, it can be inferred that value tree analysis is suitable for capturing stakeholder's perceived value. This is because of its ability to meet up with the factors highlighted for effective value measurement.

Justification for the selection of value tree analysis

Selecting an appropriate method for measuring stakeholders' perceived value for enhancing value creation in OSM in Australia involves comparing and contrasting multi-dimensional value measurement techniques. Multi-dimensional method was chosen due to the ability to measure stakeholder's perceived value in multiple dimensions as against the one dimensional that only considers value measurement as one entity.

In comparison, value tree analysis, customer value hierarchy, customer value typology and analytic hierarchy process measure the stakeholder perceived value and rank them based on the importance ascribed to them by the stakeholders. The methods aim to improve the market share of the product, assist in decision making process and deliver customer perceived value. In application to OSM, the methods are capable of identifying the stakeholder perceived value, which would assist the OSM industry in delivering the needs of the stakeholders.

Value tree analysis as a multi-dimensional value measurement is more suitable for measuring stakeholder's perceived value compared to other techniques based on the following reasons

Firstly, the system adopted by customer value hierarchy and customer value typology in measuring stakeholder's perceived value is unsuitable for measuring stakeholder's perceived value in OSM because it is difficult to classify the OSM stakeholders perceived value to extrinsic, intrinsic, objective, consequence and attribute layer. The two methods of value measurement mostly target customers rather than the entire stakeholders in the supply chain. On the other hand, AHP measures the stakeholder's perceived values in hierarchal way with goals, sub goals or factors and alternatives. Its technique of measuring stakeholder's perceived value is similar to value tree analysis except the pairwise comparison and means of achieving the stakeholder's perceived value.

Secondly, value tree analysis involve identifying stakeholders, capturing of stakeholder's perceived value, identifying the attributes and relationship between the attributes and value, which other methods failed to consider in their value measurement process. It enables the OSM industry to see the relationship between the stakeholders' perceived values and the influence of one stakeholder's perceived value over the others. These two benefits prompted the adoption of value tree analysis over other multidimensional value measurements

Thirdly, value tree analysis has been used in various industries to measure the impact of a project, identify and structure values to guide integrated resource planning. It was used in evaluating multi-stakeholder perceptions in forest industry in order to improve project effectiveness (Prabhu & Mendoza, 2009). The adoption for the evaluation was due to its suitability for multi-stakeholder impact assessment and direct participation of stakeholders in the impact assessment process. The process is able to capture values, perception of the stakeholders and a procedure to estimate measure of relative importance of the stakeholders' value. The result of the assessment assists the forest industry to evaluate their performance against the stakeholders' expectation.

Furthermore, British Columbia gas employed value tree analysis to develop an integrated resource plan that addressed multiple objectives and participation of stakeholders (Keeney & Mcdaniels,1999). This was carried out by capturing value trade-offs from each stakeholder. Through the answering of value trade off questions, stakeholders provided their perspective about the relative value they associate with reduction in environmental impacts, improvement in reliability and social economic benefits. The result was used to evaluate integrated resources plan alternatives value and relationship between these value.

The application of value tree analysis in the above-mentioned industries proved the suitability of the method for capturing stakeholders' perceived values. The result obtained through the use of value tree analysis helped the industry to capture the stakeholders' perceived values, relative importance of the values and assist during decision-making process. Other value measuring techniques does not emphasise the significance of stakeholders' involvement in value measuring process.

APPLICATION OF VALUE TREE ANALYSIS

Value tree analysis requires certain steps for capture the OSM stakeholders' perceived values. It is achieved through asking each stakeholder what is important to them in making decision and values they expect OSM building to deliver.

1) Identifying the measures or attributes or objectives for evaluation: Measures or attributes are the means objectives or means value. The means objectives or value are means of achieving the fundamental perceived values.
2) Creating hierarchical model of the value: This stage is the ranking of the stakeholders' perceived values to show the level of importance attached to them. It reveals ranking hierarchy of different OSM stakeholders.
3) Relationship between the stakeholders' perceived values and means objectives: Networking of the stakeholders' perceived values and means values is the fourth stage in value tree analysis. It shows the link and interconnection between the stakeholders' perceived values and means of achieving them. This stage would assist towards understanding the relationships between the stakeholders' perceived values and designing a decision making model to guide OSM industry during manufacture of OSM in Australia

Value tree analysis output

Value tree analysis output is the expected result from the application of value tree analysis to measure stakeholders' perceived values. It shows the hierarchical classification of the captured values, network of the values and means of attaining the values to meet stakeholders' expectation.

The hierarchical classification of perceived values would enable the OSM industries to understand the level of importance attached to each perceived value. Through this knowledge, OSM industry can understand the need of their stakeholders, which assist them during decision making process of manufacturing OSM.

In addition, the network of perceived values shows the relationship between the values. It indicates the dependency of one value on the others. This helps OSM industry to foresee the likely effect of altering the quantity of sets of values over the others.

Furthermore, the result can also show the means of achieving the stakeholders' perceived values. The output reveals the stakeholders' level of agreement on the means of achieving the stakeholders' perceived values.

CONCLUSION

There is a limited research on the value analysis and measurement in OSM. To address the gap, the paper presents value tree analysis as a suitable method for capturing stakeholders' perceived values.

The paper explained the concept of value and its definition according to different industries. It emphasis its definition and value measuring technique used in the construction industry. It stated that value is beyond the ratio of function to cost or waste reduction rather it is the sustainability properties of a building, such as environmental, social and economic value.

Furthermore, it discussed different types of multi-dimensional value measurement and the justification for the selection of value tree analysis as a suitable method for capturing stakeholders' perceived values. Value tree analysis steps were reported in this paper for effective value measurement in OSM. The output of the value tree analysis shows that the method is useful in decision making process by considering the stakeholders' perceived values. This is the major problem in the slow adoption of OSM in Australia as stakeholders failed to perceive its benefits.

FUTURE RESEARCH WORK

The future work of this research will focus on capturing stakeholders' value through the use of questionnaires and classification of the perceived values based on stakeholders' perspective. Furthermore, the perceived values will be ranked in order for the OSM industry to identify the most important values to the stakeholders. The mentioned steps assist towards the measuring of stakeholders' perceived value for decision making process in OSM.

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THE MODEL ANSWER- INVESTIGATING THE USE OF BIM DIGITAL MODELS TO PROVIDE ASSESSMENT FEEDBACK

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ABSTRACT

This research study has various objectives. To investigate whether BIM models can complement online quizzes providing a resource augmenting assessment and feedback in Construction modules of the National Diploma in Architectural Technology. To also analyse whether embedding rich text data in models provides effective feedback to large student numbers. Text information within the BIM models supply answers to the quiz questions. Another study aim investigates whether this approach could be used to alleviate onerous assessment and feedback workloads in courses with large numbers. Finally, embedding answers within the model elements seeks to encourage students to engage with digital BIM models and become comfortable in their use. The term "Model answer" is often used in education but here the intention is that the model really will be the answer. The research involved implementing the model answer approach across four course assessments, surveying the student cohort plus a previous student sample that had taken the same course the semester before to compare opinions on the differing assignment and feedback approaches. Staff who taught Construction Systems 1 or similar courses were also interviewed to get their views on the strengths and weaknesses of this proposed new assignment feedback structure.

Keywords: Assessment, BIM, Engagement, Feedback, Tertiary

INTRODUCTION

This research project aims to investigate the efficacy of using BIM models to provide a degree of feedback to students who have undertaken online quizzes assessing here, the design of timber frame systems for a simple New Zealand dwelling. Analysing feedback is not the only priority however but also the provision process which mirrors BIM model use within industry thereby developing valuable student skills in preparation for potential future roles working in the new BIM paradigm. The context for this research is a Constructions Systems 1 course previously part of the National Diploma in Architectural Technology at Unitec. The catalyst behind the Model Answer idea was the sheer number of students enrolled in the course in semester 2 of 2015 and the assessment and feedback challenges facing the lecturer. In semester 1, four lecturers taught and assessed four separate day streams of approximately 20 students each. However in semester 2, one lecturer taught a cohort of 85, indicating the traditional approach to providing feedback would be onerous. The author had piloted using a Moodle quiz in semester 1 2015 to enable assessment of a Timber Wall Framing assignment and suggested using this approach supplemented this time by BIM models providing a degree of feedback to students which might otherwise be arduous.

Literature review

BIM in education is a topic researched many times across recent years and published papers from a variety of international sources address many and often similar themes. These range from highlighting the BIM model as a primary communication means to exploiting such potential to achieve the paradigm shift from traditional 2D to full 3D BIM based documentation(Ambrose 2007;Wong et al.,2011). Enhancing communication of threshold principles using interactive models is strongly expressed by Clevenger and colleagues who also emphasise the education opportunities 3D platforms present(Clevenger et al. 2010). Increasing student engagement is seen as an additional incentive to BIM model use with an added benefit being that this helps relieve the training burden on construction companies(Lee & Hollar 2013). Another related point stressed in much literature regards industry’s lack of skilled BIM users who are both aware of and comfortable with the whole new way of working that BIM presents and requires(Sacks & Barak 2010;Macdonald 2011). There is a widespread realisation that BIM models are the future with some writers even stating that transition is unavoidable(Boeykens et al. 2013). Others identify the pressing need to give students experience of emerging changes to industry practice and BIM enabled workflows(Clevenger et al.,2010; Ku & Mahabaleshwarkar, 2011).

The research author notes the challenges around embedding BIM into the content of already crowded courses and access to suitable models with an appropriate level of detail (Suwal et al.,2013;Puolitaival et al.,2015). However much discussion here relates to learning in some cases the “ profound skills” required to use authoring software whereas this project’s software interactions required only basic ability with BIM viewers (Suwal et al.,2013). Introducing BIM concepts using Model viewers is quite simple and appropriate for transition pedagogy such as this research where the focus course was delivered early in programme. Most BIM viewers are also free neatly sidestepping some of the hardware and IT issues mentioned in some literature(Clevenger et al. 2010). Model viewers by revealing rich data as assignment answers were crucial for this research mirroring industry BIM methods and aligning with a construction company representative quoted in one of the papers reviewed.

"We don't train how to model, but how to use the model to help daily activities" (Lee & Hollar 2013)

Managing data from multiple sources and extracting the important information is something which this project sought to replicate and by so doing help prepare students for future careers in construction.

Papers addressed assessment only briefly but one discussed Adobe Captivate reflecting somewhat the use of model viewers in this study(Clevenger et al.,2010). A course matrix discussed in another paper includes assessment but neither work details assignment feedback methods, fundamental objectives of this research(Sacks & Barak, 2010).

Research method

Methodology involved document analysis, survey and interviews. Two student groups who had studied Construction Systems 1 were surveyed A and B, and interviews held with teaching colleagues, group C. Group A comprised 85 semester 2 students who undertook online quizzes receiving model answer feedback. Disappointingly only 10 students returned completed surveys. Group B were 19 previous semester students who received feedback traditionally via comments and discussion with 8 students returning surveys. Group C was 5 colleagues, who taught Construction Systems 1 or other courses using BIM models. Research preparation involved devising 4 assignments related to designing a Basic then Advanced timber Sub floor, a timber framed Wall system and finally some timber Roof framing options. Assignment instructions included relevant drawings with design worksheets provided to help resolve proposals. Framing design was to New Zealand Standard 3604. (Fig 1)

Bearer Spans. Loaded Dimension and other criteria for use in Table 6.4 — Box 3

Establish the BEARER SPAN which will be the same as the PILE SPACINGS.

= ___________M

Check the LOADED DIMENSIONS of the bearers referring to NZS 3604 Figs 1.3 F and 1.3 G.
Refer also to BRANZ Guide on Loaded Dimensions available on Course Moodle website.
Note the bearer with the largest LOADED DIMENSION . This is usually a central bearer but an external bearer supporting a stringer and deck should be checked and compared. * (*Loadbearing walls over bearers require additional consideration but may be ignored in this introductory exercise)*

MAXIMUM LOADED DIMENSION = ____________m

Bearer Sizes resolved using Table 6.4 OF NZS 3604 . 2011 — Box 4

Using the BEARER SPAN and also the LOADED DIMENSION from Box 3 above we use Table 6.4 to work out a DESIGN SIZE for our bearers.

Pick the BEARER SPAN box first on the left hand side then pick a figure in the centre column which is equal or greater than our LOADED DIMENSION . The corresponding value in the column on the right hand side is our -:

BEARER DESIGN SIZE = __________

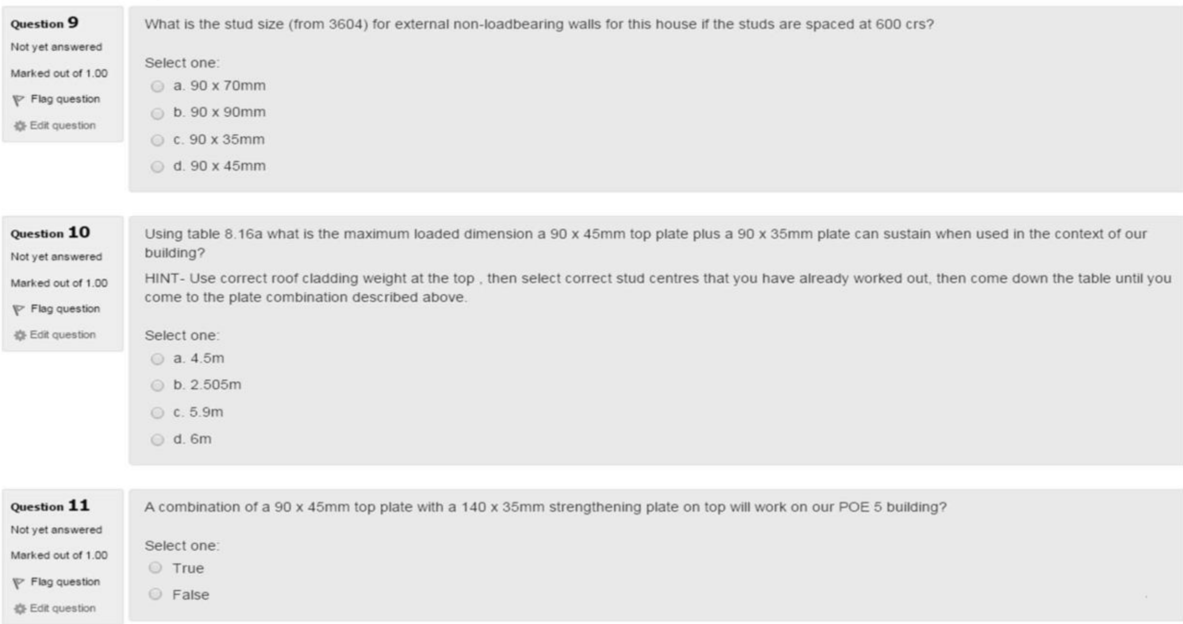
This is the minimum size expressed in width by thickness that must be used to comply with the standard. However built up members or more commonly available timber sizes may be substituted and this is sometimes called the -:

NOMINATED BEARER SIZE = ____________

Figure 1 Subfloor Design Worksheet Abstract

(Source: M McGarrigle Unitec 2015)

Assessment used Moodle multiple choice assignment based quizzes set up ensuring answers could be found by completion of the worksheets.(Fig 2)


Question 9
Not yet answered
Marked out of 1.00
Flag question
Edit question

What is the stud size (from 3604) for external non-loadbearing walls for this house if the studs are spaced at 600 crs?

Select one:
a. 90 x 70mm
b. 90 x 90mm
c. 90 x 35mm
d. 90 x 45mm

Question 10
Not yet answered
Marked out of 1.00
Flag question
Edit question

Using table 8.16a what is the maximum loaded dimension a 90 x 45mm top plate plus a 90 x 35mm plate can sustain when used in the context of our building?

HINT- Use correct roof cladding weight at the top , then select correct stud centres that you have already worked out, then come down the table until you come to the plate combination described above.

Select one:
a. 4.5m
b. 2.505m
c. 5.9m
d. 6m

Question 11
Not yet answered
Marked out of 1.00
Flag question
Edit question

A combination of a 90 x 45mm top plate with a 140 x 35mm strengthening plate on top will work on our POE 5 building?

Select one:
True
False

Figure 2 Typical assignment multiple choice questions on Moodle

(Source: Moodle, Unitec 2015)

Assignment feedback was provided generically using BIM models created in Archicad authoring software. Models contained assignment answers embedded into elements such as joists and bearers and accessed by students clicking the relevant element in a BIM viewer. Solibri Model viewer was mainly employed but the IFC (Industry Foundation Class)model format used enabled access using a variety of free BIM viewers such as Tekla BIMsight, BIM Vision, Navisworks or even an online viewer such as BIMer. Students had access to the feedback models after quiz submission dates had passed and the activity was closed.(Fig 3)

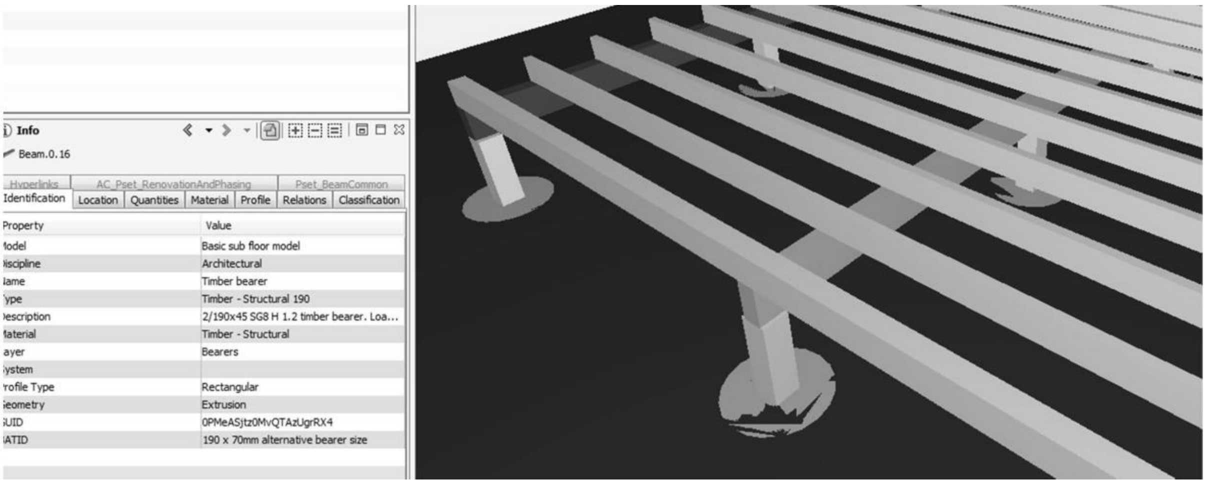


Figure 3 Subfloor BIM model viewed n Solibri

(Source: M McGarrigle Unitec 2015)

Surveys sent to students consisted of questions related to their experience of BIM, ease of accessing model viewing software and whether they thought the models effective feedback provision. Questions varied slightly between the groups as group B had gone through a more traditional assessment and feedback process. They were specifically asked to compare this with the proposed new BIM centred approach. Group C lecturers took part in semi structured interviews around open ended questions. BIM experience was addressed and also opinions on the support materials provided including ease of access to resources. Discussions prioritised the high BIM content feedback model approach to see if it was considered valuable and to explore possible developments.

Results and discussion

Despite the small size of group A, it still yielded some valuable data reaffirming findings in the literature review. Around half of the group had heard of BIM and used it to some extent before. All found the classroom demonstration of the Solibri Model Viewer useful but some felt that more time could be spent learning package basics and that a dedicated lab session for this could be useful.

Having more emphasis on BIM was requested by some to help alleviate the fact that not many students have actually visited building sites. This also negates issues such as insurance cover for colleges who consider large group visits. Downloading software was found to be easy and the majority found the support resources provided useful. Generally the sample had no issues using Solibri and could find the relevant assignment answers fairly easily in the models. All enjoyed using the models and agreed they were an effective feedback mode especially for large classes.

The 8 group B students also found software use and accessing answer models simple although a Solibri auto update feature was a minor issue for some. Support resources provided were again deemed helpful. The majority identified easily the specific model elements and found the embedded data permitting review of assignment answers.(Fig 3.) Most enjoyed software use with only 2 out of 8 not stating this categorically.

Many students raised the visual nature of BIM models and their power as an effective communications tool. Noted also was the additional benefit that having model access online allowed ready reference and checking. 2 students favoured semester one's assessment approach with one preferring individual feedback over generic although both agreed the new procedure was useful in providing large group feedback. Overall the sample approved of the digital models approach using words such as excellent and great although one suggestion involved supplementing models with photos of building works in progress. Group B agreed with Group A that BIM models could aid students with no site experience and prominently noted also that BIM use helped impart skills and knowledge considered crucial in future industry where BIM is no longer an emerging practice but a present and significant one.

Most of the staff in Group C had used Solibri model viewer to some extent but some much more than others and consensus was that it was very easy to use. Most staff had referred to the support resources and found those helpful. All found accessing and opening the model answers easy as was also locating the embedded data specifying assignment answers. All believed strongly that this method was a useful means of providing feedback and especially to large classes. Many benefits both present and potential were discussed including the power of 3D models to aid learning and communication, ability to access models off campus and how the visual nature of the approach would greatly aid English second language students. A BIM model's ability to help students comprehend traditional plans was highlighted and also its' potential to simulate basic construction sequencing. Preparation and set up time for resources was noted but this was seen as overwhelmingly worthwhile in the final analysis.

Problems for students accessing required technologies were noted, machine specs, cost etc, and also that some engaged with BIM models only when they formed a course requirement or a summative assessment. Prevailing views expressed however were that the new approach was an excellent idea and that BIM models should be employed even more to reflect the move towards BIM in New Zealand construction. (Fig 4)

Figure 4 BIM clash checking on Christchurch Bus Station federated model.

(Source: Architectus, Auckland 2014)

Summary

The findings of this research project show that using BIM software such as Solibri Model viewer is a fairly simple process for both students and staff although having some access to support material is considered helpful and preferable. All participants found the relevant information embedded in model answers easily enabling review of their Moodle quiz responses. The majority of students enjoyed using and interacting with the BIM software and models with the ability to access them remotely an advantage noted by both students and staff. The 3D capabilities and visual nature of the models were highlighted by almost all as a powerful communication tool which helps bridge learning gaps. The idea of using quizzes backed up by feedback provided in BIM models was endorsed by practically all students especially where large classes involved. All staff participants concurred with this and expressed approval in terms such as "great feedback" and " excellent idea".

CONCLUSIONS

A very common theme found throughout the literature review for this research was that BIM is the future and the opinions expressed in this project especially by students would strongly uphold that assertion. Students being themselves the future and subscribing to this view makes it especially pertinent in this author's opinion.

Another significant discovery of this project is that students find feedback provided in the form of interactive BIM models useful and whilst some may prefer individual and detailed feedback, there is a recognition that in many cases this is not realistic. Any perceived drawback is offset to some extent though by student participants enjoying interaction with the BIM model answers and realising the benefits for their future employability.

Following on from this finding was the suggestion by some staff and many students that we should be making even more use of BIM models in our teaching. Prime reasons stated here were that it linked to what industry aspires, and the powerful communication and learning opportunities that the BIM models presented. In this project, the models were employed as feedback tools for summative assignment submissions but there is certainly scope for earlier inclusion delivering content related to threshold concepts to aid student learning. The model's interactive nature will be of use here too as this study confirms students enjoy using the software and it could therefore help improve student engagement. However, model use may have to be linked to mandatory work to avoid the issue noted by some lecturers where students did not engage with the models as hoped.

A challenge alluded to frequently in the literature reviewed for this study was that learning BIM software is difficult involving a lot of time and effort to achieve useful operating skills. In fact the word leverage was used on more than one occasion suggesting a degree of forceful exertion. This may be the case for powerful authoring software such as Revit and Archicad but do all construction students really have to be proficient in these packages unless they are studying Architectural Technology? Most information a Project Manager or Quantity surveyor needs can be accessed using model viewers such as Solibri which are free and much simpler to use. Basic skills acquired can provide valuable motivation for students to attempt fully featured professional versions of such packages with confidence despite the perceived challenges achieving another definition of leverage when considered a verb which is to use something to maximum advantage, in this case BIM.

Remote access to digital models at home or on site was seen as a positive factor tempered slightly by the need to have some form of device enabling actual viewing and access to the embedded data. Devices such as Ipads have a range of compatible viewers but some only open files from native parent software such as Autodesk, for example their BIM 360 Field application. BIMx by Graphisoft for Archicad is similarly constrained and ideally a viewer that can open the recommended Open BIM file format Industry Foundation Class (IFC) is preferable reflecting the " software agnostic" approach alleged at many BIM seminars. Another consideration is to use an online BIM viewer such as BIMer where tutors can upload models that can be viewed online by students for a certain time period. Author experience of this method however has shown limitations with larger model uploads and the limitations may be due to the viewer package or browser RAM limitations. Nevertheless, for simple models used by construction students starting out on their careers, online viewers are an option though care should be taken as with any BIM viewer to check if any data has been lost in translation.(Fig 5)

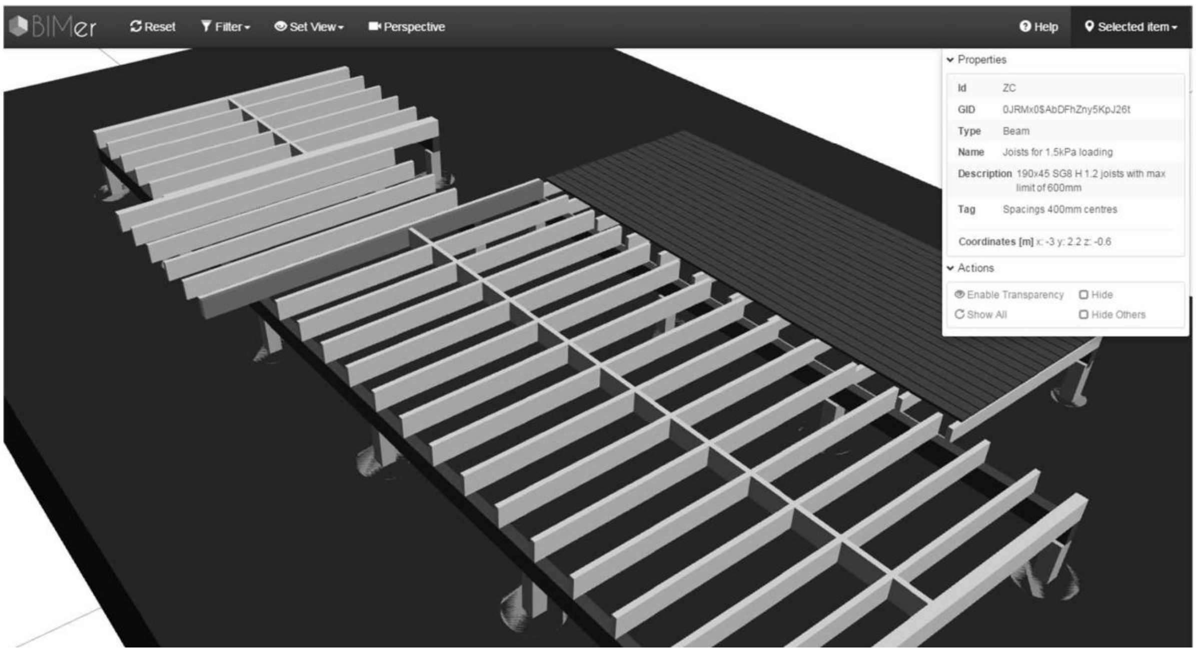


Figure 5 Subfloor BIM model in BIMer online Viewer

(Source: Unitec 2015)

Another strong finding from this study is how many participants realise the power of 3D BIM models to not just aid communication and bridge normal learning gaps but interestingly, also to perhaps help overcome some forms of learning difficulty. Dyslexia and Dysgraphia were identified in the literature review but lecturer participants in this study pointed out how strong visual communication means could be employed to help students for whom English is a second language(Sacks & Barak 2010). This demographic may presently grapple with technical jargon and local terminology therefore using a model as an interactive visual dictionary could prove an invaluable resource. Students also suggested augmenting the BIM models with photographs of relevant construction works. This could reinforce the information presented in the models which already helps according to the staff surveyed in enabling the students to better understand drawings presently used within industry such as plans , sections and elevations.

Embedding BIM successfully in education does present challenges. However this study has shown how some of its' potential can be harnessed to provide an effective degree of assessment to students with only one of many additional spin off benefits being that it provides a soft landing introduction to rapidly emerging practice in the New Zealand Construction industry and worldwide. Students in this study realise and concur with the literature finding that BIM is the future. Teaching staff have to accept this also and fulfil the request to make more use of BIM to align with industry. The initial capital efforts required may be substantial but this research has found that they are worth it.

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SUPPORTING CONSTRUCTION MANAGEMENT EDUCATION: EXAMINING THE IMPACT OF LEADERSHIP, MANAGEMENT AND STAFF DEVELOPMENT

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ABSTRACT

Universities in Australia face a range of challenges as they renew curricula. Several of these arise from the federal government's compliance monitoring entities which focus on academic standards and quality assurance. In addition, the sector is experiencing increased emphasis on research performance and postgraduate education. Against this backdrop, this paper examines academic leadership, management and staff development, and considers the implications of these processes on construction management higher education. This paper draws on data gathered from surveys, interviews and focus groups with leaders in construction-related academic disciplines across Australia, and provides a critical review of their attitudes and concerns. The data were analysed in terms of themes relevant to leadership and management, and highlight issues for the future of the construction management discipline.

Keywords: academic leadership, construction management, staff development

CONTEXT

The higher education sector in Australia has changed dramatically in recent decades. Scott, Coates and Anderson (2008) identified the most important *change forces* affecting academic leaders in rank order to be "decreased government funding, growing pressure to generate new income, balancing work and family life, managing the pressures for continuous change, having to deal with slow and unresponsive administrative processes, finding and retaining high-quality staff, and increased government reporting and scrutiny" (p. xiii). Successive governments have reduced funding to support mainstream teaching of undergraduate students. In addition, the processes by which teaching quality is assessed have also changed with successive governments.

Other challenges face academics in general and those in the construction sector in particular. They need to adapt to rapid developments in information and communications technology, and the litigious nature of some cohorts of students. These challenges are set against the increasing casualisation of the academic workforce. According to Loussikian (2016) "Less than 1 per cent of all full-time equivalent positions created at Australian universities in the past decade have been tenured teaching and research roles, with casuals now making up nearly 80 per cent of all teaching-only positions." (p.1)

Scott et al (2008) note that little has been written about leadership in business and industry. They observe that "much of it is neither empirical nor tested for its applicability to the distinctive operating environment of a university" (p. viii). This paper provides insights into the current state of construction management (CM) tertiary education.

RESEARCH METHOD

This paper is based on an investigation (Williams, Sher, & Simmons, 2010) that was designed to identify and understand the factors that significantly impact on both a CM academics' day-to-day and longer-term activities. A substantial amount of data were collected but were not reported on in the aforementioned publication. This paper explores these data through the lens of the lived experiences of CM academics.

A mixed-method research methodology (MMR) was adopted. Qualitative data from an online survey were used to confirm some of the findings of interviews and focus groups. MMR was used to triangulate as well as to complement the quantitative survey results with those of the interviews and focus groups. All full time CM academics employed in the Australian higher education sector were invited to complete the survey, and a response rate of 54% was achieved. The survey included 137 items in a range of formats including Likert-scale options, ranking of options, choice from a range of options, as well as free format responses.

Following an analysis of the survey data, focus groups and interviews were conducted with the academics and Heads of School of 11 of the 12 universities delivering CM programs at the time (Williams et al., 2010). The audio recordings of the focus group discussions and the interviews were transcribed and analysed using NVivo (QSR, 2008). The findings that relate to academic leadership, management and staff development are described and discussed below.

CAREER PATHS OF CONSTRUCTION MANAGEMENT ACADEMICS

When asked if they had worked in more than one university (Figure 1) during their academic career, 55.5% answered in the affirmative, 38.1% stated that they had worked in one only, and 6.4% did not answer this question. Participants who had moved universities were asked if they had moved inter-state. One third of participants answered that they had, whilst 19% had not and 47.6% of participants did not reply to this question.

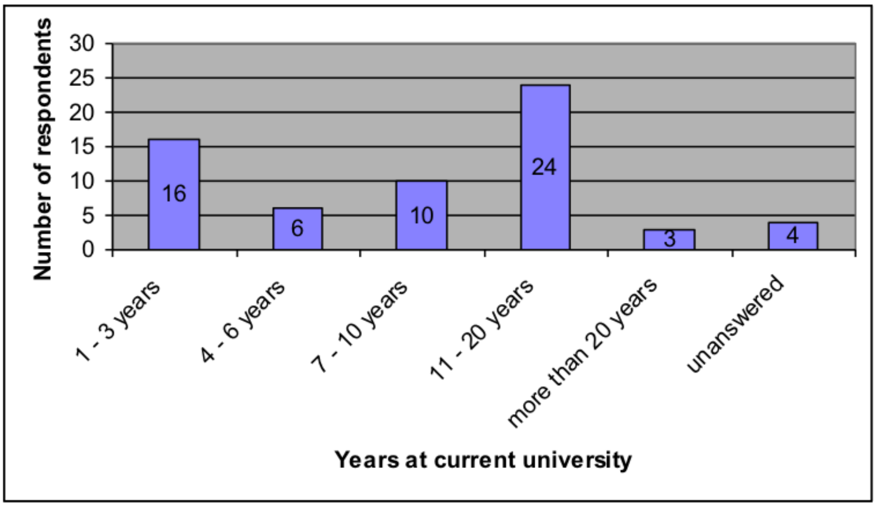

Figure 1: Length of time participants employed in their current university

Two thirds of participants had been teaching in their primary discipline for between 5 and 20 years (20.6% between 5 and 10 years, and 46% between 11 and 20 years). Fewer (12.7%) were novice teachers with up to four years experience. While 14.3% had taught for more than 21 years, 6.3% did not specify the extent of their experience.

The data indicated that 28.6% of academics had not been promoted, while a third had been promoted once, 15.9% had been promoted twice, 7.9% three times and 7.9% four or more times. 6.3% of participants did not answer this question. Those who had been promoted were asked to indicate the academic level from which they were promoted and the level they were promoted to for each promotion. Their responses are shown in Table 1, Table 2,
Table 3 and

Table 4.

Participants identified the following issues as those that had significantly affected their careers: research, bureaucracy, administration, difficulties getting promoted, poor leadership, teaching, lack of respect for construction disciplines, low pay, casualisation of teaching, unsupportive professional institutions, funding and their curriculum. Positive influences were seen to be mentors and colleagues, good management and experience overseas.

Table 1: First promotion of construction management academics

Gender	From…	To…	Number
Males	Assistant / Associate Lecturer	Lecturer	11
	Lecturer	Senior Lecturer	21
	Senior Lecturer	Associate Professor	1
Females	Assistant / Associate Lecturer	Lecturer	5
	Lecturer	Senior Lecturer	1

Table 2: Second promotion of construction management academics

Gender	From…	To…	Number
Males	Lecturer	Senior Lecturer	6
	Senior Lecturer	Associate Professor	8
	Senior Lecturer	Professor	1
Females	Lecturer	Senior Lecturer	2

Table 3: Third promotion of construction management academics

Gender	From…	To…	Number
Males	Senior Lecturer	Associate Professor	2
	Associate Professor	Professor	5
Females	Senior Lecturer	Associate Professor	1

Table 4: Fourth promotion of construction management academics

Gender	From…	To…	Number
Males	Associate Professor	Professor	1
Females	Lecturer	Senior Lecturer	1

Participants were asked to consider the factors contributing to the low rate of promotions amongst construction management academics. The aspects they identified are described below.

Contribution of teaching to promotion prospects

Several participants noted that their prospects for promotion were limited, especially if teaching was a major component of their workload. In this regard, one participant wished for "Better opportunities for promotion within the universities especially for those academics who are mainly interested in providing good education." Furthermore, several participants observed that the teaching-related promotion criteria espoused by some universities were regarded as inferior to those of research. For example one academic said "Even so-called teaching universities, they'll put the spin that teaching is important. But the promotional prospects are very dependent on research. So let's not kid each other."

Another academic said

> "Focusing on teaching here is not going to do you any good at all if you're going for a promotion, as we found out; three occasions failed, two occasions failed to get promotion because not enough research. Not teaching research, this is research, research."

HoSs held similar views, as the following quotes show:

> You show me someone who's promoted from associate professor to professor based on extraordinary, excellent - whatever adjective you want to use - teaching, and okay research, then I'll show you a very rare object."

> "The University's strategy… has made it very clear that it's aiming to move up the pecking order and teaching is very important but it's not really rewarded even though if you look at all the documentation it talks about promotion. Teaching is a very important part of promotion but it's almost impossible to get promoted unless you do very well in research."

Notwithstanding these observations, some participants noted that promotion practices at some universities were changing and that account was being taken of teaching performance, as an academic noted:

> "I've sat on the promotion committee every year since I've been here, except the year I applied. At the beginning when I first came here, there was no way that you would get promoted if you didn't have a PhD and didn't have publication(s), and a really good research track record. Just absolutely no way. Now it has changed. There is a greater support for teaching."

In addition, one HoS described the promotion process as follows:

> "... we require them, and all the unis are the same, require them to achieve a threshold across the three basic areas of teaching, research and administration and to excel in one of them. And it's usually research that they're looking to be the point of excellence. But it doesn't have to be. People will be promoted on the basis of teaching excellence but they will still have had to achieve the threshold in research and so on... "

Participants therefore generally believed that the teaching performance promotion criteria in place at their universities were ineffective. They were of the view that their research performance was all-important. This situation may be changing as some noted that their universities were acknowledging teaching performance as a promotion metric.

PhD requirement

Academics are expected to have doctorates, as research capacity is a basic requirement of contemporary universities (Coaldrake & Stedman, 1999; Marginson, 2002). Academics generally consider it necessary to complete a PhD or MPhil. While this might be viewed as staff development and a path to leadership, many academics regarded it as a necessity. In this regard a Head of School (HoS) said "We've got seven staff here and the staff that haven't been promoted haven't got PhDs. It's as simple as that." Another HoS said "I've never seen anyone promoted except from level A to level B. I've never seen that happen. And it won't happen for anyone until they have their PhD." Similarly, an academic participant said "... if you're not doing a PhD definitely you will not be promoted" and a participant stated that "without a PhD there is no future (career progression wise) regardless of my ability".

No dissenting observations were made about the need to obtain a research higher degree. Not having a PhD was seen as an inhibitor to construction management academics being promoted.

Research output

Several participants noted that promotion also depended on their research outcomes. For example, one participant said:

> "... there's no question about the fact that not only do you have to publish…..So it is driven – research drives the promotional prospects of the people... Any university will judge a staff member's promotional prospects by PhD and research outcomes. In fact, research grant applications and success."

Similarly, a HoS noted that "... promotions (are) very largely are driven by research performance."

Another participant noted the disparities between the funding of other disciplines and that of construction management disciplines. This was seen to exacerbate the challenges construction management academics faced in being promoted. This academic said:

> "We are in an industry which doesn't by its nature have lots of money for its research. Where if you look at any form of medical industry and there is research money for them all over the place."

Funding for research was seen as a compounding issue. A participant observed that a "(t)eaching career is now attached to research and (the) limited capacity of the industry to fund adequate research... will hinder (construction management) academics to climb the academic ladder."

These observations highlight the need for construction management academics to have a research track record to be promoted. However, the modest funding opportunities and the relative youth of the discipline were seen to compound the difficulties these academics faced.

Succession planning

Many participants observed that it was difficult to recruit academics with the required combination of academic qualifications and industry experience. For example, one HoS said "I think the inability to attract in general good quality academic staff with solid industry experience as well as academic experience... is the biggest challenge."

Furthermore, an academic said "We have gone beyond the stage now where there was a sort of surplus of good people to call upon. I think we are at the stage where it is very difficult to find good teachers."

The reason frequently mentioned for this shortage of staff was the pay difference between industry and university. Graduate construction managers were earning substantially more that academics and this made the lifestyle of university lecturers financially unattractive:

> "Well, one of the reasons why it exists is because industry people can earn a heap more money in industry than they would do as academics. Half of my students earn more than I do. So I'm talking about prior to graduation. So I don't think there's an awful lot of incentive to come into academia."

> "Staffing is a real issue. The salary levels, compared with what industry's paying. There's no attraction for an industry professional to come – to turn around and become an academic."

To address the shortage of lecturers, several participants mentioned that overseas applicants were finding employment in Australia. However, whilst these academics might have post-graduate qualifications, they were unlikely to be familiar with local conditions. In this regard some HoSs said:

> "You have to go (overseas) to source (academic staff). The problem is of course then the work experience becomes dubious. There are a lot more potential candidates overseas, particularly in our region that have PhDs, but won't necessarily have the relevant work experience."

> "... it's very hard to attract people... So when we advertise for staff (we get applications from) maybe a local applicant and maybe not. We tend to get some from… and some from other places. But they have little or no industry experience and they certainly have very little knowledge of the Australian experience. So that's hard."

In summary, most HoSs agreed that recruiting appropriately qualified staff was a significant challenge. Staff also recognised this as a challenge for the discipline. The dearth of local applicants had resulted in the appointment of overseas applicants, and this trend was likely to continue.

Workload concerns

Leadership and management roles in schools involve excessive workload much of which is bureaucratic in nature. Academics observed that the volume of administrative works is the greatest factor preventing them from considering becoming a leader or manager. Moreover, they maintained that this situation worsens with seniority, with management typically being only bearable at program or degree level, becoming more difficult at the level of Head of Discipline or Department and almost impossible at the level of Head of School or Dean (Ostwald & Williams, 2008). Staff generally believed that to undertake these roles a person needed to give up their teaching or research careers, their chances of promotion and their quality of life. Most schools had little or no succession planning in place because no one was willing to take on these roles.

DISCUSSION

There is little empirical evidence of tried and proven approaches to leadership that apply in university settings. Furthermore, there are no past studies of leadership and management of the construction management discipline in Australia with which to triangulate the present data. Some past studies of academic leadership and management are relevant in the present context. Indeed, almost the complete range of opinions reported here have strong parallels to those recorded in past research into academic leadership and management (Rowley & Sherman, 2003; Sarros, Gmelch, & Tanewski, 1997a, 1997b). Past studies into academic leadership and management positions have also suggested that high levels of personal stress are common (Gmelch, 2000; Gmelch & Burns, 1993; Gmelch & Seedorf, 1989). This lends credibility to the majority of the interview and focus group data. Nevertheless, the purpose of this paper is not to construct an argument against taking up a leadership or management position; it is clear that people are needed in these roles. However, based on the responses recorded, it is clear that the roles of Dean, Head of School and Head of Discipline are especially onerous in the specific context of the construction management discipline. One of the primary reasons for this is that, in the past, universities have valued and promoted the autonomy of individuals, the derivation of authority from academic standing, and the sovereignty of an individual’s research. Inevitably, these values, along with an ambivalence to administrative tasks on the part of academics, has come into conflict with successive governments’ agenda for universities (Marginson 2002, Ostwald & Williams 2008). The emphasis on performance and accountability has led to increased workload pressure and lower morale.

The egalitarian and collegial structures of the past are being replaced with autocratic and managerial systems (Marginson & Considine 2000).

All of the changes described above and which manifest so clearly in the demands on academic leaders and managers are brought into focus when considering staff development.

CONCLUSION

This study was founded on the observations of CM academics at a specific stage of their careers. It was based on the resources they had available at the time, the environment in which they found themselves and the students enrolled in their courses. It is likely and expected that these conditions will change with time but this does not undermine this study. It provides a snapshot against which future developments may be measured.

Academic leaders in construction management clearly feel overloaded, mired in bureaucracy and burdened with the expectation that they will keep their teaching and research active while being a leader / manager. What is evident is that the demands of leadership leave little scope for innovation and may even deter some staff with an interest or skills in teaching from aspiring to leadership and management positions. This means that many new staff have their attention swiftly diverted from seeking staff development in teaching and learning by their higher degree studies. This also contributes to staff not perceiving teaching as a viable career path. Certainly, the findings of this study identified that changes in promotion criteria that recognise teaching are gaining momentum, but this was countered by the belief that research remains the primary means for career advancement.

The question must be asked whether the current academic system is able to ensure the delivery of the types of education programs that provide the range of learning experiences needed in CM education. It is apparent from this study that it is unlikely that academic leaders will drive this delivery. Administrative and quality assurance tasks detract from their ability to focus on curriculum issues. Coupled with academic managers' lack of capacity to commit to teaching/curriculum innovation is a parallel lack of willingness to take on this responsibility

Where there is little prospect of change in resourcing and no willingness amongst academics to take on a leadership role, it is likely that the status quo will continue. This will not enhance student learning. One aspect that offers some hope is that, as more staff complete research higher degrees, there may be new capacity to devote to teaching innovation, the pressing issue of teaching quality and its management, and an even larger pool of potential applicants for leadership and management roles.

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DESIGNING LEARNING EVENTS FOR CONSTRUCTION MANAGEMENT CURRICULUM UTILISING 4d LEARNING ENVIRONMENTS

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ABSTRACT

Work-integrated learning has been acknowledged as a means to achieve a balance between theory and practice: the application of disciplinary knowledge and skills within a real world context. The intent being to produce graduates who engage effectively in their professional environment. However, within the discipline of construction management, the ability to contextualise learning as a realistic experience is often impeded by the hazardous nature of the industry, large cohorts, blended delivery and distance education. This paper reports on the development and preliminary use of a multi-disciplinary digital learning environment as an alternative approach to simulate the real world environment. Based on time lapse 3 dimensional (4D) photographic images of a real building and documentation associated with design and construct activities, the environment was trialled across 3 construction management courses. The environment was used as a lecture tool and/or an assessment instrument involving group or individual tasks. Interview and questionnaire feedback was obtained in relation to the capacity of the environment as a demonstration tool and upon 4 critical areas: graphical appearance, usability of the environment, degree to which the environment and course activities enhance discipline understanding, and the contribution towards enhanced learning and skill development. Initial results indicate that the environment provided a crucial platform to assist with explanation of on-site processes and assemblies. Student participants further commented on the ability of the environment to increase understanding of construction activities in terms of contextualising theoretical material and assisting with problem solving skills.

Keywords: construction management, virtual site visit, 4D panoramic tour, immersive learning scenarios, work integrated learning

INTRODUCTION

Work-integrated learning has been acknowledged as a means to achieve a balance between theory and practice: the application of disciplinary knowledge and skills within a real world context. The intent being to produce graduates who engage effectively in their professional environment (Gribble et al., 2015; Patrick et al., 2008) and the benefits have been well documented (Patrick et al. 2008; Stoker, 2015, Wilton, 2012). However, within the discipline of construction management, the ability to contextualise learning as a realistic experience is often impeded.

The industry is acknowledged as hazardous by nature (Safe Work Australia, 2012); therefore, the ability to access suitable sites for demonstration purposes is extremely limited given liability constraints. However, a further challenge rests with the changing educational environment. Large cohorts, blended delivery and distance education all contribute to impede the ability to attain such valuable experience and cement theory with practice. The provision of an equitable learning experience within the contemporary teaching environment, particularly in relation to distance students, is rarely aligned with work-integrated learning principles.

Virtual technologies have been identified as mechanism to assist with the provision of bridging the gap between theory and practice. This paper reports on the development and preliminary use of a multi-disciplinary digital learning environment as an alternative approach to simulate the real world environment. It focuses upon the deployment of the environment across three cohorts studying within the discipline of construction management.

THE PROJECT

As part of an Australian Government Office of Teaching and Learning Innovation and Development grant, led by the University of Queensland, the University of Newcastle and the University of South Australia partnered to work on a multi-disciplinary 4-dimensional digital learning environment for students, as an alternative approach to simulate the real world environment. The learning environment was developed to extend the platform provided by Professor Ian Cameron involving a 3-dimensional environment and British petroleum (Cameron et al., 2009).

This particular project focused upon the newly constructed University of Queensland, Advanced Engineering Building (AEB) (Refer Figure 1). Thus, providing a real life building where on-site construction processes were surveyed to produce a 4-dimensional learning environment portraying a real world environment. Construction documentation was also embedded into the environment to provide a holistic approach to student learning and development. In this respect, students were presented with a learning environment providing the opportunity to observe, analyse and critique operations; appreciate and understand construction activities; and enhance their critical thinking or decision making abilities.

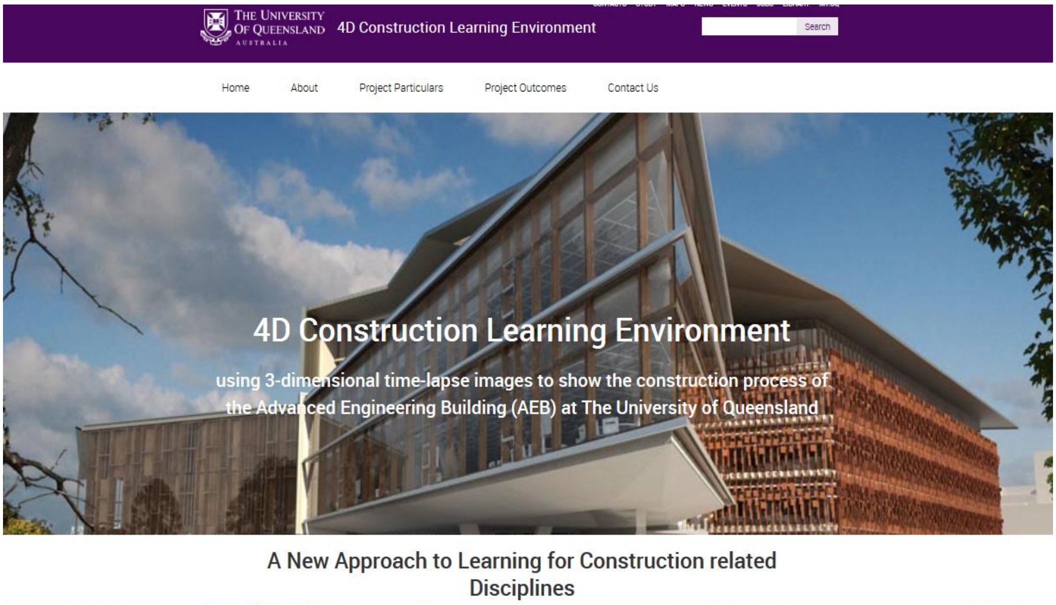

Figure 1 The Advanced Engineering Building

(Source: http://4dconstruction.uqcloud.net/VirtualTour/action/3DEnv/index)

The 4D learning environment

The learning environment consists of a digital (virtual tour) application that uses 3-dimensional time-lapse (4D) digital images. Images were obtained throughout construction of the AEB. They consist of high resolution, 3-dimensional digital photographic surveys, subsequently processed into a 4-dimensional digital learning environment. Within the learning environment the ability to select various building levels and move chronologically throughout the many stages of construction is possible. Each stage is identified as a node: examples of various stages of construction are shown in Figure 2, Figure 3 and Figure 4. There are 3 primary tools that support navigation. First, the floor plan facilitates movement between nodes on a level. Second, a vertical bar supports navigation vertically between levels. Third, a timeline allows movement amongst surveys.

The environment has also been designed to support image rotation and enhanced view capabilities. As mentioned, it also contains design and construct related documentation, *inter alia*, architectural and structural drawings through to fire engineering reports. Thus, providing students with a valuable resource to enhance their learning experience.

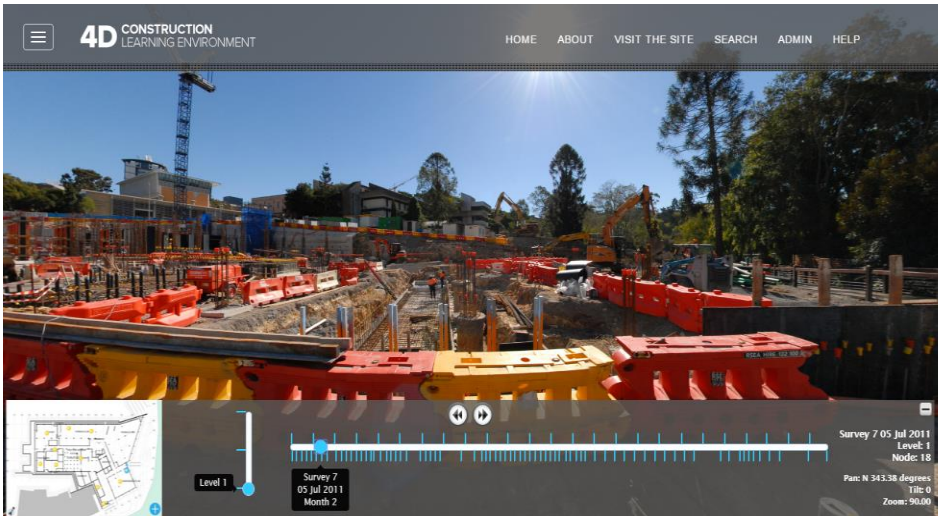

Figure 2 Level 1: Node 18, 5 July 2011

(Source: http://4dconstruction.uqcloud.net/VirtualTour/action/3DEnv/index)

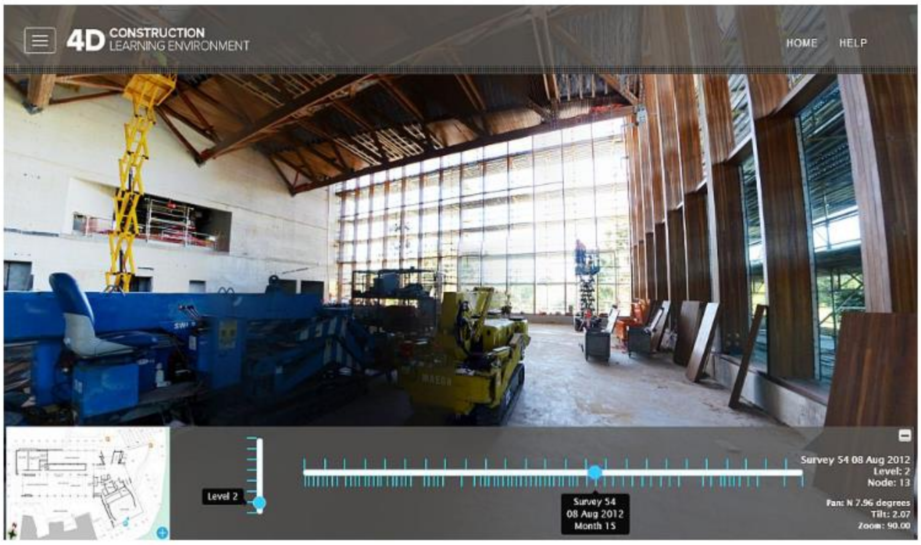

Figure 3 Level 2: Node 13, 8 August 2012

(Source: http://4dconstruction.uqcloud.net/VirtualTour/action/3DEnv/index)

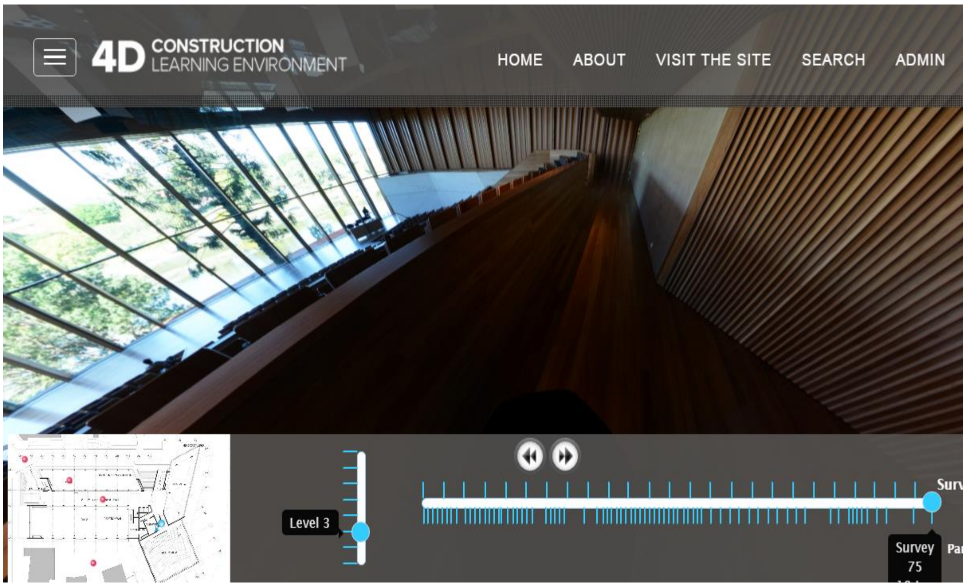

Figure 4 Level 3: Node 22, 19 June 2013

(Source: http://4dconstruction.uqcloud.net/VirtualTour/action/3DEnv/index)

RESEARCH METHOD

The learning environment was trialled at the University of Newcastle, within the degree: Bachelor of Construction Management (Building). It was presented to students across 3 construction management courses involving different year levels, large cohorts, blended delivery and distance education. The learning environment was used as a lecture tool and/or an assessment instrument involving group or individual tasks. Details on each courses is provided below.

Interview and questionnaire feedback was obtained in relation to the capacity of the environment as a demonstration tool and upon 4 critical areas: graphical appearance, usability of the environment, degree to which the environment and course activities enhance discipline understanding, and the contribution towards enhanced learning and skill development.

ARBE 1101 Construction Technology 1

The aim was to employ the learning environment as a lecture tool to understand its capabilities as a demonstration too. The learning environment was used in the initial lecture series for this course which concentrated upon site preparation, excavation and soil types, steel reinforcement, concrete and framing. Hence, preliminary construction operations within the learning environment were employed. In conjunction with standardised lecture presentation tools, the learning environment was used to rationalise theory and for practical observation of on-site applications. Cohort size was 275 undergraduates: on-campus and distance combined with the majority being first year students.

ARBE 1304 Building Codes and Compliance

Within this course, the main focus of the learning environment concerned individual assessment tasks. Although students were exposed to the 4D learning environment during lecture periods on multiple occasions, their assignment required them to move beyond the use of standard 2-dimensional drawings and into the 4D environment to apply their knowledge of regulations.

Students were presented with 3 questions. Question 1 concerned regulatory planning and assessment. Using specific legislation, students were required to make planning determinations including the nomination of applicable legislative sections and the identification of the consent authority. Question 2 was specific to the auditorium and required students to identify issues related to access and egress with regard to the National Construction Code, Building Code of Australia Volume One (BCA). Question 3 also focused on the auditorium in which students were to make a determination on the mandatory services and equipment required under the BCA. With all tasks, students were required to explain and justify their determination. The cohort size was 277 undergraduates: on-campus and distance combined with the majority being first year students.

ARBE 3300 Construction Business Management

The intent was to utilise the learning environment to add realism to problem solving in a reflective practitioner exercise: to improve learning through 'reflection in action' and 'reflection on action' project management problem scenario. Of the 10 standard trigger readings employed within this course, 2 were replaced with 'provocations' where students were to apply 'reflection in action' to solve the problem and 'reflection on action' to justify the solution.

The learning environment revolves around a single building project, so it was essential that the provocation provided to students had severe implications for the firm that they represented. The cohort size was 144 undergraduates: on-campus and distance combined with the majority being second or third year students.

RESULTS

ARBE 1101 Construction Technology 1

The lecturer identified that for the majority of the students, this course represented their first exposure to construction processes and assemblies. The learning environment provided the opportunity for students to experience a virtual site visit providing them with a realistic representation of the different aspects of a project, particularly given most had no prior on-site experience. The lecturer commented that the learning environment served as valuable demonstration tool to assist in explaining theory. Students were presented with theory and able to contextualise it through the learning environment. Based upon its potential value in this course, the lecturer stated that they will continue to use the environment in future lectures.

ARBE 1304 Building Codes and Compliance

Students were provided with the opportunity to give feedback on their experience with the learning environment across the 4 areas related the usability and potential benefits of the learning environment. They also had the opportunity to provide comment on their experience. A total of 63 students responded to the survey. According to the survey most students considered the environment enhanced their understanding and learning experience. It was seen to provide a more practical experience compared to the standard method of text-based learning. In addition the sequencing of events and ability of revisit site operations were identified as beneficial features of the environment.

ARBE 3300 Construction Business Management

In a process aligned with ARBE 1304, students were given the opportunity to provide feedback related to the 4 critical areas and optional comment. A total of 39 students responded to the survey and the feedback highlighted that the learning environment had a positive impact upon overall class performance in the assessment.

Assessments highlighted that the provocations, developed form the content in the learning environment, provided students with the opportunity to reflect both in action and on action. Students who were developing into reflective practitioners distinguished themselves through mature and introspective responses. The learning environment was viewed as a realistic approach to construction operations particularly given the inclusion of site documentation. The ability to interact with the building, its plans and documentation was viewed as important in decision making processes.

DISCUSSION/CONCLUSION

In general, the 4D learning environment was viewed by both lecturers and students as a tool to enhance the learning experience and assist with work-integrated learning practices. As a lecture tool, the environment served to enhance understanding of on-site operations taking theory into context. From an assessment perspective, it enabled students to develop their theoretical knowledge through application to actual construction activities. The environment provided a solid base from which students could take their knowledge of building regulations and undertake a real life building inspection. Additionally, with the associated documentation, students were able to enhance their critical judgement and decision making skills.

Through the feedback process, improvements to the environment were identified. Approximately 10% of students highlighted that descriptions or explanations at various stages of operation would further enhance learning. Multiple methods were proposed: video footage, voice over recordings or the use of bubbles around certain structural areas. A larger navigation map was favoured to improve accessibility and an optional overlay to describe details to assist with sequencing operations.

Overall, the learning environment provided a tool by which to enhance assist the bridge the gap between theory and practice. The assessment processes will be further refined to enhance student skills in the area of construction management, replicating on-site activities. Future research will consider course and student learning gradients over defined periods. Additionally, use of alternative building areas and materials will be investigated in terms of ability to further enhance learning. The 4D Construction Learning Environment offers a real life building that students can inspect, analyse, critique and use to enhance their critical judgement and decision making skills.

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VIRTUAL LEARNING ENVIRONMENTS: CONVERSION OF BIMS INTO GAMING ENGINES AND THE CONSTRUCTION MANAGEMENT DISCIPLINE

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ABSTRACT

Within education, site visits are acknowledged as a beneficial means to reinforce association between theory and real world practice. For those involved with the discipline of construction management, specifically building regulatory codes, the ability to attain on-site experience as a cohort is limited. Firstly, the industry presents an environment wrought with danger, risk and liability. Secondly, distance education and large cohorts present an issue of equity across the learning experience. Thus, on-site visits become practically impossible. Increasingly, educators are moving towards virtual technology to replicate the real world experience; however, development of interactive environments is complex, demands significant time and resources. Populating a gaming environment using data from a Building Information Model (BIM) via a BIM-to-game engine pipeline to provide a realistic virtual environment has the potential to overcome such issues: creating an environment that delivers an accurate representation of a building, provides functionality associated with movement and has capacity for inclusion of tools to replicate real-world activities. This paper describes initial steps towards a realistic virtual learning environment constructed from a BIM and enabled by gaming technology. It reports the results of a “proof of concept” evaluation where a virtual environment was presented to a student cohort who had completed a building codes course: equipped with knowledge, the environment served as an instrument to replicate the real-world enabling on-site regulatory inspections. Qualitative feedback favoured the environment, particularly the realism of the virtual environment, its potential benefit as a learning tool to contextualise theory and suitability to achieve set tasks.

Keywords: virtual environments, building information models, gaming engines, construction management, site visits

INTRODUCTON

Site visits within educational environments are acknowledged as a beneficial means to reinforce association between theory and real world practice (Ashford and Mills, 2006; Wilton, 2012). Wilton (2012) identifies that such experiences contribute to employability skills and provide graduates with an advantage upon entering the professional market and this is also applicable to the domain of regulatory building certification.

The University of Newcastle (Australia), Bachelor of Construction Management (Building) degree is accredited by the building certification authority in which regulatory building codes is a foundation subject To provide students with a holistic learning experience - to amalgamate theory with practice and ensure a deeper understanding of regulatory application –site visits are necessary. However, the ability to attain on-site experience as a cohort is limited. The industry is acknowledged as one which presents an environment wrought with danger, risk and liability. From an educational perspective obstacles associated with distance education and large cohorts present an issue of equity across the learning experience. Therefore, the use of site visits becomes unfeasible, if not practically impossible.

A shift towards virtual reality technology has been seen as a mechanism to replicate the real world experience. Virtual environments can be built to mimic real-world buildings with increasing levels of realism (for examples see Figure 1). However, the development of such interactive environments is not only a complex process but demands significant time and resources. Building Information Models (BIM) may provide the solution. These models are commonly employed within construction practice today and may serve as the basis from which building information can be manipulated to populate an environment within a gaming engine, providing a realistic virtual environment in which to navigate and undertake activities.

This paper introduces the steps involved with the conversion of a BIM to a virtual gaming environment. It then proceeds to report upon the results of a “proof of concept” evaluation where a virtual environment was presented to a student cohort who had completed a building regulatory course. The environment served as an instrument to replicate the real-world enabling on-site regulatory inspections to see whether the realism of virtual environment and its functionality would serve as benefit learning tool to contextualise theory.

Figure 1.Example views from a real-world building modelled in a virtual environment.

THE VIRTUAL ENVIRONMENT

The use of gaming technology is considered robust as these platforms present rigorously tested environments that provide modelling tools enabling them to be reused (Trenholme and Smith, 2008). Gaming technology presents students with a virtual environment and ultimately the opportunity to navigate their surroundings as if undertaking an on-site inspection.

In terms of BIM, this serves as a means by which to import content including geometry and finishes, a common method for constructing a virtual environment (Kandil et al., 2014). The conversion from a BIM to a gaming engine, specifically from Revit (www.autodesk.com) to the Unity3D platform (www.unity3d.com) will be briefly introduced. Broadbent (2011) highlighted the process for producing a visualisation of a BIM using Unity 3D (see Figure 2). This process consists of a Revit BIM model, the process of exporting objects into Navisworks creating a timeline, the importation of the model into 3D Studio Max and from there importation of information into the Unity 3D gaming engine. (Also see Bille et al, 2014).

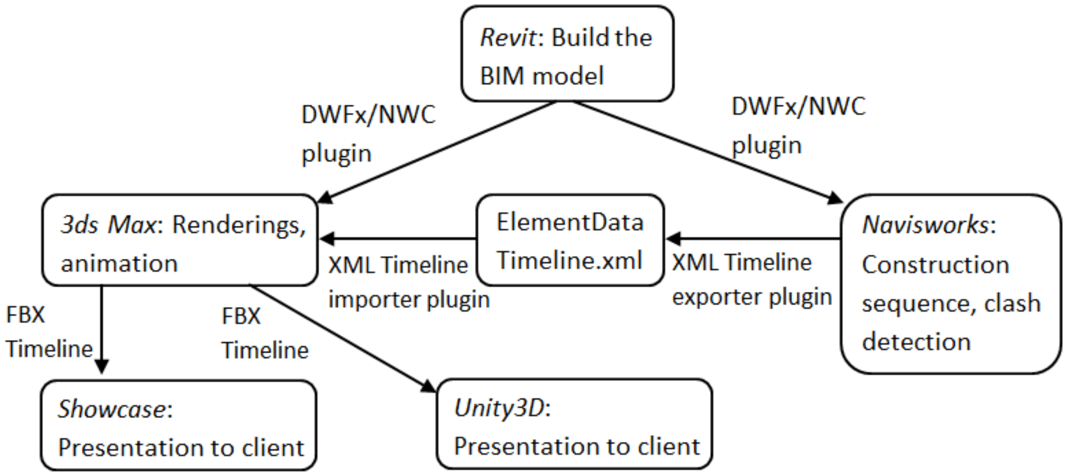

Figure 2. Generic pipeline as described by Broadbent (2011).

METHOD

The virtual building developed by Smith and Trenhome (2009) using the Source Engine (www.valvesoftware.com), that created a fire drill environment, was employed as the platform for this research. Modifications occurred to the environment to create a building devoid of fire services and equipment: not compliant with regulatory building code requirements. Figure 3 provides an example of a non-modified and modified room within the virtual environment.

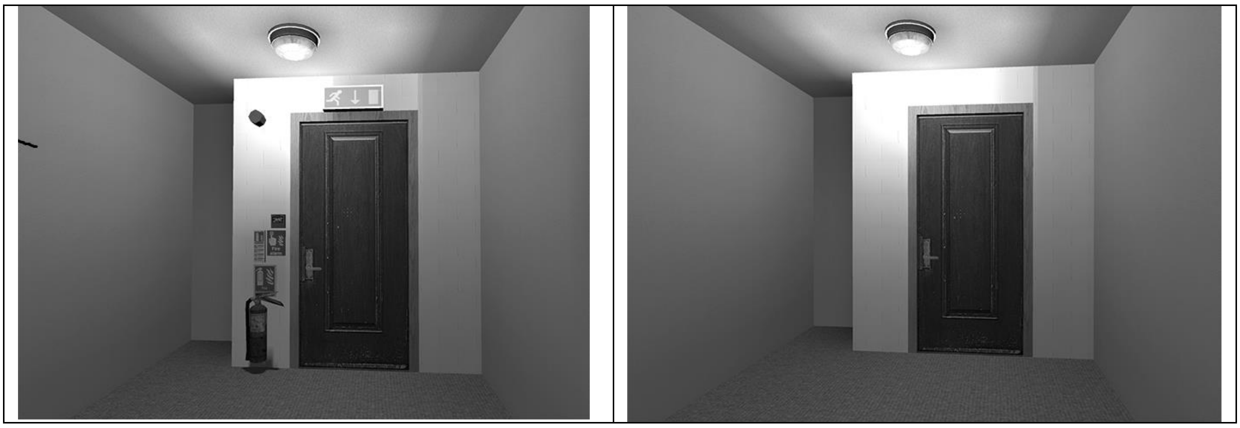

Figure 3. Original virtual room showing fire services and non-compliant virtual room

(Source: Brewer, Smith and Maund, 2015)

Upon modification of the original virtual environment, an initial trial was conducted with a small number of participants enrolled in the Bachelor of Construction Management degree. Inclusion criteria mandated completion of the course: ARBE1304 Building Codes and Compliance. This course is designed to explore the principles and practice of building legislation and associated policy applicable to construction processes, in conjunction with the regulatory assessment of buildings and structures. The intent of the course is to develop knowledge and skills in the interpretation and application of regulation and in doing so develop an in-depth understanding of building performance theory and practice.

The focus for this project was the National Construction Code, Building Code of Australia, Volume One that relates directly to non-residential buildings. The intent being to provide an environment in which participants could undertake a regulatory inspection to replicate on-site activities. The research design employed a two stage process which will now be outlined.

Stage 1

Participants were provided with the opportunity to walk through the virtual environment to complete computer based tasks: assess and identify regulatory compliances and non-compliances. Individually each participant was directed to the testing room and seated at the desktop computer being a Dell Precision T1600: CPU 3.40GHz, Windows 7 with Dell UltraSharp U2412M 24-inch monitor. To ensure participants were able to navigate the virtual environment, they were given a five minute introduction to gaming environments using the Unreal Engine (www.epicgames.com). The aim here was to ensure that all participants were familiar with navigation in a game engine-based virtual environment but without exposing them to the actual test environment, e.g. the building modelled in the Source Engine.

Participants were provided with relevant extracts from the National Construction Code and a set of architectural plans: ground floor plan, level plans (see Figure 4) and a section view, that nominated areas to be inspected and assessed. They were then furnished with a 2 page document specifying the scenario and questions. Questions were separated into those that could be answered using the Code and architectural plans (Refer Table 1) and those that required the Code and virtual environment (Refer Table 2). Participants were given with 5 minutes to review the paperwork and the questions. The test then commenced with 20 minutes allocated to the navigation of the virtual environment and completion of the set tasks.

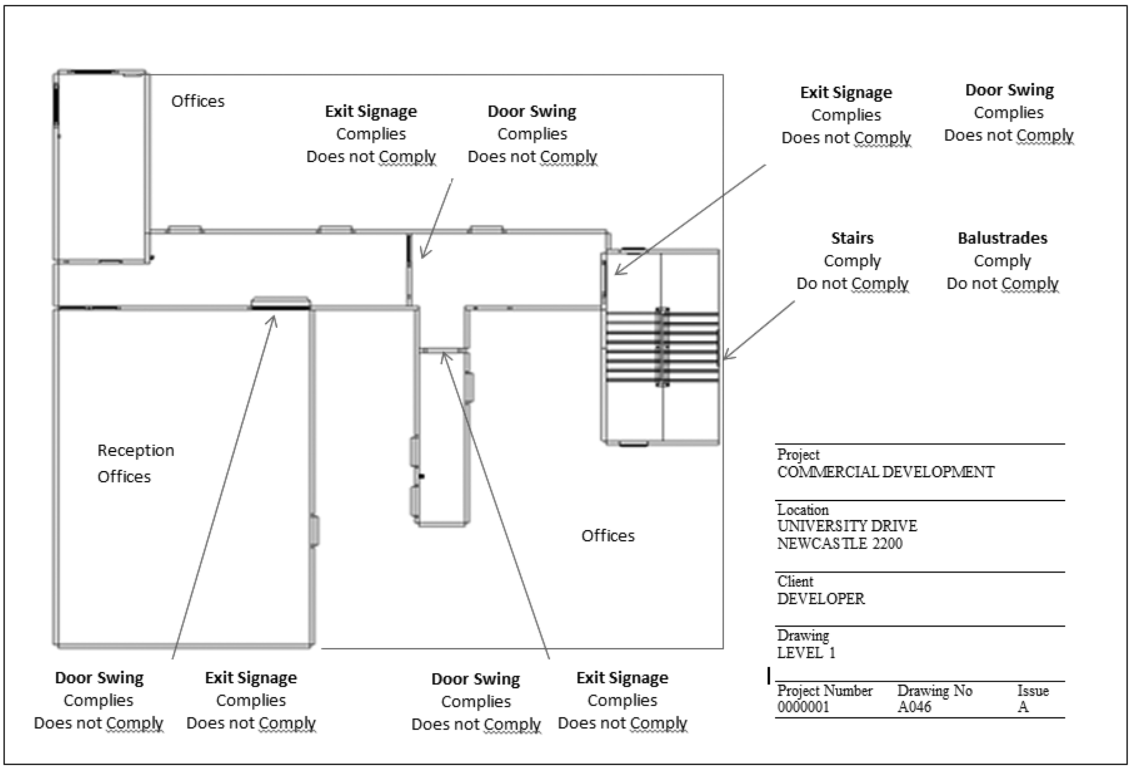

Figure 4. Example floor plan provided to study participants.

Table 1. Questions related to Code and plans only

BCA 2014, Vol. One Section/Part			
Section A General Provisions, Part A3 Classification of buildings and structures			
	BCA Clause	Question	Answer
	Clause A3.2	Determine the building classification	Class 9a Class 5 Class 7b Class 6
Section C Fire Resistance, Part C1 Fire resistance and stability			
	Clause C1.2	Determine the Type of Construction	Type A Type B Type C

(Source: modified from Brewer, Smith and Maund, 2015)

Table 2. Questions related to Code and virtual environment

NCC, BCA 2014, Volume One, Section/Part	Question
Section D Access and Egress Part D2 construction of exits	Review the stairs and identify whether they comply with clause D2.13(a)(i)
Section D Access and Egress Part D2 construction of exits	Review all the exit doors and identify whether the door swing complies with clause D2.20(b)
Section E Services and Equipment Part E4 Emergency lighting, exit signs and warning systems	Review the exit signage and identify whether it complies with clause E4.5

(Source: modified from Brewer, Smith and Maund, 2015)

Table 3. Examples of demographic questions

Demographic questions	
Typical computer usage	Daily, weekly, monthly, less frequently, never
Types of devices regularly used	Keyboard, mouse, touch-pad, joystick, gamepad, pointer/Wii remote, other
Gaming experience	Master, expert, intermediate, novice, none

Table 4. Examples of focus questions

Focus questions
How did you find the navigation of the virtual learning tool?
Did you find the visualisation of the models realistic?
Did the models provide the facilities to enable assessment of non-compliance issues?
What areas do you believe could be enhanced to assist student learning?

Stage 2

Upon completion of the Stage 1 assessment, participants were interviewed to elicit their experiences with the virtual environment. Interviews were semi-structured in nature with questions designed to cover two primary areas. Firstly, multiple questions were designed to collect demographic information that would assess computer and gaming experience as this would impact upon their impression of the virtual environment (refer Table 3). Secondly, feedback was obtained in relation four critical areas: navigation, visualisation, assessment capabilities and learning outcome (refer Table 4).

RESULTS/DISCUSSION

All participants were enrolled in the Bachelor of Construction Management (Building) degree and had completed the subject ARBE1304 Building Codes and Compliance. A total of six participants were involved in the initial trial with an age range of 20-44 (average 30 years) and the cohort included both genders.

Gaming experience differed considerably amongst the participants: no prior experience (n=2), frequent use (n=3) and master (n=1). Those familiar with gaming technology had experience with a range of devices including a keyboard, mouse and joystick. Computer usage was rated daily by all participants. Although the initial test involved a small sample size, the experience of the participants served well to emulate a real world scenario where the use of information technology is diverse across the cohort.

The period allotted for the test, excluding gaming introduction and paperwork review, was 20 minutes. All participants completed the test within the allocated timeframe and used all sources of information – architectural drawings, Code text and the virtual environment – to answer the questions. Given ARBE1304 is a first year subject, the range of questions posed in the test were focused upon reinforcing basic principles: the intent being to enhance learning and provide a realistic learning experience rather than present complex scenarios. At this stage the virtual environment capabilities placed limitations upon the type of questions that could be presented as the environment is yet to incorporate measurement tools.

Interviews were conducted with each participant immediately after the testing period. Overall the feedback on the virtual environment was positive with multiple students commenting on the ease of navigation and realism of the environment. The use of the environment within the lecture setting was seen as beneficial to explain fire service and equipment type and location.

Multiple participants noted that the environment would serve as a useful tool in preparing students for the reality of professional practice, serving as a mechanism to enhance not only theory but practical application.

Participants noted a range of issues that could be addressed in future versions. A number of doors were considered awkward to open given the need to be perfectly positioned to gain access or open towards the user. A navigation map within the environment was favoured as a tool in which to assist with establishing ones position within the environment. However, the use of such a map would not emulate a real-world environment and would detract from the intent of the learning exercise. Similarly, colour coding of doors was seen as a potential enhancement: to distinguish between those that are locked and unlocked allowing passage. This form of graphical change would not be representative of standard building practice and was seen as an area that would again impact upon learning intent. Particularly when undertaking inspections for the purpose of fire safety.

CONCLUSION

This study reports on the possible use of a BIM to game engine virtual environment to simulate a real-world experience and enhance student learning and graduate possibilities. The student cohort involved with the initial testing received the virtual environment favourably. Primarily, the realism of the environment and the ability to undertake inspections created a learning tool that placed theory into context: allowing for application of learned material. It was viewed as an important means of demonstrating professional activities and seen to enhance learning of the topic area.

The next phase of the research involves the potential development of multiple buildings to represent building of different types and scales. This will further involve the refinement of drawings to present those employed within professional practice. In addition, the system is being analysed to determine the capacity for inclusion of measurement tools to further aid inspection determinations and expanding upon the range of Code areas that can be assessed.

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SUSTAINABLE ASSET MANAGEMENT – SELECTING OPTIMAL MAINTENANCE STRATEGIES BASED ON MULTI-CRITERIA DECISION MAKING – A RESEARCH AGENDA

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ABSTRACT

Infrastructure maintenance is one of the largest maintenance sectors in Australia. For instance, according to the Department of Infrastructure and Transport (2015), the market value of road maintenance activities is $7.8 billion in 2013, accounting for 5.2% of the total road network value of $150 billion. Major infrastructure authorities in Australia hold the belief that the performances predicted from current maintenance planning do not fit their real behaviours and conditions. This has been proved to create a significant loss of productivity and a misallocation of maintenance resources (Chen and Martin, 2012). The aim of this project is to develop an innovative Life Cycle Assessment (LCA) approach through integrating cost, performance, and environmental impacts to achieve the optimal maintenance productivity for road assets. This approach integrates (1) life-cycle cost modelling; (2) performance calibration and evaluation; and (3) environmental impacts.

Keywords: Life cycle cost, road pavement, environmental sustainability, asset management

INTRODUCTION

According to the Department of Infrastructure and Transport (2015), Australian governments spend more than $7 billion maintaining and renewing the road estate every year. There is also evidence of significant maintenance deficit when there is a 15% per annum reduction in road maintenance expenditure over the three years from 2014-2017 (Government of Western Australia, 2014). According to the Australian

Local Government Association (2013), there is a forecasted shortfall of $17 billion for maintenance and renewable expenditure for local roads across Australia between 2010 and 2024, representing 39% above the estimated funding availability for the corresponding period. As such, particular attention should be directed towards improving the whole life asset management processes and ensuring that adequate long-term funding strategies are in place in the infrastructure sector (GHD, 2015).

Definitions: In this paper, the term "infrastructure" refers to road assets and the term "asset management" is restricted to the maintenance management of road pavement. "Road user benefit and cost" refer to direct cost borne by the road users, such as fuel, wear and tear of vehicles, and travel time. Saved marginal cost is equal to benefit.

INDUSTRY PROBLEMS

LIFE CYCLE COST MODELLING

Existing life cycle costing (LCC) method is mainly based on an evaluation of the present worth cost (PWC) or equivalent uniform annual cost (EUAC) of asset management strategies. Although the LCC method can help evaluate the life cycle economic performance of asset, it is limited as many studies have reported that the user benefits and costs, an element which is not included in LCC method, accounts for a significant portion of the life cycle cost (Litman, 2002). Current life cycle cost is often minimized for the considered asset without considering the often significant cost for the users of the asset and without even considering the long-term effects of the decision (Thoft-Christensen, 2009). Life cycle cost benefit (LCCB) analysis is an extended LCC analysis which all indirect cost, such as user cost and benefit as well as externalities, are included. Thoft-Christensen (2009) also found that the main reason leading to the non-adoption of LCCB in infrastructure projects is that engineers in general do not understand or appreciate the probabilistic concepts behind LCCB analysis. As such, an in-depth understanding of the LCCB method and its application in the asset management aspect is necessary.

CALIBRATION OF PAVEMENT PERFORMANCE

The pavement management system (PMS), either in HDM–4 (a computer software for Highway Development and Maintenance Management System) or dTIMS (Deighton's Total Infrastructure Management System), is a complex function of combined effects of traffic and weather, which induce stresses and strains within the pavement layers. It should however be noted that, these models were derived from a broad empirical base and may be volatile in predicting the performance of road pavements in local conditions. Context, location and environment specific calibration is a necessity to achieve optimal asset management performance.

Based on the HDM-4 and dTIMS modelling of deterioration, pavement deterioration models are provided with a set of default calibration coefficients, which aims to help adjust the models for different climatic conditions (Henning et al., 2006). However, there are studies which find that simply adjusting the calibration coefficients does not help improve the prediction accuracy. A more accurate deterioration model is required by using local rather than global parameters. For example, Henning and Tapper (2004) found that some models, such as the roughness progression model, do not necessarily follow the model format as described by HDM-4 and dTIMS. Uncalibrated use would predict pavement performance that might not accurately match the observed values on road sections (Jain et al., 2005). As such, fundamental understanding of the pavement performance and deterioration with regional variation is imperative.

ENVIRONMENTAL CONSIDERATION IN ASSET MANAGEMENT

A significant number of environmental protection measures have emerged over the past few years. The concept of sustainable development calls for a change of the way about how assets and projects should be appropriate managed. As major infrastructure stakeholders, including Main Roads WA (MRWA) and Road and Maritime Services (MRS), are integrating sustainability in their organisational strategic plans, there is a definite urge to include sustainability factors in making asset management decisions. In recent years, there is also a shift of public demand and supply towards more environmentally friendly products (Faith-Ell et al., 2006). As such, calculating the emissions and waste is useful to understand the environmental impact of a certain maintenance strategy and the effectiveness of green procurement can be evaluated (Guistozzi et al., 2012).

WHAT WILL BE PROPOSED

Asset management is a complex problem including the analysis of the trade-off between economic, performance and environmental parameters, based on which the most satisfactory and efficient solution will be sought (Pohekar and Ramachandran, 2004). Asset inherits both internal uncertainties (e.g. the deterioration of pavements) and external uncertainties (e.g. the availability of maintenance resources). Managing assets in a complex and uncertain environmental requires integration, because different situations require different solutions. In addition, integrated consideration ensures efficiency because only what is needed (processes, tools, resources, etc.) is used (Fernandez and Fernandez, 2008). We therefore propose a multi-criteria decision making tool to integrate life cycle cost, performance and environmental considerations.

RESEARCH METHOD

LIFE CYCLE COST

In this section, user benefit and cost will be included in the life cycle cost model. User benefit is usually measured by the reduced travel time (Jong and Bliemer, 2015). A comprehensive review of potential sources of user benefit will be conducted. Mathematical models, which incorporate all sources of user benefit due to improved pavement, will be developed. Previous studies on calculating user benefits, e.g. the value of time (VOT) model developed by Fosgerau and Hjorth (2007), will be useful for this project. The aggregation of all sources of user benefit will then be converted to the present value using a time-dependent annual discount rate.

Road user cost includes all the opportunity cost of travel rather than simply financial cost. Usually, road user cost includes travel time cost and vehicle operating cost (Thoft-Christensen, 2012). The mean value of such cost will be investigated using historical transportation data. For example, vehicle operating cost is highly related to a number of factors including speed and road conditions. There are four commonly used models, including the World Bank HDM – Road User Effect (RUE) model (see Bennett and Greenwood, 2001), the Texas Transportation RUC model (Daniels et al., 1999), the New Zealand vehicle operating cost model (Bennett, 2003) and the Cost Benefit Analysis (COBA) model adopted by England, Wales and Northern Ireland (UK Government, 2006). A new Integrated User Cost (IUC) model will be developed based on the vehicle operating cost model. The inclusion of specific user cost factors and the weighting of each factor in an Australian context will be investigated to develop the new IUC model. It will also integrates externalities, such as accident costs (see Liu and Xia, 2015). This will transform the cost-based methodology into a more holistic methodology.

ROAD PAVEMENT PERFORMANCE

Road pavement performance explores how well the data provided in the pavement performance prediction model represent the reality of current conditions and how well the predictions of the model fit the real behaviour. It is based on the calibration of the two models used in predicting road pavement performance, including road user effect (RUE) and road deterioration and works effect (RDWE) model.

The calibration of both RUE and RDWE models is based on a three-step procedure. A full review of the deterioration models, such as the models used in HDM-4, dTIMS and those developed by Austroads, will be conducted at the beginning of the project. This review will also identify the current calibration process and investigate possible calibration coefficient for each factor from relevant studies (i.e. desktop research). A simulation will be adopted to test whether by simply applying these relevant calibration coefficients, the predicted condition will match the current condition. Sample pavement segments will also be selected to accurately calculate the calibration coefficients for each factor.

ENVIRONMENTAL IMPACT

This section explains how environmental impacts, such as emissions and waste generated from asset management plans can be integrated into the asset management model.

A life cycle assessment of carbon emissions will be conducted. This assessment will be carried out to assess the emissions from maintenance activities. All inputs that will generate emissions will be recorded. Conversion factors for each emissions source will be investigated. Australian-specific conversion factors are preferred and the investigation of these conversion factors will be conducted. For example, conversion factors for different engine types will be examined based on the technical specifications including brake specific fuel consumption, horse power, etc. (Zhang, 2015).

There are various sources of waste from maintenance. The sub-topic will firstly identify the waste streams from maintenance activities of road assets. The quantity of each waste stream will then be determined. Once the quantities have been determined, the expected volume of waste will be calculated. The expected volume of waste from each waste stream will be calculated using a conversion factor. The estimation of the conversion factor is based on a regression model which is developed by considering user experience, industrial standard and various databases.

MULTI-CRITERIA DECISION MAKING

The development of the computerised tool is based on a multi-criteria decision making process, which aims at evaluating the trade-offs among life cycle cost and benefit, pavement performance and environmental considerations. The trade-offs can be evaluated using fuzzy set theory (Zimmermann, 2010), Analytical Hierarchy Process (AHP) (Chen, 2006) or other multi-criteria decision making methods (Liu et al., 2014). The integrated life cycle assessment tool (hereinafter referred to as the tool) can provide the optimal maintenance strategy in many sets of scenarios, such as pavement segments with varied requirements on cost, performance and environmental considerations. Multiple Attribute Value Technique (MAVT), as Multiple Criteria Decision Making (MCDM) technique, aims to provide support for decisions concerning multiple attributes by developing a scoring system (Belton and Stewart, 2002). The technique has three steps: (i) ascertaining the importance weight of each attribute; (ii) rating an option against each attribute; and (iii) aggregating the weights with the ratings. MAVT was suitable for this study because it gives more consistent rakings and the scores derived from the

MAVT enable different types of structural frames to be ranked (Belton and Stewart, 2002).

CONCLUSIONS

This research will focus on establishing a new asset management model for road infrastructure which can capture the constantly changing requirements on economic, performance and environmental considerations. The proposed new model is expected to achieve a new maintenance management paradigm which can establish maintenance strategies that fit real behaviours and conditions of roads, achieve cost-effective maintenance and deliver environmental benefits. For asset owners or maintainers, the proposed approach can change the conventional methods of the road maintenance. Much more return on investment can be gained from the proposed approach. In the meanwhile, the technology provider can learn about the exact requirements among the business of road infrastructure maintenance and thus refine and improve the related technical supports to fulfil its market needs. Future studies will focus on the three industry problems as mentioned in the research agenda.

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MEASURING SUSTAINABILITY PERFORMANCE FOR A MULTIUNIT RESIDENTIAL DEVELOPMENT CASE STUDY IN SYDNEY

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ABSTRACT

Multiunit residential development numbers are on the rise close to Sydney Central Business District (CBD) as more people are choosing to live in apartments. Energy efficiency and water savings in these developments are significantly important to develop sustainable communities of future. This paper selects and examines a large multi-dwelling residential estate case study in an eastern suburb of Sydney, located approximately within eight kilometres radial distance from Sydney's CBD. Based on the electricity and water usage data, current electricity consumption for common areas and water usage for gardens are estimated. Three key sustainable options examined are: potential onsite renewable electricity generation from roof solar PV installation; techniques for reducing swimming pool heat loss and to maintain year wide adequate water temperature and roof rainwater harvesting potential. Associated costs are examined to comprehend useful energy and water efficient solutions. Recommendations suggest that solar PV installation, using an appropriate swimming pool cover and rain rainwater collection from the roof could meaningfully improve overall sustainability performance of the selected case study.

Keywords: energy efficiency; rain water; residential development; solar energy; sustainability

1 INTRODUCTION AND REVIEW

Ever increasing energy demand and depletion of finite resources on earth and their subsequent environmental, ecological and health impacts have raised significant concerns about the future of this planet. Climate change is one of the greatest challenges facing the world today. One of the initiatives to address climate change is to reduce greenhouse gas (GHG) emissions which are closely related to the consumption of fossil fuels. Australia is the ninth largest energy producer, accounting for 2.4% of world energy production and the world's 20th largest primary energy consumer (Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) 2011). Approximately 32% of the total energy produced was consumed locally with an annual growth of 1.7% for the next decade. Approximately 94% of the primary energy consumption in Australia is composed of fossil fuels and coal and oil remain the main fuels for Australian's energy production. The production of renewable energy has remained stable by about 6% (Department of Industry and Science 2015).

Energy production and use contributed about 68% of Australia's GHG emissions and is expected to grow to 72% by 2020 (Ding 2013). Buildings contribute to a large share of national and global GHG emissions. About 15% of GHG emissions from residential buildings are due to heating and cooling usage. In 1990, the residential sector contributed 43.4 mega tonnes of CO_2 and by 2050 emission from the residential sector will rise by 28.6% to 55.8 mega tonnes of CO_2 (ABARES 2011).

The energy consumption required for heating and cooling in residential buildings is a function of both climate and thermal performance of the building envelope which can be addressed during the design stage. However, new dwellings only contribute about 2% of the housing stock and 98% of existing dwellings will continue to be inefficient. Therefore, any energy efficiency improvements to the existing housing stocks will have a profound impact on the demand for fossil fuels and GHG emissions. Renewable energy generation is a long-term strategy and development of a robust industry because of higher cost compared to conventional fossil fuel electricity generation. Solar photovoltaic technology has become popular as it generates energy directly from sunlight. Australia has great potential for solar energy as Australia has on an average seven hours of sunshine each day (Bureau of Meteorology (BOM) 2016), which provides a perfect environment for developing solar power technology and has become an important alternate source of energy to residential buildings.

Following public interests for living in apartments close to in inner city, Sydney, a study had been conducted by Energy Australia regarding energy consumption in multi-unit residential developments (Myors, O'Leary and Helstroom 2005). Findings confirmed that despite of low energy consumption expected in multi-unit residential buildings, per capita energy consumption and subsequent GHG emissions is comparatively greater than detached dwellings (Myors et al. 2015). This outcome is mostly resulted because of inefficient energy usage in centralised heating and ventilation systems as well as in common area services such as, pools and underground car parks and lighting. Therefore, there is a huge potential for saving energy at a community scale.

Improvement in water management could also significantly decrease the water usage, using cost-effective measures (Green Strata 2015) and renewable water sources such as rain water. Zhang, Chen, Chen and Ashbolt (2009) estimated potential of rainwater harvesting in four cities, Sydney, Darwin, Perth and Melbourne in Australia. Out of these cities, Sydney is most suitable for applications of rain water harvesting practices (Zhang et al. 2009).

The importance of sustainability is now the forefront of planning, building and managing communities in cities and towns across the world. Developing appropriate policies and measuring progress towards sustainability have become increasingly important in building industry. In response to the growing priority for sustainable development, this paper selected and examined a large multi-dwelling residential estate as a case study in an eastern suburb of Sydney, located approximately eight kilometres from Sydney's Central Business District (CBD) and analysed how an existing multi-unit residential developments could be successfully retrofitted to implement sustainable technologies.

2 AIM AND OBJECTIVES

The aim of the paper is to recommend meaningful sustainable and effective technologies that are appropriate to reduce further energy use and water consumption in the existing multi-unit residential development. The main objectives of this paper follow.

- To measure current energy use in common areas such as basement, car parks, lobbies etc. and water heating for a swimming pool and water demand for gardens within this residential development.
- To estimate potential onsite renewable energy or electricity generation from roof solar PV installation;
- To explore techniques for reducing swimming pool heat loss and for maintaining adequate water temperature throughout the year and
- To measure roof rainwater harvesting potential for gardens and lawns.
- To recommend appropriate energy and water efficient onsite solutions and practices for reduction in current energy use and water consumption.

3 METHODOLOGY

The methodology focused on reducing the energy and water use in common areas consisted of mainly five steps.

(1) To collect data on actual electrical energy and water usage for common areas;

(2) To estimate of current energy use and water consumption and actual costs involved;

(3) To calculate onsite energy generation potential using solar PV on roof, technologies for swimming pool and water savings from roof rain water harvesting and associated approximate costs;

(4) To evaluate whether these technologies when applied could make meaningful differences or not to the community;

(5) To recommend appropriate and cost effective onsite solutions.

In this research, electricity and water usage assessments was based on current data. Electrical energy consumption for common areas included: lighting in basement car parks and lobbies, centralised hot water systems including circulation pumps, pool water filtration pump and heating. The water consumption data includes swimming pool top-up and water use for gardens and lawns. Potential onsite energy generation potential using roof solar PV panels, heat loss minimisation technologies for swimming pool and water savings from roof rain water collection possibilities from available roof areas as well as storing strategies were explored. Finally, costs for some of these technologies were examined to ensure the sustainability practices could deliver long-term reduced water and energy benefits for residents. Limitations of this methodology is that, at this stage, this research measured energy and water practices separately in this case study. Measuring the combined sustainability impacts of different factors as carbon or energy footprint values at a site scale would be more useful. Future research should focus on developing these aspects.

4 RESULTS

4.1 Energy use and solar energy potential for common areas

For this research project three years' electricity consumption were collected and analysed for the base buildings. There was no gas consumption for the base building. The purpose of analysing three year electricity consumption for the estate was to identify potentials and opportunities for renewable energy to offset electricity from the national grids. Figures 1 and 2 below demonstrate findings of the analysis. Electricity consumption and GHG emission were presented monthly for the three year period. These figures reveal downward trends in a similar pattern for the electricity consumption and GHG emissions in the past three years but there was a slight upward trend for the GHG emissions at the end of 2014. The downward trend for electricity consumption is likely related to the replacement of more energy efficient light fittings in the common areas since 2014. The figures did not demonstrate seasonal variations in the records as electricity is mainly consumed for providing lighting in the common areas inside and outside the buildings, basement carpark and tennis court. There was no heating and cooling required for the base building for the estate.

The monthly electricity consumption and GHG emissions were presented in an aggregated format in Table 1. The estate consumed approximately 690-790 kWh electricity and emitted approximate 1 tonnes of GHG per day for the past three years.

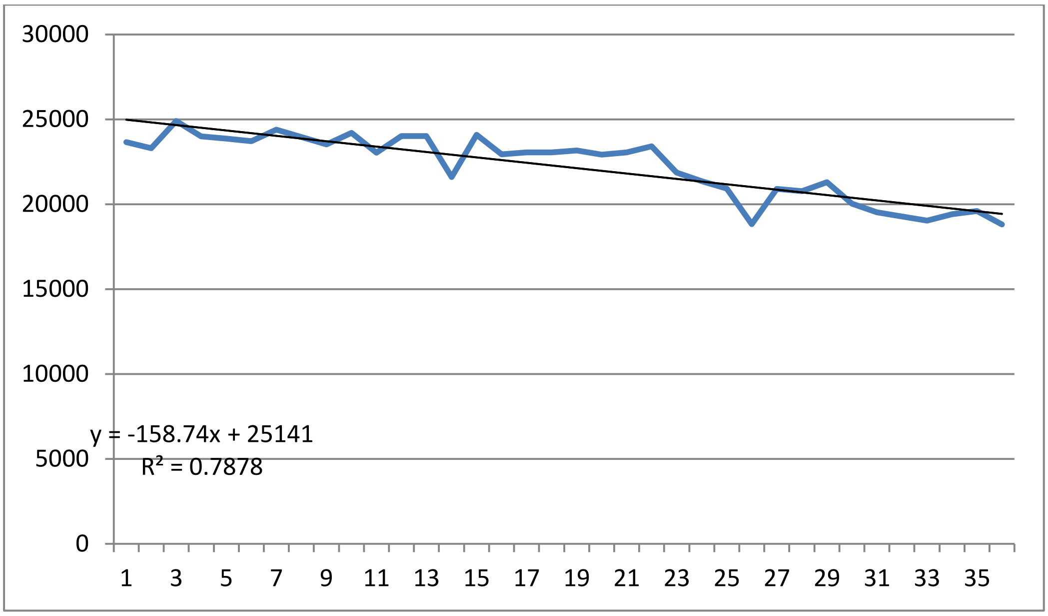

Figure 1: Monthly electricity consumption (Source: Prepared by the author)

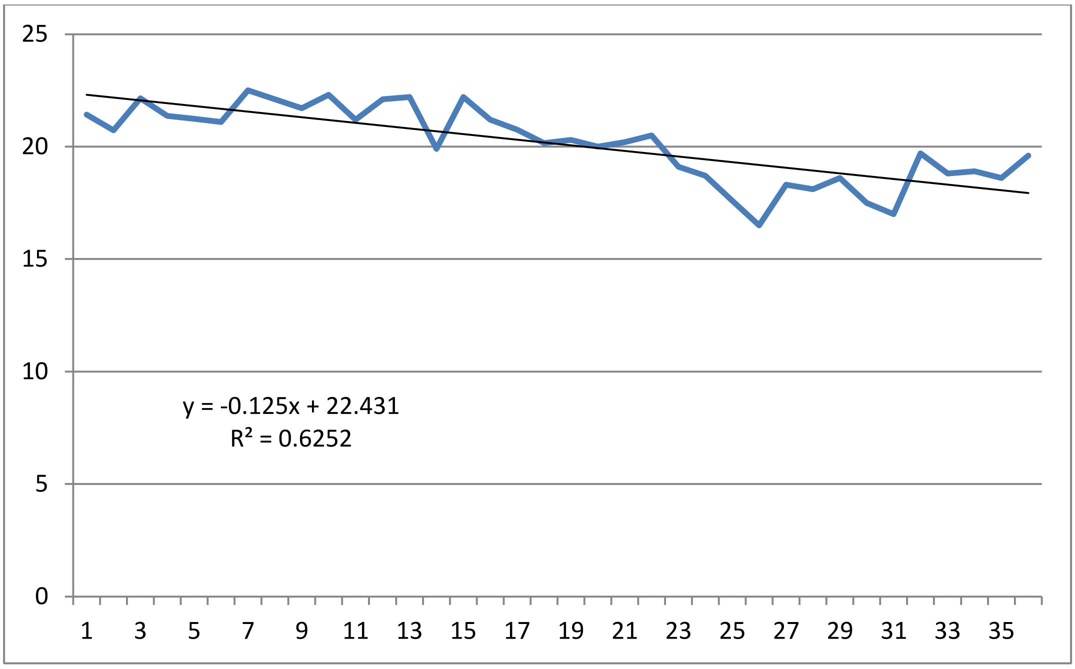

Figure 2: Monthly GHG emissions (Source: Prepared by the author)

There was no detail in the total number of occupants for the estate therefore these figures were not normalised per person of electricity consumption and GHG emissions in the study. Based on the monthly energy consumption an investigation was undertaken to explore potentials and opportunities for renewable energy sources to offset the electricity consumption from the national grid.

There were two possible renewable energy sources for estate: small-scale wind mill and photovoltaic panels. The installation of a wind mill will require council approval which can be complicated in the process and occupants are also concern with the aesthetic appearance of the estate should a will mill is installed. Therefore the will mill option was removed from the investigation and focus entirely on solar energy.

Table 1: Three years electricity consumption and GHG emissions

	2012	**2013**	**2014**
Electricity consumption (kWh)			
Total	286,500	274,500	254,100
Monthly average	23,875	22,875	21,175
Daily average	783	752	696
GHG emissions (tonnes)			
Total	260	245	219
Monthly average	22	20	18
Daily average	0.7	0.7	0.6

Currently the Federal Government offers financial incentives for solar power systems in two schemes: the Small-scale Technology Certificates (STCs) and feed-in tariff incentives. These incentives allow residential buildings to reduce the upfront construction costs of PV system. Firstly, STCs are in the form of an electronic currency which is equivalent to one megawatt-hour of electricity generated by solar PV system and the STCs can be traded in the market. Secondly, feed-in tariffs are related to the electricity generated by the PV system and extra electricity will be exported back to the grid.

Since the estate consumes approximately 700 kWh per day the strategy is to install 10 kW solar panels. The total cost is approximately $15,000 (including STCs subsidy) based on the current market prices. Each year the solar panels can generate approximately 14,600 kWh (based on average 40kWh per day from 10 kW solar panels) to offset the electricity required from the grid (Clean Energy Council 2016). An investment decision is based on net present value analysis (NPV) and payback period using the following
NPV formula:

$$NPV = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}$$

C_t = net cash flow expected at time period t
n = project life span
r = selected discount rate and t the time of the cash flow.

The analysis was undertaken on a life span of 15 years at a discount rate of 5%. The initial calculation was based on current energy rates of $0.25/kWh for an approximately of 14,600 kWh electricity generated by 10kW solar panels for the construction cost of $15,000. The NPV was positive of $22,886 and a payback period of just over 4 years.

4.2 Energy use and reduction potential for swimming pool

The temperature of water is the most important parameter, which determines the comfort in swimming pool (Somwanshi, Kumar, Tiwari and Sodha 2013). The most appropriate swimming temperature, according to the American National Red Cross (2009), is 25.6 degree centigrade (^{o}C) and 26^{o}C was adopted for this case study.

According to Czarnecki and CSIRO Division of Mechanical Engineering (1978), water temperature in a swimming pool, depends on the total heat loss from the water and total heat gain. It means that exact heat demand is determined by the difference between the total heat loss and the total heat gain.

According to US Department of Energy (DOE) (2016), from a swimming pool, 70% energy is lost by evaporation; 20% is by radiation and 10% is lost by other means. Suggested solutions are discussed below. Conduction through pool walls could be reduced by providing insulation while convection wind effects could be minimised by windbreaks or pool cover (Finn and Barnes 2007). Pool blanket could improve radiation effects, and both pool blanket and an enclosure could provide significant reduction in heat losses by evaporation (Watts 2005). A pool cover with good thermal properties would also stop heat losses through the fabric.

Outdoor pools can gain a significant amount of heat from the sun, by absorbing 75% to 85% of the solar energy striking on the pool surface (DOE 2016; DOE 2000).

Table 2 Average annual water loss from swimming pool in Sydney

Location	Annual evaporation loss of water (millimetres)	Water loss from a 70sqm unheated pool (litres)	Water loss from 70sqm heated pool (litres)	Evaporation loss saving by pool cover (mm)	Water savings from a 70sqm pool by a pool cover (litres)
Sydney	1400	98,000	196,000	1330	186.2

Source: Calculated by the author based on data from BOM 2015 and Yao, Zhang, Lemckert, Brook and Schouten 2010

The application of a 'Solar Pool Blanket' would heat the un-shaded outdoor pool by up to 8°C using solar energy. With a Pool Blanket, the usual pool heating system could extend swimming season (Table 2), and would not need to use nearly as much energy. This is because the water would be comparatively warmer to begin with and already insulated to prevent heat loss. Table 2 estimated average annual water loss in Sydney (BOM 2015; Yao et al. 2010). Table 3 predicted efficiency of using a pool cover for heat savings (BOM 2015; Francey, Golding and Clarke 1980).

Table 3 Extension of swimming season by using a pool solar cover

	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
No blanket	24.3	23.5	22.8	19.0	15.1	12.3	11.9	13.7	16.9	20.2	22.6	23.7
With blanket	29.9	28.2	27.4	22.3	17.8	14.6	14.5	17.0	21.1	25.6	28.7	29.5
	+3.9	+2.2	+1.4	-3.7	-11.8				-4.9	0.4	+2.7	+3.5

Source: Calculated by the author based on data from, BOM 2015 and Francey et al. 1980

4.3 Water use for gardens and roof rain water harvesting potential

Using GIS analysis, total roof area from the georeferenced aerial photographs was calculated to be equal to a total of 2726 sq. m. Assuming 80% of the roof would be available for rain water harvesting, available roof area was 2181 sq. m. Based on 2012-2015 water consumption data current annual water demand for gardens calculated to equal to 13,765 Kilolitres (kL). The daily water demand is 38kL and the daily water cost is approximately around $80.00. Approximate annual roof rainwater collection potential was calculated using the following formula (Ghosh and Head, 2009).

$$\sum_{n-1}^{i} R_v = \sum_{n-1}^{i} R_b X C_1 X (A_r/1000) - \sum_{n-1}^{i} R_b X (F_f/1000)$$

where R_v is total roof rain water collection volume in cubic metres, R_b is total building roof areas in square metres and $_i$ is the number of building roof areas in the development. C_1 is the constant equal to 0.9 assuming rest 10% of the collected rain water would be lost due to evapotranspiration. A_r is the mean annual rainfall data in millimetres for 2009-2014 for Sydney and F_f is the amount of water required for first flush diverters and is equal to 0.2 Litres/m² (Ghosh and Head, 2009).The potential is estimated to be equal to 2268 Kilolitres (kL) considering annual average rainfall data obtained from BOM (2015). This water could supply only 16.5% or 13,765 kL of current total water demand. If 2268kL of water could be harvested from roof, it could reduce approximately slightly less than $5000.00 of total current cost of reticulated water annually for gardens and lawns.

Potential convenient location of rainwater tanks would depend on the site layout and configuration. Rainwater collection would also be effected by the sizes of rain tanks available in the market. Two scenarios were considered using rain tanks of capacities (a) 20,000 litres in Scenario 1 and (b) 25,000 litres in Scenario 2. Calculations were conducted using 'Tankulator', an online tool developed by Alternative Technology Association (ATA), Australia for improving rainwater tank performance (ATA, 2015) and presented in Fig 3 and Fig 4.

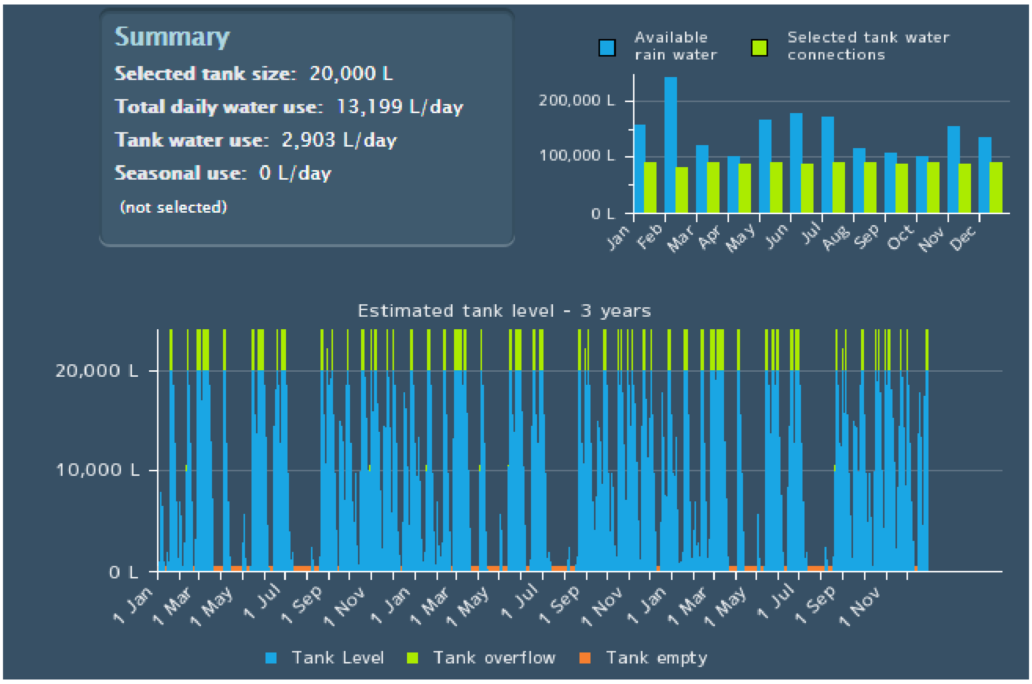

Figure 3: Scenario 1 annual water availability (20000 L rain tank)
Source: Calculated by the author using the tool at ATA, 2015

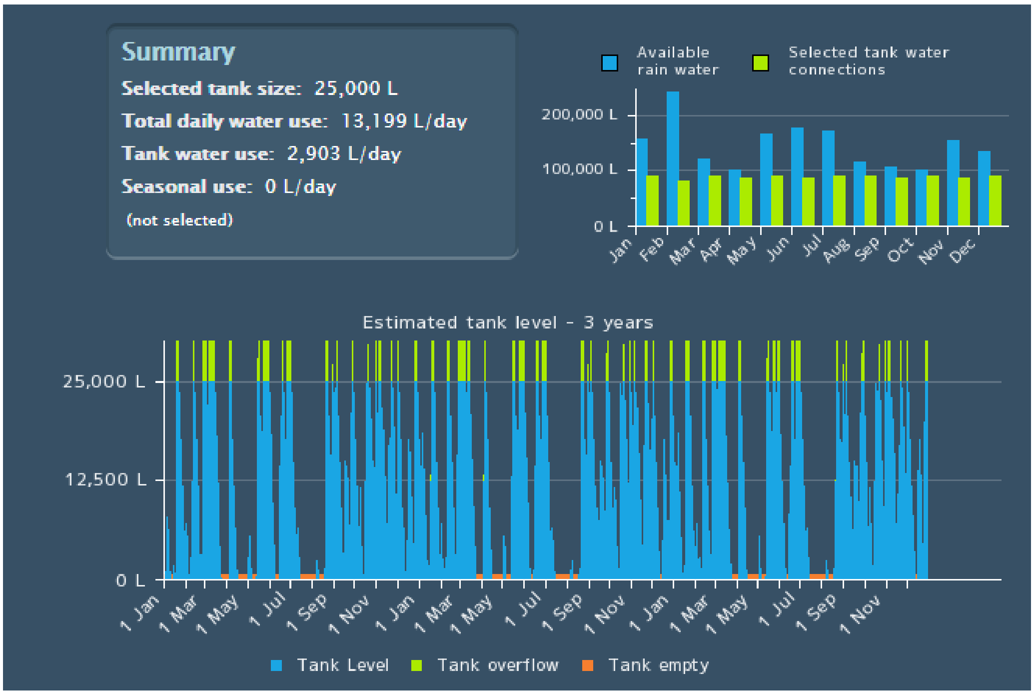

Figure 4: Scenario 2 annual water availability (25000L rain tank)
Source: Calculated by the author using the tool at ATA, 2015

In Scenario 1 (Fig. 3) 70% of days of the year rain water would be available for garden; approximately 1011kL of rain water would overflow in seasonal times and approximately 30% of the year water would be required from a reticulated supply for gardens. In Scenario 2 (Fig. 4) yearly rain water availability would increase to 75% of the days for the garden; approximately rain water overflow would be 957kL and approximately 5% less water volume would be required from a reticulated supply for gardens compared to Scenario 1.

Approximate annual surface rainwater on lawns and paved pathways were calculated using GIS methods. Total approximate area of lawns was equal to 1453 sq. m. and annually lawn areas would capture 1511kL of water. Similarly, paved pathways area was calculated to be a total 624 sq. m on which 649kL of rain water would fall annually. But part of this water would flow to the grass and flower beds although most of this water would flow back into the storm water system. Water from impervious pathways could be treated using water sensitive urban design technologies such as bio retention system, rain gardens and wetlands to reduce and treat the rain water before releasing to the storm water networks. This is not within the scope of this paper, therefore, further analysis is not included.

An advanced finding from this study is that sustainability performance of a multi-unit development should be estimated at a site scale considering unified impacts different sustainability factors. Equally important are sustainable energy and water practices applied in common areas in the base buildings as well as in areas under private ownerships such as, apartments and also in its public realm, such as, gardens, lawns, paths and swimming pools etc. Inclusion of all these factors in the sustainability performance assessment could generate better realistic solutions and positive contributions in retrofitting existing and designing new efficient multi-unit residential developments.

5 RECOMMENDATIONS AND CONCLUSIONS

The paper has examined the opportunities of PV systems for a multi-unit residential estate. The study has revealed that installing PV system is an ideal and feasible solution to reduce electricity demand from the grid so as to reduce GHG emissions. The paper has also reviewed the Australian government incentive schemes to promote the use of renewable energy sources. The research concludes that government policies on encouraging renewable energy by using incentive schemes have important impact to the uptake of renewable energy. The NPV and payback period calculations have revealed that PV systems are still expensive but feasible. Residential estate has great potential for PV systems and it will be more attractive to occupants in multi-unit estates if both local and federal government can provide greater incentives to subsidise the upfront installation cost so that it becomes more affordable to home owners in the future.

The paper recommends the use of solar pool covers on the basis of their capacity to: lowering or eliminating radiation and evaporation heat loss from the pool surface; decreasing in loss of heat through convection; reducing chemical use; reducing leaves and debris removal from the pool and providing further solar heating to heat the pool.

At this stage, rainwater harvesting from the roof would be a beneficial and an immediate solution for this multi-unit residential case study. There are sufficient spaces on the site to install adequate size rain tanks which could store collected rainwater and distribute. This rainwater collected used for gardens would reduce their annual water cost to a reasonable extent. Water sensitive urban design solutions would be useful for better storm water management but could be considered in future. The limitation of this study is that at an initial stage, detail cost assessment for pipelines for distribution of rain water from tanks to different parts of the gardens and rainwater features are not calculated. These would depend on rainwater tank types, materials for pipelines and other accessories. As this is the first paper in a series, the future publications would include all these details.

As investigated in this paper, solar PV installation, using an appropriate swimming pool cover and rain rainwater collection from the roof could meaningfully improve overall sustainability performance of the selected case study. The measurement methodologies developed in this case study could be applied to various multi-unit residential developments in other cities in Australia and in different countries with appropriate substitution of data. In future, more numbers of similar case studies would be investigated in Sydney and in other cities in Australia to develop an integrated energy and water sustainability model specifically applicable in multi-unit developments. More relevant sustainability factors, such as, potential of green infrastructure (e.g. trees), energy consumption within the apartments, water sensitive urban design applications and behavioural patterns of the residents could be added to this model. There are significant benefits associated with retrofitting existing and designing new community scale residential developments for improved sustainability performance. If the existing and emerging multi-unit developments adopt these sustainable practices, collectively they could contribute positively towards energy efficiency and water conservation in higher density cities.

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EXAMINING THE APPROACHES TO DIMINISH JUDICIAL INTERVENTION IN STATUTORY ADJUDICATION IN AUSTRALIA

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ABSTRACT

In Australia, statutory construction adjudication is a fast payment dispute resolution process designed to keep the cash flowing down the hierarchical contractual chain in construction projects. Its rapid, highly regulatory and temporarily binding nature have led to it being often described as a 'quick and dirty' process that delivers 'rough and ready' justice. Adjudicators often have to grapple with complex legal issues related to jurisdictional facts and interpretation of contract provisions, though the majority of them are not legally trained. This has often led to a poor quality of adjudication outcome for large and complex payment claims which has, in turn, led to a mounting dissatisfaction due to the many judicial challenges to adjudicators' determinations seen in recent years. The evolving tension between the object of the security of payment legislation and excessive involvement of the courts has often been the subject of comment by the judiciary. This paper aims to examine the legislative and judicial approaches to support the object of the security of payment legislation to ease cash flow. The paper adopts a desktop study approach whereby evidence is gathered from three primary sources – judicial decisions, academic publications and governmental reports. The paper concludes that there is a need to adopt other measures which can provide more convenient relief to aggrieved parties to an adjudication process, such that the adjudication process is kept away from the courts as far as is possible. Specifically, it is proposed that a well-designed expanded legislative review scheme of allegedly flawed adjudication, based on that provided in the Western Australian legislation, might stand as a promising remedy to eliminate the evolving tension.

Keywords: judicial review, remittal, review mechanism, statutory adjudication, severance

INTRODUCTION

Statutory construction adjudication is a fast-track payment dispute resolution process designed to keep the cash flowing down the hierarchical contractual chain on construction projects. Its rapid, highly regulatory and temporarily binding nature have led to it being often described as a 'quick and dirty' process that delivers 'rough and ready' justice. In the context of disputed payment claims for relatively small amounts of money for construction work carried out, it may be argued that such a nature is both appropriate as well as justified in order to protect a vulnerable class of smaller businesses within the construction industry. However, the eventuating 'one size fits all' coverage of the adjudication scheme has, anecdotally, resulted in a mounting swell of complaints and dissatisfaction with adjudication outcome of large and/or more complex cases. Adjudicators of such cases often have to grapple with complex legal issues and large volumes of submissions from the parties within very limited timeframes (typically two weeks) with limited investigative powers. Such dissatisfaction is manifest in the large amount of judicial challenges to adjudicators' determinations in recent years on grounds related to errors of law.

Since the enactment of legislation in Australia, a significant number of judicial review applications have been filed in the State Supreme Courts in relation to the security of payment legislation. According to the Society of Construction Law Australia (2014, p37), around 80% of adjudication determinations that were challenged in the courts in Victoria, Queensland and NSW were quashed in 2013. The report also identified the commons ground for quashing as breach of natural justice by the adjudicator; want of good faith by the adjudicator; want of jurisdiction of the adjudicator; actual or reasonable apprehension of bias by the adjudicator; and failure by the adjudicator to perform his or her essential role. This may justify the conducted investigations on the causes as well as the increased calls for reform to limit judicial review to reinstate the main intention of the legislation to provide quick and low cost relief to aggrieved parties.

Via a thorough desktop study approach whereby evidence is garnered from three primary sources – judicial decisions, academic publications and governmental reports – this paper aims to examine not only the diverse approaches in judicial review in dealing with determinations but also the main legislative approaches to ease the tension between the SOP object and court involvement.

BROAD APPROACH TO JURISDICTIONAL FACTS

The courts in the East Coast model jurisdictions have adopted a narrow approach when considering jurisdictional facts for the purpose of judicial review, which has led to the quashing of many determinations[1]. Accordingly, the Victorian Supreme Court has recognised that, "*critically, an adjudicator is given no express power in s 23 of the Victorian Act, or anywhere else in the Act, to decide facts which may go to his or her jurisdiction*"[2]. Notwithstanding this, however, the Victorian Supreme Court has also highlighted the drawbacks if a broad approach is not required by the legislation to be adopted by the courts when considering essential jurisdictional facts, other than those established in *Brodyn*, stating:

> "[*i*]*f the Act does make the jurisdiction of an adjudicator contingent upon the actual existence of a state of facts, as distinguished from the adjudicator's determination that the facts do exist to confer jurisdiction, in my opinion the legislation would not work as it was intended to. Unnecessary challenges to the jurisdiction of an adjudicator appointed under the Act would expose the procedures to delay, cost and expense. The very purpose of the Act would be compromised"*[3].

His Honour went on to propose:

> *"For these reasons, in my opinion, in order to serve the purposes of the Act, the intention of the legislation is to confer upon an adjudicator the capacity to determine facts which go to his or her jurisdiction, subject to exceptions of the type to which I have referred. It follows that, in making those determinations, the Act confers on adjudicators jurisdiction to make an incorrect decision in relation to such jurisdictional facts which will not be overturned by* certiorari" [4].

In Western Australia, the Supreme Court has been consistent in adopting a broad approach when dealing with jurisdictional facts under section 31(2)(a), considering the adjudicator's role to be analogous to an inferior court[5]. However, in the recent judgment of *Laing O'Rourke Australia Construction Pty Ltd v Samsung C & T Corporation*[6], Mitchell J, expressed his reservations about the broad sense approach which an adjudicator is empowered to authoritatively to determine.

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[1] See, eg, *Sugar Australia Pty Ltd v Southern Ocean Pty Ltd* [2013] VSC 535 at [66]; *Chase Oyster Bar v Hamo Industries* [2010] NSWCA 190.

[2] See *Sugar Australia Pty Ltd v Southern Ocean Pty Ltd* [2013] VSC 535 at [107].

[3] *Grocon Constructors Pty Ltd v Planit Cocciardi Joint-Venture* [2009] VSC 426 at [115].

[4] *Grocon Constructors Pty Ltd v Planit Cocciardi Joint-Venture* [2009] VSC 426 at [116].

[5] See, eg, *Wqube Port of Dampier v Philip Loots of Kahlia Nominees Ltd* [2014] WASC 331 at [78]; *Cape Range Electrical Contractors Pty Ltd v Austral Construction Pty Ltd* [2012] WASC 304 at [83].

[6] [2015] WASC 237.

The Society of Construction Law Australia (2014, p68) endorsed the broad sense approach and elaborated that:

> *The legislation might explicitly provide that an adjudicator must proceed to determine an application for adjudication if the adjudicator is satisfied on reasonable grounds that the application was made within any relevant time limits, rather than providing that the adjudicator must proceed to determine an application for adjudication if the application was (in fact) made within time. Decisions of adjudicators under the former type of provision would still be subject to a level of judicial supervision but would limit the availability of judicial review and discourage applications for judicial review*.

Whilst such recommendation looks promising on its face, it is argued that unless adjudicators are well experienced and legally trained in identifying jurisdictional matters, the risk of judicial review against errant adjudicators will remain high.

REMITTING JURISDICTIONALLY DEFECTIVE DETRMINATIONS

Australian case law has been inconsistent regarding the remittal of invalid determinations to the adjudicator. The Australian Capital Territory legislation includes a unique section which gives the Supreme Court express authority to remit adjudication decisions referred to it to the original adjudicator or a new adjudicator appointed by the court, for reconsideration with its opinion on the question of law the subject matter of appeal.[7] If an adjudication decision is remitted, the adjudicator must make the new adjudication decision within ten business days after the day the decision was remitted, or within a time period directed by the Supreme Court[8]. The ACT Supreme court exercised its remittal authority for the first time in *Fulton Hogan Construction Pty Ltd v Brady Marine & Civil Pty Ltd*[9]. In that case, Mossop AsJ found that the adjudicator made a manifest error of law which could substantially affect the legal rights of the parties and held:

> *"In my view it is appropriate to remit the adjudication decision to the adjudicator who made the original decision. That is because there will be cost and time efficiencies in having the original decision-maker reconsider the claim. I do not accept that the fact that the adjudicator has been found to have made an error of law is a reason for remitting the decision to a different adjudicator."*

In Victoria, despite the fact the Victorian Act is silent regarding remittal, the Victorian Supreme Court has nevertheless remitted several cases to

[7] *Building and Construction Industry (Security of Payment) Act* 2009 (ACT), s 43 6(b).
[8] *Building and Construction Industry (Security of Payment) Act* 2009 (ACT), s 43 (7).
[9] [2015] ACTSC 384 at [67] (Mossop AsJ).

the relevant Authorised Nominating Authorities for further remittal to the original adjudicator[10]. In *Maxstra Constructions Pty Ltd v Joseph Gilbert[11]*, Vickery J held that, where an order in the nature of *certiorari* is granted, the usual form of relief is to quash the decision (or part thereof) under review and remit it back to the tribunal for reconsideration according to law. In the recent case of *Plenty Road v Construction Engineering (Aust) (No 2)[12],* Vickery J examined whether the flawed determination should be remitted to the original adjudicator, or a different one, eventually deciding to remit the case to the original adjudicator to avoid delay in the process, since the original adjudicator was fully familiar with the case. Vickery J further asserted that "*minimisation of delay in the decision-making process promotes a central aim of the Act*"[13].

In NSW, the Act is also silent as to whether the court has power to remit erroneous determinations. However, an order under section 69 of the Supreme Court Act 1970 (NSW) in the nature of *mandamus* could be made, so that the court may order an adjudicator to reconsider an application and make a determination according to law. This possibility was discussed, *obiter* by McDougall J in *Trysams Pty Limited v Club Constructions (NSW) Pty Ltd*[14]. However, his Honour opined that "*there may arise cases where it would be inappropriate to make such an order, and more appropriate to leave the dissatisfied claimant to its rights under s26(2)*".[15]

Eventually, the NSW Court of Appeal, in *Cardinal Project Services Pty Ltd v Hanave Pty Ltd[16],* resisted the possibility of remittal. In that case, Macfarlan JA, with whom Tobias AJA agreed, pointed out that, by the time the adjudicator decided the matter after remittal, circumstances might have changed significantly from the time when the adjudicator was considering his original determination (eg the payment schedule may be outdated, other defects may have come to light and so on.). His Honour went on to say that the exemption of adjudicators' decisions under the Act from the scope of judicial review is a further indication of a legislative desire that the Act's mechanisms be quick, cheap and simple. Also, any remittal order would necessarily require the adjudicator to make a decision outside the time permitted by section 25(3), unless the parties agreed to an extension of time. Macfarlan JA further opined that:

> "[*i*]*f the legislature had adverted to the question of what should happen when a purported but void determination is issued pursuant to an adjudication application, it may have provided that that*

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[10] See *Maxstra Constructions Pty Ltd v Gilbert t/as AJ Gilbert Concrete* [2013] VSC 243; *Metacorp Pty Ltd v Andeco Construction Group Pty Ltd (No 2)* [2010] VSC 255.
[11] [2013] VSC 243 at [72].
[12] [2015] VSC 680.
[13] *Plenty Road v Construction Engineering (Aust) (No 2)* [2015] VSC 680 at [31].
[14] [2008] NSWSC 399 at [80]-[89].
[15] [2008] NSWSC 399 at [90].
[16] *Cardinal Project Services Pty Ltd v Hanave Pty Ltd* [2011] NSWCA 399 at [100-103].

application should remain on foot but be remitted to the original adjudicator"[17].

In Queensland, the Court of Appeal, in *Heavy Plant Leasing Pty Ltd v McConnell Dowell Constructors (Aust) Pty Ltd*[18], followed a similar position to that of Macfarlan JA, in which Muir JA, with whom Gotterson JA and Morrison JA agreed, held that "*the provision of such a remedy would be contrary to the quick, cheap and simple processes envisaged by the Act*". In *BM Alliance Coal Operations Pty Ltd v BGC Contracting Pty Ltd*[19], Muir JA, with whom Holmes JA and Lyons J agreed, stated that no arguments were raised by the parties on whether remittal to the adjudicator was legally possible and concluded that remittal is doubted to be a desirable option for that case. Wallace (2013, p224) also argued that any legislative amendment providing the court with an express power to remit the matter to the adjudicator or another adjudicator is not a preferable outcome.

SEVERANCE OF INFECTED PART OF DETERMINATION

Sometimes, a part of the adjudication decision may be infected by a jurisdictional error, which would, generally speaking, invalidate the entire determination. This rule has been criticised as it "*produced inconvenient consequences".*[20] However, in *Emergency Services Superannuation Board v Sundercombe,*[21] McDougall J, in an attempt to give indirect effect to an invalid determination, required the respondent to pay the amount unaffected by the error as a condition to set aside the adjudicator's determination. In *Cardinal Project Services Pty Ltd v Hanave Pty Ltd*[22], the NSW Court of Appeal held that:

> *"Such an approach has much to recommend it, particularly, it might be added, if the claimant is otherwise unable to pursue its original payment claim to achieve a second adjudication. However, such conditional relief can itself only be valid if it is designed to achieve a legitimate purpose".*[23]

In Victoria, it was judicially decided that severance is technically possible as a common law doctrine which helps attain the object of the legislation in some cases[24]. Wallace (2013, p224) explained the logic of allowing severance from a commercial perspective as "*the parties may have already expended significant costs on the adjudication and court processes. If the court is able to sever the affected part of the*

[17] *Cardinal Project Services Pty Ltd v Hanave Pty Ltd* [2011] NSWCA 399 at [97].
[18] [2013] QCA 386 at [67].
[19] [2013] QCA 394 at [87].
[20] *Sunshine Coast Regional Council v Earthpro Pty Ltd* [2015] QSC 168 at [73] (Byrne SJA).
[21] *[2004]* NSWSC 405.
[22] NSWCA 399 at [52].
[23] *Cardinal Project Services Pty Ltd v Hanave Pty Ltd* [2011] NSWCA 399 at [52].
[24] *Gantley Pty Ltd v Phenix International Group Pty Ltd* [2010] VSC 106 at [115-116]; *Maxstra Constructions Pty Ltd v Gilbert t/as AJ Gilbert Concrete* [2013] VSC 243 at [77].

adjudication decision then there will be significant cost advantages in doing so". As a result, Queensland amended its Act in 2014, introducing, *inter alia*, a new section which provides that:

> *"If, in any proceedings before a court in relation to any matter arising from a construction contract, the court finds that only a part of an adjudicator's decision under Part 3 is affected by jurisdictional error, the court may identify the part affected by the error and allow the part of the decision not affected by the error to remain binding on the parties to the proceeding"*[25].

In many other cases, the courts have emphasised that the legislation should be amended so as to permit so much of an adjudicator's decision as is not affected by jurisdictional error to stand[26]. Having said that, introducing such a provision within legislation, without sufficient guidance on how a court is to allow part of an adjudication decision, could bring many other difficult questions and valid concerns regarding its practicality and application. For instance, Davenport (2015, p8) argued: "*Is a breach of natural justice by an adjudicator a 'jurisdictional error' within the meaning of s 100(4)*"? However, it has been applied without issue.[27]

IMPROVING THE QUALITY OF ADJUDICATION OUTCOME

In the wake of such inevitable drift in the legislative intent where more adjudication determinations concerning large claims have been challenged successfully in court, the Queensland legislation was substantially amended in December 2014[28]. The amendments include, *inter alia*, allowing longer timeframes for adjudicators, as well as respondents, in complex cases and strict regulations to train and maintain competent adjudicators. To cope with the introduced changes, the legislation imposed mandatory transitional training upon all adjudicators, alongside the "legally oriented" mandatory training course[29]. That transitional training covers modules including the 2014 amendments, contract law, construction law, making and writing decisions, judicial ethics and natural justice, deciding jurisdiction, valuing work and legal principles. As such it was argued that with the longer timeframes, it becomes more difficult and costly for contractors to obtain progress payment. Appointing adjudicators where the government is party to adjudication, selection criteria of

[25] *Building and Construction Industry Payments Act* 2004 (Queensland), s 100(4).

[26] See, eg, *James Trowse Constructions Pty Ltd v ASAP Plasterers Pty Ltd* [2011] QSC 345, [57-[59]; *Thiess Pty Ltd v Warren Brothers Earthmoving Pty Ltd* [2012] QSC 373, [61]-[62]; eg, *BM Alliance Coal Operations Pty Ltd v BGC Contracting Pty Ltd (no 2)* [2013] QSC 67 at [35-37]; *Multiplex Constructions Pty Ltd v Luikens [2003] NSWSC 1140* at [90-92] (Palmer J); *Lanskey Constructions Pty Ltd v Noxequin Pty Ltd* [2005] NSWSC 963 at [21-22].

[27] See *Sunshine Coast Regional Council v Earthpro Pty Ltd* [2015] QSC 168, and previous excision prior to the BCIPA being amended is evidenced in *Hansen Yuncken Pty Ltd v Ian James Ericson trading as Flea's Concreting* [2011] QSC 327.

[28] See *Building and Construction Industry Payments Amendment Act* (2014), Act No. 50 of 2014 (Qld).

[29] See the Building and Construction Industry Payments Regulation 2004, schedule 1, part 2.

adjudicators, and imposing further training on adjudicators were also criticized for the Registrar's lack of probity (Davenport, 2015).

Despite these amendments in Queensland, however, the latest monthly report by the Queensland Building and Construction Commission in December 2015 revealed that there have been seven judicial review court applications between December 2014 and November 2015, (comparing to 15 applications in the preceding year), in which the Queensland Supreme Court found that adjudicators committed jurisdictional errors in three cases. The continuation of erroneous determinations indicates that the quality assurance measures may not be sufficient. On the other hand, the number of judicial challenges may further emphasise that many desperate respondents may always seek to knock on the door of judicial review as a gaming tactic in an attempt to delay payment regardless of the quality of adjudication outcome. Having said this, it may be too early to have any certainty as to the effectiveness of the recent amendments to the Queensland legislation.

INTERNAL REVIEW OF ADJUDICATOR'S 'DECISION TO DISMISS'

Under the Australian West Coast model, unlike all other jurisdictions, there is an express right of review by application in respect of an adjudicator's decision to dismiss without a consideration of the merits of the application on certain grounds. These grounds include that the contract concerned is not a construction contract, the application has not been prepared and served in accordance with the requirements of the Act, and the adjudicator is satisfied that it is not possible to fairly make a determination because of the complexity of the matter or the prescribed time or any extension of it is not sufficient for any other reason (See, eg, *Construction Contracts Act* 2004 (WA Act), s 31(2)(a)).

This review is carried out by the State Administrative Tribunal (WASAT) in Western Australia (WA) and by the local court in the Northern Territory (NT). The WASAT has jurisdiction to review the adjudicator's 'decision to dismiss' upon application by either party and the reviewed decision can be affirmed, varied, set aside, or sent back to the adjudicator for reconsideration, in accordance with any directions, or recommendations, which the WASAT considers appropriate.[30] If the decision is reversed and remitted, the adjudicator is to make a determination within 14 days after the date upon which the decision was reversed, or any extension of that time consented to by the parties.[31]

Judicially, it was decided that all grounds upon which a review is sought are jurisdictional facts.[32] In *O'Donnell Griffin Pty Ltd v John Holland Pty*

[30] *State Administrative Tribunal Act* 2004 (WA), s 29 (3).
[31] See Construction Contracts Act 2004 (WA), section 46 (2).
[32] See *Perrinepod Pty Ltd v Georgiou Group Building Pty Ltd* [2011] WASCA 217 [16].

Ltd,[33] Beech J held that the WASAT also has jurisdiction to review the adjudicator's 'decision not to dismiss'. To reach this proposition, Beech J examined the object of the WA Act and found that the review by the WASAT of an adjudicator's decision not to dismiss was *'more expeditious'*[34] and more consistent with the scheme of the WA Act than the '*slower and more cumbersome prerogative relief*'.[35] That proposition was eventually overturned by the Court of Appeal in *Perrinepod Pty Ltd v Georgiou Group Building Pty Ltd*,[36] in which the Court held:

> *…insofar as the Tribunal would provide a quicker avenue for relief, a right of review to the Tribunal where an application is dismissed is conducive to the statutory purpose of 'keeping the money flowing'. On the other hand, no evident statutory purpose is served by expediting a review of a 'decision' 'not to dismiss', with a view to rendering inapplicable the adjudication process facilitated by the Act.*

A review by the WASAT involves a hearing de novo on the merits in which material which was not before the decision-maker may be considered.[37] Apparently, there is an inconsistency between the *WA Act* and a hearing de novo. In *Marine & Civil Bauer Joint Venture and Leighton Kumagai Joint Venture,*[38] strict limitations have been imposed upon allowing new submissions before the WASAT and it was held: '*In my view, no new material should be permitted because, if the decision under review is reversed, and the matter referred back to the adjudicator, I consider that the adjudicator must remain bound to decide the matter on the material which was originally before the adjudicator*…'

Interestingly, the WA Act, section 46(3) provides that, except as provided as grounds for the limited review, a decision or determination of an adjudicator on an adjudication cannot be appealed or reviewed. The WA Supreme Court interpreted this section in *Red Ink Homes Pty Ltd v Court,*[39] stating that the provision only limits the appeal before the Tribunal, whilst judicial review will still be open for the aggrieved party. Furthermore, section 105 of the WASAT Act provides for an appeal to the Supreme Court from a decision of the WASAT, provided that the Court grants leave to appeal which is limited only on a question of law.

Since the commencement of the WA Act in 2005 until end of June 2015, the WASAT has reviewed 37 decisions of adjudicators dismissing applications without considering the merits. In 25 cases, the adjudicators'

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[33] [2009] WASC 19 (Beech J).
[34] [2009] WASC 19 [122].
[35] [2009] WASC 19 [131]. See Also, *Thiess Pty Ltd v MCC Mining (WA) Pty Ltd* [2011] WASC 80 [44] (Corboy J).
[36] [2011] WASCA 217 [129].
[37] State Administrative Tribunal Act (2004), s 27.
[38] [2005] WASAT 269 [70]-[71].
[39] [2014] WASC 52 [72]-[76].

decisions were upheld while, 12 cases (amounting to **37%)** were set aside or remitted to the original adjudicator to revisit the original decision to dismiss. Notably, the review applications before the WASAT have been constantly increasing over the years. Table (1) below demonstrates an extract from the relevant annual reports on the operation of the review mechanism from 2008 until 2015.

Table 1 Operation of the review mechanism of adjudicators' decisions to dismiss in WA[40]

Description	**Annual review applications by the WASAT**						
Financial year	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
No. of lodged applications	105	172	197	178	208	175	235
No of dismissed application by adjudicators for no jurisdiction.	25	57	57	40	74	47	52
No. of review applications by the WASAT	4	4	3	5	5	7	8
No. of remittal/set aside cases by the WASAT	0	0	0	2	1	3	2

CONCLUSIONS AND FURTHER RESEARCH

This paper has examined the main legislative and judicial approaches to diminish court involvement in the operation of the SOP legislation. The paper concludes that the examined approaches do not provide effective and practical measures, and there is a need to adopt other pragmatic measures that can provide a more convenient relief to either party aggrieved by the hasty adjudication process. This would help to confine adjudication process away from court and reinstate the object of the security of payment legislation to facilitate cash flow within the construction industry.

Moving forward, a well-designed expanded legislative review scheme of erroneous adjudication decisions on jurisdictional grounds might stand as a more convenient remedy. The lead Author is currently undertaking a further research as part of his PhD study upon the need, features and potential impact of such review mechanism throughout Australia.

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AUSTRALIAN SECURITY OF PAYMENT LEGISLATION: IMPACT OF INCONSISTENT CASE LAW

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Abstract

In Australia, a supreme court has a supervisory role over the statutory adjudication process that has been established within the security of payment legislation. In this role, the courts have quashed many adjudication determinations on the grounds of jurisdictional error in recent years. This is a problem as the courts' involvement in statutory adjudication is contrary to the object of the legislation. When reviewing adjudication determinations, the courts have adopted different approaches with respect to determining the role of adjudicators and the essential jurisdictional facts that must exist in order for an adjudicator to have jurisdiction to hear a referred disputed matter. This diversification of judicial interpretation with respect to jurisdictional error is confusing, not only to construction professionals, but also to many lawyers. Via a desktop study– where the evidence is mainly garnered from case law, governmental reports and commentaries – this paper reviews the legal complexities involved in diagnosing jurisdictional errors. In doing so, the paper aims to answer the question as to why the adjudication process has become bogged down in the quagmire of judicial review. The paper concludes that the evolving inconsistency of case law in relation to statutory adjudication is a crucial factor contributing to the erosion of the object of the security of payment legislation in Australia. Moving forward, the paper argues that establishing a legislative review mechanism of jurisdictional challenges may be sufficient to address this problem.

Keywords: judicial review, jurisdictional error, review mechanism, statutory adjudication, security of payment

1. INTRODUCTION

Statutory construction adjudication is a fast-track payment dispute resolution process that has been established within the Security of Payment (the SOP) legislation to keep the cash flowing down the hierarchical contractual chain on construction projects. Its rapid, highly regulatory and temporarily binding nature have led to it being often described as a 'quick and dirty' process (Wallace, 2013, P68:71) that delivers 'rough and ready' justice (See *Watpac Construction (NSW) Pty Limited v Austin Corp Pty Limited* [2010] NSWSC 168 at [127] per McDougall J). As such, adjudicators are always susceptible to make errors of law or fact. The supreme courts have a supervisory role over the statutory adjudication process. In this role, the courts have quashed many adjudication determinations on the grounds of jurisdictional error in recent years. This is a problem as the courts' involvement in statutory adjudication is contrary to the object of the SOP legislation. When reviewing adjudication determinations, the courts have adopted different approaches with respect to determining the essential jurisdictional facts that must exist in order for an adjudicator to have jurisdiction to hear a referred disputed matter. This diversification of judicial interpretation with respect to jurisdictional error is confusing, not only to construction professionals, but also many lawyers.

It is suggested that the court's inconsistent approach could be a result of lacunae within the SOP legislation. The drafters of the legislation may have not anticipated the risk of the court's involvement by way of judicial review where the court has no limitations in exercising its supervisory role. There is nothing in the legislation nor in case law that exhaustively defines jurisdictional facts that must exist in order for an adjudicator to have jurisdiction. This leaves the door always ajar for aggrieved parties to an adjudication determination to apply for judicial review on the basis that an adjudicator's error is jurisdictional in nature.

This paper initially reviews the real object of the legislation. The nature of errors in adjudication are then discussed, thereby revealing the legal complexities involved in diagnosing jurisdictional errors. In doing so, the paper aims to answer the question as to why the adjudication process has become bogged down in the quagmire of judicial review.

2. THE OBJECT OF SECURITY OF PAYMENT LEGISLATION

Understanding of the object of the SOP legislation will help justify the quick, rough and ready justice inherent in the adjudication process. Generally speaking, all Australian States have a consistent and express object of facilitating cash flow down the hierarchy of construction contractual chain through establishing a rapid and cost effective alternative scheme of resolving payment disputes compared to traditional lengthy and expensive avenues such as litigation and arbitration[1]. As such, any delay in releasing the due payment following an adjudication decision by challenging it in court will hinder the legislation attaining its object. In *Hickory Developments Pty Ltd v Schiavello (Vic) Pty Ltd [2009] VSC 156 at [46]-[47],* the Victorian Supreme Court mentioned the deficiency of the NSW legislation in achieving its object due to the vast amount of judicial review in a very short period of time, and stated: "*If the Victorian Act became prone to challenges founded on fine legal points, an important object of the Act would be defeated by the twin adversaries of cost and time*."

In Western Australia and the Northern Territory, the SOP legislation has an additional express object of determining the dispute fairly and as rapidly, informally and inexpensively as possible[2]. In *K & J burns Electrical Pty Ltd v GRD Group (NT) Pty Ltd [2011] NTCA 1* at [48], the court criticised the use of the some ill-defined notion of 'fairness' in the legislation because the court may be led into reassessing the merits of the decision in a manner which fails to draw a firm distinction between procedural and substantive unfairness. The design and purpose of the rapid adjudication process was well explained as "*a trade-off between speed and efficiency on the one hand, and contractual and legal precision on the other. Its primary aim is to keep the money flowing in the contracting chain by enforcing timely payment and sidelining protracted or complex disputes*."[3]

There is no reason to believe that the WA legislative intention of ensuring an expeditious, inexpensive, informal and fair adjudication process should be different from its counterparts in the Eastern States. In *Brodyn*[4], his Honour Hodgson JA at [31] explained the requirement of adjudicators to act fairly and noted at [51] that the intention of the SOP legislation is to resolve payment disputes with minimum of delay as well as minimum of opportunity for court involvement.

In Queensland, it was held that the Act "*emphasises speed and informality".*[5] Also, the requirements of natural justice under the SOP legislation were well discussed in *J Hutchinson Pty Ltd v Cada Formwork Pty Ltd [2014] QSC 63* which held at [50] that: *"There is nothing in the BCIP Act which would exclude the requirements of natural justice".* In Victoria, Vickery J considered procedural fairness and noted that:

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[1] See *Grocon Constructors Pty Ltd v Planit Cocciardi Joint Venture [2009*] VSC 426 at [33].
[2] See *Construction Contracts Act 2004* (WA) section 30*; Construction Contracts (Security of Payments) Act* 2004 [NT] section 26.
[3] See the Minister's Second Reading Speech (WA Hansard, 3 March 2004, 275).
[4] *Brodyn Pty. Ltd. t/as Time Cost and Quality v Davenport [2004] NSWCA 394.*
[5] *Minimax Fire Fighting Systems Pty Ltd v. Bremore Engineering (WA Pty Ltd)* [2007] QSC 333 at [20].

The procedures will call for adaptation in each case in the light of the clear legislative intention of the Act, namely that an adjudicator's determinations are to be carried out informally: s 22(5A); and speedily: s 22(4); and 'on the papers': ss 23 and 28I; and bearing in mind that there is always the facility for erroneous determinations to be corrected upon a final hearing of the issues in dispute between the parties: s 47(3).The legislative intention, in my opinion, points strongly to the position that, in approaching his or her task, an adjudicator's determination will only be brought into question if there has been a substantial denial of the measure of procedural fairness required under the Act.[6]

3. JURISDICTIONAL ERRORS IN STATUTORY ADJUDICATION

Errors made by adjudicators, that may possibly give rise to legal challenge, can essentially be categorised into two types: jurisdictional errors and errors of law on the face of the record. There are two types of jurisdictional errors in adjudication. The first type relates to the existence of essential jurisdictional facts upon which the validity of the adjudicator's appointment is founded, including the existence of a construction contract and duly made payment claim. Any error by an adjudicator in finding such facts will automatically invalidate the adjudication process and any emerging determinations from that process. The second type relates to the adjudication making process where the adjudicator may exceed his or her jurisdiction by, for instance, failing to give both parties enough opportunity to respond to any issues or relying on evidence not advanced by either party. Although errors of fact may be jurisdictional in nature, most errors of fact made by adjudicators are regarded by the courts as being non-jurisdictional for the simple reason that a high level of precision cannot be expected from such a rough and ready process. As stated by Vickery J:

"*An adjudicator charged with the making of an adjudication determination under the* Act *is entitled to make an error of fact and not have that decision reviewed judicially. This is sometimes described as the power to make a wrong decision*".[7]

Having said this, it needs to be recognised that certain errors of fact may give rise to jurisdictional errors by dint of the existence of the fact being necessary to enliven an adjudicator's authority to make a determination under the SOP legislation. As stated by the Supreme Court of WA, "*ordinarily, an error of fact does not give rise to a jurisdictional error and thus is outside the scope of the court's review power. Not so when a fact is jurisdictional. The court must be satisfied that a jurisdictional fact actually (objectively) exists*".[8]

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[6] *Grocon Constructors Pty Ltd v Planit Cocciardi Joint Venture (No 2)* [2009] VSC 426 at [143]-[144].

[7] *See Sugar Australia Pty Ltd v Southern Ocean Pty Ltd* [2013] VSC 535 at [9].

[8] *See Perrinepod Pty Ltd v Georgiou Group Building Pty Ltd* [2011] WASCA 217 at [11].

The law concerning the difference between jurisdictional errors and errors of law on the face of the record is notoriously confusing. As Vickery J states in the recent decision of *Amasya Enterprises Pty Ltd & Anor v Asta Developments (Aust) Pty Ltd*,[9] "*the difficulty in drawing a bright line between jurisdictional error and error on the face of the record is well recognised*".[10] Vickery J considered the question of what may amount to an absence of a jurisdictional fact by referring to *Chase Oyster Bar v Hamo Industries*,[11] where McDougall J observed that a 'jurisdictional fact' had previously been described by the courts as "*a criterion the satisfaction of which enlivens the exercise of the statutory power or discretion in question*".[12] Vickery J noted:

> *If the exercise of power is challenged on the basis that the jurisdictional fact does not exist, the court must itself inquire into the existence of that fact. It may grant relief against the exercise of jurisdiction if it finds that the jurisdictional fact did not exist. If on the other hand the legislature confers on the decision-maker the power to authoritatively determine the existence of a jurisdictional fact, the court may inquire into the decision-maker's decision that the jurisdictional fact exists, but it will not itself inquire into the existence of that jurisdictional fact*.[13]

The former approach (i.e. whether the jurisdictional fact actually existed) has been termed a 'narrow' judicial approach, whereas the latter approach (i.e. whether it was reasonable for the adjudicator to believe that the jurisdictional fact existed) has been termed a 'broad' judicial approach (Society of Construction Law Australia, 2014, p248). The courts in NSW and Victoria have considered that the "*proper approach to construction, where some fact is specified as a pre-condition to the exercise of jurisdiction by a court, is to regard it as a matter for that court to decide whether or not the fact exists, unless the statute clearly precludes that approach*".[14]

An error of law on the face of the record is generally held to be understood as an error contained within the pleadings and certified order made at the conclusion of the matter.[15] In the context of adjudication, this equates to the adjudication application, adjudication response, perhaps any further written submissions and comment thereto requested or permitted by the adjudicator and the determination itself.[16] It is

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[9] [2015] VSC 233.
[10] *Amasya Enterprises Pty Ltd & Anor v Asta Developments (Aust) Pty Ltd* [2015] VSC 233 at [74].
[11] (2010) 78 NSWLR 393 at [164] to [172].
[12] *Amasya Enterprises Pty Ltd & Anor v Asta Developments (Aust) Pty Ltd [2015]* VSC 233 at [83].
[13] *Amasya Enterprises Pty Ltd & Anor v Asta Developments (Aust) Pty Ltd* [2015] VSC 233 at [86].
[14] *Chase Oyster Bar v Hamo Industries* (2010) 78 NSWLR 393 per McDougall J at [172]; *Sugar Australia Pty Ltd v Southern Ocean Pty Ltd & Anor* [2013] VSC 535.
[15] *Kirk v Industrial Court (NSW)* [2010] 239 CLR 531 at [82]; *Amasya Enterprises Pty Ltd & Anor v Asta Developments (Aust) Pty Ltd* [2015] VSC 233 at [91] to [93].
[16] *Musico v Davenport* [2003] NSWSC 977 at [66].

possible for an error of law on the face of the record to be jurisdictional or non-jurisdictional in nature depending on whether or not it leads to an erroneous decision. Under administrative law, it is possible for the courts to make an order in the nature of the prerogative writ of certiorari in order to quash the impugned decision for either jurisdictional error or error of law on the face of the record,[17] which are considered separate and distinct bases for the making of such an order.[18] With respect to statutory adjudication, the courts have from the beginning to the present day taken a consistent approach in ruling that non-jurisdictional errors of law on the face of the record are not sufficient to warrant judicial review.[19] In other words, any errors of law made by an adjudicator acting within jurisdiction will not be amenable to judicial review. However, the court's approach to judicial review for jurisdictional error has not been so consistent.

4. THE EVOLVING INCONSISTENCY OF CASE LAW

In the first case to consider whether judicial review was available to challenge an adjudicator's determination – *Musico v Davenport* [2003] NSWSC 977 – the NSW Supreme Court applied the same scope of judicial review to adjudicators as that previously applied by the High Court of Australia to administrative tribunals. As such, it was held that where an adjudicator falls into an error of law that causes him or her to make an erroneous finding or to reach a mistaken conclusion, jurisdictional error could occur. As McDougall J stated at [46]: "*In some cases, an error of law may lead to jurisdictional error, although the distinction between jurisdictional and non-jurisdictional errors of law is easier to state than to apply*". As such, in *Musico,* the Court held that patent errors of law made by the adjudicator, that led to him failing to value the payment claim in accordance with the relevant provisions of the contract as required by the SOP legislation did amount to jurisdictional error. *Musico* was subsequently followed in several decisions.[20]

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[17] It has been held that whilst State Parliaments cannot legislate to take away from State Supreme Courts their power to grant relief for jurisdictional error, State Parliaments can deny State Supreme Courts relief for non-jurisdictional error appearing on the face of the record. This is due to the federal constitutional roots of judicial review for jurisdictional error. See Kirk v Industrial Court (NSW) [2010] 239 CLR 531 at [99] to [100*]; Amasya Enterprises Pty Ltd & Anor v Asta Developments (Aust) Pty Ltd* [2015] VSC 233 at [94](f).

[18] *Amasya Enterprises Pty Ltd & Anor v Asta Developments (Aust) Pty Ltd* [2015] VSC 233 at [72].

[19] *Musico v Davenport* [2003] NSWSC 977 at [54] (McDougall J); *Brodyn v Davenport* [2005] NSWCA 394 at [51] (Hodgson JA*). In Musico* at [54], McDougall J referred to section 25(4) of the NSW Act as evidence of Parliament's intent that review on the basis of non-jurisdictional error was not to be permitted. Section 25(4) prohibits a respondent from challenging an adjudicator's determination in any proceedings initiated by the respondent to set aside an adjudicator's determination which has been filed by the claimant as a judgment for a debt in court.

[20] *See, eg, Abacus Funds Management v Davenport [2003] NSWSC 1027; Multiplex Constructions Pty Ltd v Luikens [2003] NSWSC 1140; Quasar Constructions v Demtech Pty Ltd [2004] NSWSC 116.*

The tide turned, however, in the NSW Court of Appeal's 2004 decision in *Brodyn Pty Ltd v Davenport* [2004] NSWCA 394, in which the NSW Court of Appeal found that relief in the nature of the prerogative writ of certiorari was not available for adjudicators' determinations. Hodgson JA found at [54]-[55] that, given the legislative intent, the jurisdictional error approach "*has tended to cast the net too widely*", and that exact compliance with the more detailed requirements of the Act was not essential to the existence of a determination. Hodgson JA instead preferred the approach that an adjudicator's determination would be considered valid unless it had failed to meet one of the essential pre-conditions for the existence of an adjudicator's determination under the Act; a bona fide attempt by the adjudicator and no substantial denial of the measure of natural justice, in which case the determination would be void, and, therefore, relief would be available by way of declaration or injunction, without the need to quash the determination by way of an order in the nature of certiorari. Thus, in *Brodyn*, the Court held that relief was not available where an adjudicator had erroneously determined a payment claim (one of several made after contract termination) that should have been found invalid in accordance with the contractual provisions which permitted only one payment claim to be made after termination. This approach significantly curtailed the scope for an adjudicator's determination to be set aside.

Brodyn held as a good law for a period of around five years until the judicial approach once again changed tack, almost turning full circle, by the authority of *Chase Oyster Bar v Hamo Industries* [2010] NSWCA 190, to a position where jurisdictional error with relief in the form of the prerogative writ of certiorari was re-established in NSW as the basis for judicial review. The catalyst for this reinstatement of jurisdictional error was the High Court's finding in *Kirk v Industrial Court (NSW)* (2010) 239 CLR 531 (*Kirk*). In that case, it was held at [100] that: "*Legislation which would take from a State Supreme Court power to grant relief on account of jurisdictional error is beyond State legislative power".*

In *Chase Oyster Bar v Hamo Industries*, the NSW Court of Appeal considered whether an adjudicator had power to determine an adjudication application not made in compliance with s 17(2)(a) of the SOP Act. In that case, Spigelman CJ observed at [5] that "*the process of adjudication… is a public, relevantly a statutory, dispute resolution process, and as a consequence is subject to the supervisory jurisdiction*". McDougall emphasised at [149] that: "*The decision in Brodyn appears to assume that there is a distinction between a basic and essential requirement for the existence of an adjudicator's determination and a jurisdictional condition, or jurisdictional fact*." His Honour went on to conclude that: "*the requirement of s 17(2)(a) are jurisdictional, in the sense that the giving of notice within the requisite period is a condition that must be satisfied for a valid application to be made pursuant to s 17(1)*". As such, it was held that an incorrect finding by the adjudicator that an adjudication application had been given within the time limit prescribed by section 17(2)(a) of the *NSW Act* was vitiated with jurisdictional error. Post *Chase*, the courts, broadly speaking, have shown little appetite to broaden the opportunities to challenge adjudication determinations too far beyond *Brodyn* and *Chase*.[21] In contrast to *Musico*, for example, the Court held in *Clyde Bergemann v Varley Power* [2011] NSWSC 1039 that an adjudicator who had fallen into error by failing to correctly apply the relevant contractual provisions in order to calculate the amount of a progress payment had not fallen into jurisdictional error.

In 2015, the NSW Supreme Court of Appeal in *Lewence Construction Pty Ltd v Southern Han Breakfast Point Pty Ltd* [2015] NSWCA 288 *(Lewence)*, overturned the trial judge's finding that the adjudicator's determination of a reference date was a finding of jurisdictional fact. The Court held that the question of whether a 'reference date' has occurred, which gives rise to an entitlement to a progress payment under the SOP Act, is not a matter that the court can quash an adjudication determination over if the adjudicator gets it wrong.[22] This means that the existence of a reference date is not an essential pre-condition for having a valid payment claim, thus it is not considered as a jurisdictional fact. This decision not only overrules many previous authorities in the NSW,[23] but also completely inconsistent with the position of the Queensland courts[24] . Two months after the decision in *Lewence*, the Victorian Supreme Court of Appeal in *Saville v Hallmarc Constructions Pty Ltd* [2015] VSCA 318 handed down its decision which was completely in contrary to *Lewence* authority. In that case, the court upheld the decision of the trial judge (Vickery J) who held that the reference date fixed by the adjudicator under the Act was wrong and that as a consequence the adjudicator ought not to have assumed jurisdiction and the adjudication determination is of no legal effect.

In Western Australia (WA), the Supreme Court has been consistent in adopting a broad approach when dealing with jurisdictional facts under s 31(2)(a), considering the adjudicator's role to be analogous to an inferior court.[25] However, in the recent judgment of *Laing O'Rourke Australia Construction Pty Ltd v Samsung C & T Corporation* [2015] WASC 237*,* Mitchell J, expressed his reservations about the broad sense approach which an adjudicator is empowered to authoritatively determine. The

[21] *See, eg, Bauen Constructions Pty Ltd v Sky General Services Pty Ltd* [2012] NSWSC 1123 (Sackar J) where the court held that the adjudicator committed jurisdictional error for, inter alia, failure to consider compliance with s 13(4).

[22] [2015] NSWCA 288 per Ward JA at [60], [93]; Emmett JA at [119]; Sackville AJA at [133].

[23] *See, eg, Patrick Stevedores Operations No 2 Pty Ltd v McConnell Dowell Constructors (Aust) Pty Ltd [2014] NSWSC 1413; Omega House Pty Ltd v Khouzame [2014] NSWSC 1837.*

[24] *See Lean Field Developments Pty Ltd v E & I Global Solutions (Aust) Pty Ltd* [2014] QSC 293.

[25] *See, eg, Wqube Port of Dampier v Philip Loots of Kahlia Nominees Ltd* [2014] WASC 331 at [78]; *Cape Range Electrical Contractors Pty Ltd v Austral Construction Pty Ltd* [2012] WASC 304 at [83].

judicial reviews in WA have often been contained to a consideration of an adjudicator's decision to dismiss or not to dismiss an adjudication application under sections 31(2) and 46 of *the Construction Contracts Act 2004* (WA). The proposition that the adjudicator in WA has an authority to decide questions of law authoritatively and wrongly[26] held as a good law until the Supreme Court handed its decision in *Laing O'Rourke Australia Construction Pty Ltd v Samsung C & T Corporation* [2015] WASC 237. In that case, the scope for challenging adjudicator's determinations was broadened as the Court held that that the adjudicator committed a jurisdictional error when determining a payment dispute other than by reference to the terms of the construction contract which are before him.

5. THE CONSEQUENCES OF INCONSISTENT CASE LAW

As demonstrated above, the Supreme Court judges including those within the same jurisdiction have been inconsistent in their approaches to defining jurisdictional facts upon which the jurisdiction of adjudicator can be determined. As a result, the examination of the dynamic case law generated in connection with adjudication indicates that deciding upon jurisdiction becomes a more challenging task for adjudicators. Drawing a line to identify the boundaries of jurisdictional facts is not without difficulty. Indeed, the existing case law so far suggests that many adjudicators (whether legally trained or not) continue to make mistakes in deciding upon jurisdictional matters. To ensure that adjudicators maintain an up-to- date knowledge of the evolving case law may be an unattainable goal unless a strict and well-regulated continuous professional development (CPD) requirement is mandated.

It is submitted that even smart and well experienced lawyers advising parties on adjudication matters have become more uncertain nowadays than any time before regarding the likely approach that the court may take in dealing with any untested area of the SOP legislation. This unpredictability means that claimants relying upon a favourable adjudication determination may do so at their peril. A claimant who, for example, exercises their statutory rights to suspend works subsequent to the non-payment of an adjudication decision by a respondent, or a claimant who has to defend the soundness of an adjudication determination in their favour which has been challenged by way of lengthy judicial review, may end up in a serious trap potentially endangering the financial survival of their business.

This situation has indeed deterred many parties from using the statutory adjudication platform, instead preferring other traditional avenues although they be more expensive and lengthy. This is because the uncertainty and lack of finality of adjudication determinations, especially for large payment claims, has made the adjudication process and

[26] *See O'Donnell Griffin Pty Ltd v John Holland Pty Ltd* [2009] WASC 19 at [102].

subsequent enforcement proceedings more akin to curial proceedings in terms of time and cost concerns. Accordingly, the SOP legislation becomes not only more inaccessible to many vulnerable firms, but also more inconvenient as engaging legal counsel, in order to advise on complex issues and ensure the chances for success, becomes a necessity.

6. CONCLUSION AND FURTHER RESEARCH

This paper has examined the evolving tension between the object of the SOP legislation and the supervisory role of supreme courts. In doing so, the legal complexities and judicial inconsistencies in dealing with jurisdictional errors have been discussed. The paper concludes that the inconsistency of case law has increased the parties' uncertainty about the finality of adjudication determinations – this, it is proposed, is a key significant factor contributing to the erosion of the object of the SOP legislation in Australia.

Moving forward, reform is needed to address this serious problem. An example of one approach that could be taken to tackle the problem is to amend the SOP legislation such that essential jurisdictional facts that must exist in order for an adjudicator to assume jurisdiction are exhaustively listed with finer procedural matters being left for adjudicators to decide upon. Alternatively, another suggestion is that jurisdictional challenges be separated from the merits of the dispute, so adjudicators can only deal with the real dispute as many adjudicators lack the legal training and knowledge to adequately deal with complex jurisdictional matters. As such, any jurisdictional challenges should be dealt with in parallel by establishing a legislative review mechanism via a quick, informal and cost effective process by competent tribunal who has the jurisdiction to consider questions of law. Such an arrangement it is proposed would not only ensure a better certainty in adjudication outcome, but also discourage the parties from turning to the judicial system. As stated in *Re Graham Anstee-Brook; Ex Parte Mount Gibson Mining Ltd* [2011] WASC 172 at [64]:

> *Availability of prerogative relief will be undermined by circumstances where parties could avail themselves of alternative remedies by way of rehearing, appeal or review. Circumstances where parties have been granted and hold alternative review options bear upon the availability of prerogative relief as a matter of discretion.*[27]

The lead author is currently examining the need and features of such review mechanism via an empirical research as part of his PhD study.

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[27] See Also*, the High Court's decision in The Queen v Cook; Ex parte Twigg* [1980] HCA 36 [29], [30] and [34]*; Re Baker; Ex parte Johnston* (1981) 55 ALJR 191 *and Martin CJ in Re Carey; Ex parte Exclude Holdings Pty Ltd* [2006] WASCA 219 at [128] - [140].

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AN ACCOUNT OF FACTORS THAT CONSTRAIN THE UPTAKE OF INNOVATIVE BUILDING TECHNOLOGIES IN SOUTH AFRICA

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ABSTRACT

With all the opportunities for Innovative Building Technologies (IBTs) as well as the advantages that IBTs present, they are still not as dominant in the general South African built environment as the conventional building technologies. Research problem statement: *What are the reasons for the low levels of uptake of Innovative Building Technologies, (IBTs) in South Africa?* IBTs have not been largely incorporated into construction. The purpose of the paper is to find out what the reasons are for the low uptake of IBTs and what the way forward should be in terms of current opportunities for infrastructure development. The paper's scope will incorporate the financial and institutional barriers preventing the implementation of IBTs in South Africa; the influence of current procurement and industrial regulatory framework as well as the factors that limit the use of IBTs by end-users. A desktop research method was used. Data was gathered in the literature review and semi-structured interviews with key experts in the field. The findings include the Nature of South Africa's building regulations, lack of specialised provincial budgetary arrangements, difficulty in meeting national building regulations, increased financial costs, inaccessibility to access loans, delayed payment processes of contactors and a largely poor perception of IBTs by end-users such as the inability to extend IBTs and perceived fragile nature are barriers identified by this research. Research is however still in progress. It is envisaged that improved client briefing, procurement choices, knowledge management and change management will be needed to break the barriers to Innovation.

Keywords: Alternative Building Technologies, Construction Innovation, Innovation Barriers, Innovative Building Technologies

INTRODUCTION

According to Bloom & Goldstein 2014, in 2013, the global building stock was 138.2 billion m², of which 73% was in residential buildings. It is forecasted that the commercial and residential segments will experience compound annual growth rates in the next 10 years of 2.1 % and 2.2% respectively. Overall it is projected that the total building stock will grow to 171.3 billion m² at a rate of 2.2% over the next decade. There clearly is a demand and could this demand be satisfied through the application of Innovative Building Technologies (IBT's)?

Innovative Building Technologies (IBTs) are a variety of innovative materials and systems that aim to provide better outcomes than the traditional building materials and systems. Like other countries, IBTs are commercially available in South Africa. However to date there has not been a large scale utilisation of IBTs. The paper will provide a deeper understanding of the reasons why there is a lack of large scale implementation of IBTs country wide. Investigating the reasons why there has been a low uptake of IBTs in South Africa requires an exercise in setting the scene. One has to appreciate the large scale of variables concerned. A considerable part of the setting is on a national scale.

The Frascati Manual of 1963, the Bloomberg Innovation Index as well as the European Community Innovation Surveys are tools that are used commonly when measuring innovation on a political level. According to the 2014 Bloomberg Innovation Index, South Africa lies 49th in the world in terms of overall standings on innovation (SABS, 2015). The Bloomberg index takes into account various elements of innovation namely: patents, innovation personnel, education on innovation, high-tech companies, manufacturing as well as research and development.

Innovative Building Technologies, IBT, are defined as the materials and technologies not covered by building standards in the National Building Regulations and Building Standards Act 193 of 1977. Such IBTs, require either a rational design or an Agrément certificate. The phrase 'Innovative Building Technologies' covers alternative construction methods and materials, green building and alternative building systems and technologies (CSIR 2013).

According to Adell and Wekesa 2011, Agrément South Africa has issued over 430 certificates of which approximately 75% have been awarded to Innovative Building Technologies.

Opportunities for IBTs in South Africa

South Africa's pending massive infrastructure roll out

The South African construction industry presents several opportunities for IBTs in South Africa. According to IMIESA 2015, the minister of the

Department of Human Settlements has committed to build 1.5 million houses worth R250 billion in five years (by 2019) as detailed in the social contact for the development of human settlements. It consists of bond investments by banks, rental accommodation developments by the private sector and agencies, government subsidies, housing investments by mining companies as well as other employers, bulk services, upgrading of current community infrastructure such as schools and libraries as well as informal settlement improvements. Additionally, according to National Treasury 2014, the National Development Plan NDP has committed to public infrastructure investment of R 847 billion over the next three years. The private sector in turn has committed to invest R120.2 billion into projects under the Renewable Energy Independent Power Procurement Programme. According to De Villiers 2012, government realised that the current roll out of 3 million RDP houses over the past 18 years based on conventional building methods is simply not sustainable and that alternative means of rolling out RDP housing needs to be looked into.

Increased competitiveness

Construction innovation is a sought after advantage as it gives firms a competitive edge over their competitors in the construction industry. According to Akintoye et al. 2012, enterprises operating in the construction industry disburse a significant amount of resources in an effort to obtain various forms of innovation so as to increase their competiveness. Akintoye et al, 2012, further reveals that competitiveness of construction enterprises is inevitably linked to the national and regional systems of innovation in a country, which in turn depends on government policy.

Negative characteristics of the conventional methods of building

According to Akintoye et al.,2015, the current construction cycle is characterised by negative traits including: erratic supplies which results in erratic delivery, dependence on skilled labour, slow delivery of product, waste, inconsistent quality, an unpredictable cash flow as well as increased cost.

Increased quality

Reports from the National Home Builders Registration Council and (NHBRC) the Construction Industry Development Boards and the public protector reveal that there are legitimate complaints of quality issues with conventional building methods. According to Stats SA 2009, in 2009, more than 30% of households occupying state-subsidised/RDP housing both in the Eastern Cape and in the Western Cape, reported problems with quality of the roofs and walls. There is thus room for improvement and that is where IBTs can fit in.

Proliferation of slums and urbanisation

Proliferation of slums and rapid urbanisation are one of today's global and national problems. There is a need to solve this problem.

Job creation

The use of IBTs by certain companies is proving to be an effective job creation source. Unskilled labour can be used and the training duration is usually short term. However the issue of job creation is a highly debatable topic. Currently, the construction sector is known as a labour intensive industry especially when building with traditional building methods. One may argue that the use of IBT's may reduce the total construction workforce, as most of these building methods are mass produced in a controlled factory environment, leading to an increase in unemployment.

Rationale for IBTs in South Africa

IBTs facilitate the speedy delivery of the product

According to the Gauteng Department of Infrastructure Development (GPDID) 2015, the utilisation of Innovative Building Technologies in the construction of schools is twice as fast as with conventional methods. While conventional methods usually take one and a half years to complete a school, building with Innovative Building Technologies take 6 months to complete. The main reason for the significantly reduced construction time is due to the implementation of an Innovative Building Technology as a turn-key solution. Many IBT companies have very impressive turnaround times.

IBTs promote environmental sustainability

According to Baumert, 2005, manufacturing processes for conventional building materials namely: cement and steel, contribute to over 9% of the world's carbon dioxide emissions. Bloom & Goldstein add that commercial, residential, and industrial buildings are responsible for 47% of global greenhouse gas (GHG) emissions and 49% of the world's energy consumption (Van Wyk 2014). IBTs aim to reverse this trend by delivering products that conserve and renew energy.

IBTs facilitate construction developments in remote places

According to Inside Mining 2013, a big challenge of building construction in Africa is construction in remote locations. The logistics of getting the products to site easily and safely becomes a critical factor when the site of the building construction is in a remote region. In such cases the cost of transport is often higher than the cost of the material. This means that the number of square metres of finished building per truck becomes the ultimate measure.

Proof of low uptake of IBTs

In order to investigate the low uptake of IBTs in South Africa, the suitable point of departure is from 1994 which was the dawn of the new dispensation in South Africa. It was during this time that the then department of housing was instituted with a vision to have a nation housed in sustainable human settlements, which was informed by sentiments from the Freedom Charter. According to the Department of Human Settlements 2011, between 1994 and 2010 about 2.8 million housing units were delivered for low income earners. However only 17000 of these housing units were constructed using Innovative Building Technologies.

MAIN BODY

Information presented clearly indicates opportunities for IBTs, the rationale in using IBTs as well as proof that there is a low uptake in South Africa. One may question, why then is there a low uptake of IBTs in South Africa? The purpose of this paper is to address this by identifying the factors that limit the uptake of IBTs in South Africa. The authors have, identified institutional barriers, procurement barriers, financial barriers and end-user barriers for discussion.

Research Method

A desktop paper was done to address the identified reasons above. A literature review and interviews with some industry experts were carried out. The research is of an on-going nature and will later include interviews with industry experts as well as questionnaires to be completed by end users and decision makers.

Literature review

The paper sought to find out why there has not been a large scale utilisation of IBTs, although they are commercially available in South Africa. There are a number of reasons for this. Each of these findings were also categorised in a similar manner to the literature review. The findings in unison are the nature of South Africa’s building regulations, lack of specialised provincial budgetary arrangements for IBTs, difficulty in meeting national bureau of standards, increased financial costs, inaccessibility to access loans, delayed processes in payment of contactors and a largely poor perception of IBTs by end users. These are discussed in detail below.

Institutional barriers

South Africa's Building Regulations

The nature of South Africa's building regulations are both prescriptive and non-prescriptive (performance based). According to May, 2003, prescriptive regulations may have had the advantage of providing consistency, reliability and little room for error. However the same trait has the disadvantage of being restrictive and bureaucratic in nature allowing for little scope for construction innovation. On the other hand there are non-prescriptive regulations, Watermeyer & Milford 2003, identifying the South African National Building Regulations as a South African document having a non-prescriptive approach. The focus is on what the required level of performance a building should have rather than stipulations on how that level is to be achieved. Thus the regulations are in effect performance based regulations. An advantage of performance based regulations is that they are flexible, encouraging the diffusion of innovative materials and technologies.

However performance based regulations also have disadvantages. One of these is the difficult task of having to translate vague performance objectives into quantifiable performance criteria. Another weakness is that performance based regulation heavily depends on the professional judgment of the designer to accurately predict the performance of an IBT. Thirdly, performance based regulations are weak in terms of predicting durability. Fourthly, performance based regulations lack accountability. Fifthly, there is a general lack of critical assessment of the regulations. De Villiers, 2012 mentions that to increase innovative building technologies one should apply the performance based regulatory framework being careful to cater for all its disadvantages by having a robust regulatory framework and the right level and quantity of expertise to implement it.

If a non-standardised material or system is used in the building of a house the NHBRC prescribes that the material or system must be evaluated against performance based criteria or a competent person must submit a rational design of the system where non-standardised construction is one in which there are no standards, specifications or codes of practice or which are not referred to in the National Building Regulations (NHBRC,1999)(Act No.95 of 1998). Provinces are open to IBTs but one of the main things that inhibit provinces to procure IBTs is that procurement comes at a higher cost

Lack of specialised provincial budgetary arrangements or procedures for IBTS

Additionally, none of the provinces have special budgetary arrangements or procedures for the procurement of IBTs.

Innovators have difficulty in meeting the standards of the quality assurance processes from the NHBRC

According to IMIESA 2015, John Barnard, the director of the Southern African light Steel frame building Association, (SASFA), countries overseas such as the USA , Australia and the UK have many years of experience in using IBTs when constructing building with IBTs. In South Africa however, extra care should be taken to ensure compliance with specifications of IBTs. Barnard adds that Light Frame Steel Building (LFSB) as an IBT, is currently being used for different types of property. The LFSB industry is growing and an increasing number of larger companies are becoming involved. Barnard further states owners as well as architects should employ competent builders with trained employees

Procurement barriers

A delayed process in payment of contactors

There is not enough time to pay service providers due to the current payment procedures. The processes that the Gauteng Department of Infrastructure Development use has 60 steps before the supplier can receive remuneration for services rendered. This is a deterrent for the users of IBTs as it is a rigorous process for a service provider to receive remuneration.

According to Mokwena, 2014, flawed procurement processes and corruption are major causes of shoddy work in the construction industry, when government is involved. Mokwena reveals that the Public Protectors address to the portfolio committee on human settlements highlighted certain weaknesses with the Peoples' Housing Process (a government process in which beneficiaries are actively involved in decision making about their homes and contribute in part to their construction). She highlighted that there were planning inadequacies, procurement irregularities (corruption and fraud).

Poor inspection practices

She also noted that municipal inspectors often neglect their own duties that forego occupancy certificates. She also found it of concern that the beneficiaries sign off acceptance letters without the assistance of a suitable construction expert. She also revealed that developers often dominate the process and provide below specification dwellings. There is also a general lack of understanding by the official when it comes to employing IBT contractors or providers without Agrément certificates.

Financial barriers

IBTs costs tend to be higher than conventional building materials

According to the Department of Human Settlements, they have experienced that some IBTs tend to be of a higher cost than conventional buildings both in terms of construction cost and maintenance cost. The Department of Human Settlements gives a figure of R1004-R3600/m2 excluding land and foundation which is more expensive than the conventional technology. The costs of using IBTs often exceed the subsidy quantum. The Department of Human Settlements also adds that when considering the costs of an IBT, the life cycle costs such as energy efficiency and maintenance costs should be factored in.

Inability to access loans

With regard to financing it has been found that there is an inability to access loans, especially without Agrément certificates or a rational design or a NHBRC certificate.

Enterprises demand upfront payment

Contractors sometimes demand upfront payment, especially the smaller and micro enterprises for the services rendered. Due to the speedy delivery of the product, prompt payment is demanded for services rendered as a lack of such prompt payment may lead to insolvency. In the case of prefabrication a huge amount of capital is invested in the IBTs rather than the erection thereof and needs to be recouped quickly.

Amorphous process for IBT certification

According to de Villers, 2012, for an IBT to be certified by Agrément it will cost between R 30 000 to R 300 000 and it can take anything between 3 months and 3 years to complete the issuing of the final certificate.

End user barriers

Possibilities to extend

According to officials from the NHBRC, one of the reasons recipients of RDP housing do not prefer IBTs is because it is much more difficult to extend the property from its original specifications. This is mainly because the current regulation suggest that for an extension to be done one must contact the certificate holder which must conduct an evaluation, do a requirement analysis and perform the extension themselves. Lower income end -users tend to live in large families will have to extend their houses to better accommodate all. With the conventional system of brick and mortar, extending is quite easy anyone, mostly the end-users themselves can perform the necessary extensions.

IBTs tend to be fragile

According to one of the technical assessors from the NHBRC end-users in South Africa are accustomed to living in houses which are robust in structure as opposed to end-users living in the USA who are accustomed to live in more fragile timber structures. For end-users in South Africa a house is a very permanent property in which generations and generations will live in. Many IBTs that have been introduced in South Africa consisted of boards which are much thinner than the 220 mm brick wall structure and when end-users banged the wall structure they complained that it was hollow implying the fragility of such a structure.

CONCLUSIONS

The findings from the literature review identified various barriers to the uptake of IBTs which are: the Nature of South Africa's building regulations, lack of specialised provincial budgetary arrangements, difficulty in meeting national building regulations, increased financial costs, inaccessibility to access loans, delayed payment processes of contactors and a largely poor perception of IBTs by end-users. The limitation of this study is the fact that it is only a desktop study and the research is still in progress. Advanced findings will only be available once the quantitative and qualitative study is completed. Questionnaires with closed and open ended questions will be distributed to a variety of stakeholders, including government decision makers up to end-users. It is envisaged that once the final study is completed, that improved client briefing, procurement choices, knowledge management and change management will be needed to break the barriers to Innovation.

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PREFABRICATION - THE POTENTIAL SOLUTION TO SOUTH AFRICA'S HOUSING PROBLEM

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ABSTRACT

South Africa has a rapidly growing population but lack the development to provide enough housing to cater for this growth which may open the market for prefabricated housing. *Research problem: What impact will the use of prefabricated housing have on South Africa?* The South African residential construction has not catered for prefabricated construction on a large scale. Various factors changed the way developments were previously designed and constructed. The purpose of this paper is to examine the possibility of utilising prefabricated construction methods as an alternative to conventional construction methods and to determine whether prefabricated construction is considered as a viable option by the target market. The scope of this paper is to determine the suitability of prefabricated housing in South Africa as well as the availability of locally prefabricated housing. The author has used a mixed quantitative and qualitative approach to collect data from professionals within the built environment, municipalities, and the general public. Findings from these questionnaires and interviews were largely in favour of prefabricated construction with regard to the suitability of prefabricated construction methods and the availability of prefabricated construction methods for the supply of low cost housing. Findings from the data gathered from the questionnaire to the target communities are not in favour of prefabricated housing, raising a concern with regard to the readiness for market entry. To conclude, the government is not doing enough to alleviate the housing backlog and the target market has shown resistance to prefabricated construction methods. The target market, as well as government needs to be educated as to what the potential benefits of prefabricated construction are.

Keywords: Construction Methods, Housing Backlog, Innovation, Prefabrication

INTRODUCTION

More and more countries are becoming conscience about saving energy and becoming more environmentally friendly in construction. Prefabrication, in this regard, differs in terms of materials, design and methods from country to country (Haden, 2014). Having done a simple internet search on prefabricated housing in South Africa, it was noted that the advancement in this regard is slow. Germany and European countries, for instance, includes triple glazed windows in their prefabricated buildings (WeberHaus, 2015) where South Africa has only as recently as November 2011 implemented the SANS 10400-XA which deals with energy usage in buildings (SA Commercial Prop News, 2012).

The aim of this paper is to investigate the benefits of prefabricated housing options that are available in South Africa drawing from international examples. The question may be asked what impact does the use of prefabricated housing have on South Africa's residential market in general since the prefabricated low cost housing will be largely targeted at the poorer communities.

Up until recently, South African residential construction has not catered for prefabricated construction on a wide scale. Environmental concerns, rising quality expectations, an increasing backlog in low cost housing, new technologies and methods have lead the construction industry to start changing the way developments were previously designed and constructed. Three sub questions were identified

- What is the suitability of prefabricated housing in South Africa?
- What is the availability of locally prefabricated housing?
- What is the acceptance of prefabricated housing by the target market?

This paper is important due to the fact that potential home builders are not always aware of available alternative construction options especially prefabricated houses and the "green" benefits that these systems may offer. This study assists in providing an alternative to traditional on-site built homes. With this information a well informed decision can be made as to the type of construction that will best suit the target market needs as well as to highlight the importance of building a prefabricated home.

Literature review

In 2013, Financial and Fiscal Commission (FFC) Chairman, Bongani Khumalo, estimated that it would cost government about R 800 billion to eradicate the housing backlog by 2020. It has been reported by the department of human settlements that from between 1994/1995 to December 2013, 2.8 million housing units were delivered. (City Press, 2014) South Africa has a rapidly growing population but lacks the development to provide enough housing to cater for this growth. (Anon, 2012)

Adding to the already hefty burden of cost in relieving the backlog of RDP housing in South Africa, there have been reports by various state agencies, such as the National Home Builders Registration Council (NHBRC) and the Construction Industry Development Board (CIDB) that where the Reconstructed Development Programme (RDP) houses have been provided by government, there are many beneficiaries who were not satisfied with the quality of the homes they received. Cracks and leaks were often found and in some instances, the houses collapsed during rainy weather. The CIDB informed the Select Committee that weaknesses in procurement processes were a major problem in the construction industry, especially in the construction of houses for the poor. CIDB's Mwandile Sokupa said that the major contributor to the poor quality of RDP housing is the procurement process and that other factors were poor site management, lack of contractor expertise and corruption, in the form of collusion and nepotism.(Parliamentary Monitoring Group, 2014) Forensic investigations by the National Home Builders Regulation Council's (NHBRC) estimated that it would cost about R400million to make these problematic homes structurally sound and in line with the NHBRC minimum technical requirements. A report by the Department of Housing in the Eastern Cape noted that after assessing 20 000 houses, rectification costs would be about R360million.(Insession, 2014) It is hypothesized that traditional construction methods and materials (brick and mortar) are not necessarily the best solution to provide for the RDP housing backlog and that prefabrication and hybrid systems should be considered, along with their benefits and limitations.

Table 1: A number of significant benefits provided by prefabricated elements comparing with on-site building erection processes

Factor	Prefabrication	On-site
Quality	In a climate-controlled environment using efficient equipment operated by well-trained people.	Uncertain weather can result in less-than expected construction.
Speed	Speedy process (up to 70% less)	Time consuming. The process can be delayed by weather or scheduling conflicts.
Cost	Greater control over manufacturing results dramatically reduces the chance of cost overruns.	Uncontrollable variables such as weather and scheduling can increase the construction cost
Versatility	Less	More
Site space	Panels arrive on a flat-bed trailer and are installed with sufficient listing plants.	Bigger space is needed. In addition costly scaffolding is often necessary for installation.
Site refuse	Less waste is generated at the site.	A significant amount of waste produced and removed from the site, which often adds to cost.

Source: (Wong et al, n.d.)

More research on prefabrication is required in South Africa. As a result of this, the author researched the use of prefabrication abroad. In a study report entitled "Prefabrication Impacts in the New Zealand Construction Industry" (Burgess, 2013), it was concluded that prefabrication construction reduced waste, transport time, energy & greenhouse gas emissions during construction, when compared to traditional on site construction. The study has also shown that internationally, prefabrication construction has lowered the impact on the environment, reduced construction time, improved health and safety, improved quality, improved economic security and reduced waste. An interesting fact noted from the case study (Burgess, 2013) was that prefabrication construction methods in New Zealand actually had a higher initial cost when compared to traditional construction methods, whereas internationally the inverse was true.

There are limited sources available that reflect how many houses were built, utilizing prefabricated construction in South Africa. Statistics from the 2011 South African National Census show that of all walls in households within South Africa (South African National Census, 2011):

- 62.9% are constructed with brick
- 14.8% are constructed from cement or concrete
- 11% are constructed from iron or zinc

To illustrate this within a broader context, the author gathered data from the United States of America Census 2011 on the construction methods used for Contractor-Built Houses (United States Environmental Protection Agency, 2014):

- 22% of exterior walls were constructed with brick
- 34% from Vinyl Siding
- 19% from Fibre Cement
- 11% from wood

Statistics drawn from the 2011 South African National Census indicate clearly that prefabricated construction has not been adopted as a real alternative to the traditional residential construction. These statistics, supported by that of the United States of America National Census indicate that South Africa is lagging behind in the use of prefabricated construction. As indicated in table 1, prefabricated construction methods meet many criteria in realising sustainable construction methodologies. What then are the restrictions in getting it adopted as an alternative to traditional construction methods?

One major possibility for prefabricated construction not being adopted as a real alternative to traditional methods, is the associated perception of prefabrication among the target market: "School prefab classrooms and temporary worker housing aimed at the low-cost market, have led to a widespread perception of prefabrication representing cheap, flimsy and temporary structures." (Burgess, 2013) "

Whilst prefabricated construction methods provide many advantages in constructing homes, it would not be fair to omit that there are also a few limitations. As mentioned, the general public may view prefabricated construction as being too "industrial", as prefabricated methods have been associated with and are used in industrial applications.

Transportation may also need to be considered. Where components of a home are fabricated in a factory and need to be transported to site, ideally the factory should be located relatively close to the construction site. In some instances, this may not be possible. The costs involved in transporting components must be considered, so as to determine whether prefabricated construction would be viable. (Modular Today, n.d.)

Whilst prefabrication does allow a good deal of flexibility, there is a limit to which it can easily change the appearance of a home exactly as imagined, but because technology is so dynamic, these limits are constantly being adjusted. (Modular Today, n.d.) Whilst local zoning boards are becoming more accepting of prefabricated construction methods being used for residential construction, there could still be a fair amount of confusion when it comes to zoning regulations. (Modular Today, n.d.) The perception of the general society is that modular homes are cheap and not as durable as the on-site built homes (using brick and mortar). (Ackurst, 2015) The perception is also that modular homes look industrial and unpleasant. A big factor is the architectural design to make the house physically attractive. This perception needs to be altered in order for modular housing to be accepted and maybe one day it will become the standard method of construction. (Ackurst, 2015)

The research method

A mixed quantitative and qualitative research method was applied to the study. Individual interviews were used to gather qualitative research from professionals. Telephonic, face to face and electronic surveys have been used to gather the quantitative research. In order to provide relevant, reliable and comparable data, questions were posed to both professionals by means of interviews and the general public by means of a questionnaire. Professionals included architects, quantity surveyors and government officials. There were a total of 44 respondents.

Results

Results Concerning Suitability

When respondents were asked about the suitability of prefabricated construction methods the results were largely in favour of prefabricated construction.

When the respondents were asked whether prefabrication could reduce the cost of RDP housing when compared to conventional construction systems, 86.36% indicated that it could, 2.27% indicted that it could not and 11.36% were not sure whether the cost would reduce or not.

When the respondents were asked whether prefabrication could reduce the construction time of RDP housing when compared to conventional construction systems, all indicated that it could.

When the respondents were asked whether prefabrication is sustainable when compared to conventional construction systems, 70.45% indicated that it could, 13.64% indicted that it could not and 15.91% were not sure whether it is sustainable or not.

When the respondents were asked whether prefabrication could improve the quality of RDP housing when compared to conventional construction systems, 61.36% indicated that it could, 13.64% that it could not and 25% were not sure whether it could improve the quality or not.

When the respondents were asked whether prefabrication aesthetically could be seen as more industrial when compared to conventional construction systems, 52.27% indicated that it could, 40.91% indicted that it could not and 6.82% did not understand the word aesthetics.

In terms of the qualitative research method the following data were gathered through interviews.
Responses to various questions posed to Dennis Ryder, Deputy Mayor of Midvaal Municipality, relating to the suitability of prefabricated construction for the supply of RDP housing indicated that Midvaal Municipality in particular saw potential for prefabricated construction to meet the imminent needs of certain groups, which resulted in further investigation. Their findings were that houses could be erected more efficiently and economically, when compared to traditional construction methods being used.

Responses to various questions posed to Ashley Ackhurst, a Professional Architect and Project Manager, relating to suitability of prefabricated construction for the supply of RDP housing indicated that latent defects and quality issues due to poor workmanship could be reduced when utilizing prefabricated construction methods and as such the lifespan of the prefabricated houses would be increased. Better control of manufacturing components is available in a factory; less material are wasted and weather impact on the construction duration is minimal. It was also pointed out that if prefabricated construction methods could be used, there would be less chance of structural cracks appearing, due to the reduction of points for fixing the structure to the foundation raft.

Responses to various questions posed to Kagelo David Chamboko, the Director of Local Economic Development and Human Settlements at Midvaal Municipality, relating to suitability of prefabricated construction for the supply of RDP housing indicated that prefabricated construction methods have been considered previously in the development of house designs of the Sicelo informal settlement, where only the type of bricks were changed in the designs. It was indicated that any prefabricated construction methods proposed would have to be in accordance with the requirements of the National Building Regulations, the South African Bureau of Standards and the NHBRC.

Responses to various questions posed to Sharin Fox, a Professional Quantity Surveyor at Schoombie Hartmann, relating to the suitability of prefabricated construction for the supply of RDP housing indicated that prefabricated homes were the best value for money because they are quick to install, the cost of finishes are low, low maintenance levels, structurally solid with long life spans.

Research Questions Concerning Availability

When respondents were asked about the availability of prefabricated construction methods for the supply of RDP houses in terms of readiness for market entry, the results were largely in favour of prefabricated construction.

When the respondents were asked whether prefabrication should be considered, by government, as an alternative to conventional construction methods, all indicated that it should.

In terms of the qualitative research method the following data were gathered through interviews.

Responses to various other additional informal questions posed to Dennis Ryder, Deputy Mayor of Midvaal Municipality, relating to availability of prefabricated construction for the supply of RDP housing, indicated that this topic is a very emotive one. The responsibility for housing lies at provincial level, with the potential to devolve it down to Metros, so long as certain conditions are met (this has not yet been realized in Gauteng).

Responses to various additional questions posed to Ashley Ackhurst, a Professional Architect and Project Manager, relating to availability of prefabricated construction for the supply of RDP housing indicated that there was a backlog in the delivery of RDP houses in the country; this was based on experience and studies. They also indicated that medium density unitized/modular systems closer to the city rather than on the outskirts of the city would be the best option. The material outlay would be higher but the time and labour saved would equalize the higher material outlay. Also, better insulated housing would reduce the energy cost.

Responses to various additional questions posed to Kagelo David Chamboko, the Director of Local Economic Development and Human Settlements at Midvaal Municipality, relating to availability of prefabricated construction for the supply of RDP housing indicated that the plans the municipality has identified include Greenfield (new housing developments), informal settlement upgrades, high-density flats and provision for private sector led developments (free hold). These initiatives are dependent on the municipality obtaining the necessary grant for funding or financial support from the Gauteng housing department.

Responses to various additional questions posed to Sharin Fox, a Professional Quantity Surveyor at Schoombie Hartmann, relating to availability of prefabricated construction for the supply of RDP housing indicated that timber construction would be a cheaper alternative to traditional construction methods but steel would provide more support and thus last longer, when compared to traditional construction methods. Both these materials are readily available in South Africa.

Results concerning acceptance of prefabricated housing

When the respondents were asked whether they would consider prefabrication when constructing a new home, 54.55% indicated that they would, 22.73% indicted that they would not and 22.73% felt that they did not know enough about prefabrication methods to make an informed decision.

However, feedback from respondents with regard to questions related to suitability clearly support that some respondents don’t have the necessary knowledge on prefabrication as a construction method.

11.36% respondents were not sure whether the cost would reduce or not when comparing prefabrication to conventional construction systems.15.91% respondents were not sure whether it is sustainable or not when using prefabrication methods.25% respondents were not sure whether it could improve the quality or not when prefabrication methods are used.

Of interest, when the respondents were asked whether prefabrication is seen as more industrial with reference to aesthetics when compared to conventional construction systems 6.82% did not understand the word aesthetics.

In terms of the qualitative research method the following data were gathered through interviews. Responses to various informal questions posed to Dennis Ryder, Deputy Mayor of Midvaal Municipality with regard to the acceptance of prefabricated methods for RDP housing. The idea for utilizing prefabricated methods was rejected out of hand by target communities, who demanded brick and mortar. The target communities felt that they were promised conventional built housing and would not settle for less.

Conclusion

The limitations of this study are that the advantages of prefabricated construction were not entertained in the discussion; the questionnaires issued to target communities were only focused on low cost housing of which the majority of the end-users have limited education capabilities and that this study was conducted in the Gauteng Province, with specific focus on the Midvaal municipality. The key issue is that professionals through education need to persuade target communities and demonstrate that they can produce sound attractive and reliable housing. Based on the results obtained from this study, it is clear that provincial government and the municipalities are not driving the use of prefabricated housing for low cost housing. Target communities are not in favour of prefabricated housing, raising a concern with regard to the readiness for market entry. To conclude, the government is not doing enough to alleviate the housing backlog and the target market has shown resistance to prefabricated construction methods. A possible suggestion for further research is to determine how to educate the target market and the implementing authorities regarding the potential benefits of prefabricated construction to ensure buy-in of these systems.

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CRITICAL FACTORS FOR CONTAMINATED SITE REMEDIATION IN COMMERCIAL CONSTRUCTION PROJECTS: A SOUTH AUSTRALIAN STUDY

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ABSTRACT

Contaminated site presents a significant challenge to the management of construction projects due to substantial environmental, economic and social impacts. This research examines issues associated with the remediation of contaminated soil in South Australia through semi-structured interview with selected industry professionals. The complexity of developing consistent legislation that protects the interest of landowners, investors and builders whilst also protecting the environment and public health and safety is examined. Issues of risk management and contractual flexibility are highlighted as components of a successful strategy for planning for soil remediation. The importance of undertaking site assessment as part of the pre-construction planning process is determined to be fundamental in ensuring positive builder-client relationships and successful remediation projects. These findings provide useful inputs to the development of policies and processes for soil remediation in the commercial building industry.

Keywords: contaminated site, remediation, commercial construction

INTRODUCTION

Land contamination is perceived as a widespread infrastructural problem in varying degrees throughout the world (Ferguson, 1999). The total cost of remediating the world's full extent of contaminated land is estimated be over $250 billion AUS, with estimates pertaining to Australia alone approaching $8 billion (Deegan & Li 2008, p. 285). As the governing body responsible for contaminated land in SA, the South Australian Environmental Protection Authority (SA EPA), has conceded that the number of affected sites is largely unknown (SA EPA 2003, p. 28), whereas an estimate of 4,000 sites in South Australia was offered in the ANZAC Fellowship Report (Natusch, 1997). Sites most at risk of contamination are those with land-uses involving mining, chemical manufacturing, oil-based fuel production and timber treatments, during which contaminants frequently leech throughout the soil, causing further groundwater pollution issues (Deegan & Li 2008, p. 284).

Construction projects that include a phase of site contamination remediation are at a higher risk of encountering cost overruns, scope changes, delays and disputes in comparison to projects without a requirement for site remediation. This is due to a number of factors, including inadequacy of current legislation, poor quality of assessment and planning at project level, the changing, dynamic and technical nature of remediation techniques, a deficiency in guidance and administrative framework, and the overall lack of certainty of subsoil conditions, amongst many other possible causes. This is study aims to investigate critical factors for contaminated site remediation in commercial construction projects in South Australia.

LITERATURE REVIEW

The risks associated with the remediation of contaminated sites extend all the way to project level, specifically the planning and execution of the site remediation phase of building projects. Lane (2012) suggested there is a lack of guidance in terms of remediation planning and implementation in Australia in comparison to countries such as the UK, USA and Canada. Lane (2012) further highlighted that the content and sophistication of Remediation Action Plans are often inconsistent and highly individualised or 'random', and that planning approaches were often incomplete or superficial, culminating in a higher level of uncertainty and risk of failure. This is a reflection of the "risk-based" approach that is taken at the administrative and governing level, as it requires cooperation between a range of technical experts, regulators, property owners, designers and contractors (Edwards & Jones, 1999).

According to Ruff & Dzombak (1996), remediation projects are at high risk of scope changes, budget overruns, delays, disputes and change orders, all of which have the potential not only to be harmful to the success of the stakeholders, but also to negatively affect contractor's relationship with the owner/client. This is supported by Lane (2012) who suggested that the ability to effectively plan, manage and implement remediation is not keeping up with the increasing complexity of remediation design and that there is a substantial risk of 'inadequate and under-costed or expensive and unnecessary' remediation as a result (p. 46). Indeed, this highlights the importance of discovering the full extent of contamination on a site prior to any detailed design and procurement, not just in order to ensure that informed decisions can be made in terms of land use and design, but also so that an appropriately capable contractor can be selected (Tilford et al., 2000).

Whilst suitable investigation, planning and contract arrangements may all be applied in the early stages of a project as preventative forms of managing risks, as with any project there will always be residual risks that will need to be managed by the contractor throughout the project. These levels of risk tend to be significantly higher on a remediation project due to the tendency for cost growth, scope change and delays (Mcmanus et al., 1996). Remediation projects also inherently carry more elevated levels of site risks than typical building projects, caused by the danger posed by the contamination itself. There can even be cases where the risk posed to health and the environment as a result of remediating outweigh the potential risks if the site were left in its contaminated state, and therefore an overall 'net risk reduction' cannot always be assumed as the result of remediation (Gibbs et al., 2009).

It is important to recognise that the current state of legislation within South Australia whereby liability for contamination can be transferred to the current owner of a piece of land can put a developer in a financially damaging position and make it far more difficult to plan a viable and profitable redevelopment. Furthermore, the uncertain nature of remediation projects in regards to time and cost overruns places further obstacles and challenges to redevelopment. One strategy to mitigate these project risks that has been used by developers is to limit the extent of investigation to save money and to attempt to transfer all liability for the remediation of any discovered contamination to the contractor via contractual clauses in order to provide a level of cost and time certainty. This kind of attempt to transfer all kind of liability and limit investigation into the extent of soil contamination is thusly recognised by contractors as a huge risk, particularly in that the client is demonstrating a "run and hide" approach to cost sensitive issues (Zwarun, 2000).

In recent years there have been developments in the industry that allow the option for all risk and liability for contamination to be transferred away from a land-owner to a third party. This environmental liability solution which has been used in the USA and UK, with plans for Australia, is being offered by a company called WSP Environmental and Energy, whereby the firm offers to assume all liability for a site remediation project – a system called "Active Transfer" (Collins, 2011). For a fixed, up-front price the full extent of environmental risk and obligation for all known and unknown liabilities can be transferred to WSP, who hold the funds and takes out an insurance wrap to offset the risks. For redevelopers of contaminated sites, the certainty that it provides allows them to put forward a proposition to a lender that can facilitate the funding for the contamination clean-up (Collins, 2011).

RESEARCH METHODOLOGY

In-depth interview was adopted in this research. The interview was comprised of mostly open-ended questions that allowed the participants to respond freely, and support and explain their responses in a conversational manner. As each participant's responses varied, it was necessary to synthesise and categorise the responses in order to analyse the results. Therefore, an exercise of categorising responses was necessary in order to identify the important aspects of the responses and quantify how the subject group as a whole responded and the extent to which certain opinions were held. In presenting this information, a standardised tabulated format has been adopted – presenting succinct and categorised versions of the responses given by each participant.

The interview participants are all construction professionals who are currently working or have in the past worked for a building contractor on a commercial construction project in South Australia that involved a phase of remediating contaminated soil. Snowball sampling approach was adopted to select industry professionals that have been closely involved in the planning, management and execution of a remediation project, including contract administrators, coordinators, estimators, site managers, site engineers and project managers. As a result, nine industry professionals were interviewed. Main interview questions include: (1) what are critical issues associated with contaminated site in commercial projects? (2) what are effective approaches to deal with these issues?

KEY FINDINGS

Analysis of the interview pointed to twelve key themes that are manifested in the following key finding statements.

Key Finding 1

Projects that include a phase of site contamination remediation are more likely to suffer from disputes and damaged relationships with clients.

89% of interviewees gave responses that expressed this perception, making it one of the most common responses received in the research. It is not a surprise to receive these results, given the information provided by Ruff & Dzombak (1996)'s study of 60 construction projects that similarly highlighted the risk to client-contractor relationships.

Key Finding 2

An important aspect of risk mitigation is to exercise due diligence when ensuring that the perceived allocation of risk for remediation between client and contractor is reflected in the contract.

This is strongly linked with Key Finding 7 in that builders perceive that standard forms of building contracts protect contractors from the direct risk of site contamination because they would be entitled to additional time and money to remediate any contamination as a latent condition.

This represents the fact that despite this belief, there is still a strong sense of caution when entering into any building contract that remediation works not be unknowingly included in the contract. Liability to remediate could potentially be transferred to the contractor by the addition of specific clauses to standard forms of contract, by the inclusion of documentation pertaining to contamination investigation, remediation management, or correspondence discussing these requirements into the contract documents, or by its inclusion within a scope of works. This would likely be the subject of a dispute and, depending on the method of procurement, could possibly result in financial lost to contractor.

Key Finding 3

Maintaining working client relationships is an effective way of mitigating the risk of disputes on remediation projects.

Considering that the participants of the study perceive disputes and the breakdown of client-contractor relationships as the biggest risks, it makes sense that attempting to prevent these would be given as the foremost strategy for mitigating risk. A number of strategies were suggested by interviewees, including maintaining good lines of communication, utilising a third party environmental consultant to verify and certify remediation activities, and not rubbing salt into wounds by over-claiming on remediation variations.

Key Finding 4

Remediation projects could be improved if site contamination investigation and planning were given more consideration by the client and design team in early stage of project.

This finding agrees with the large extent of academic literature reviewed that calls for a more informed approach to be taken by clients and developers. There were a range of different opinions given by the research participants as to what the potential benefits to projects could be, including providing more accurate expectations of the time and costs associated with remediation and therefore avoiding disputes, better project planning, the opportunity for competitive tendering of remediation works, and the mitigation of health risks to workers and the public.

Although this result seems intuitive, it is also somewhat surprising, as even though the majority of contractors believe that remediation phases are profitable due to the fact that they are commonly undertaken as a variation to the contract, the majority of contractors would like to see an improvement that might prevent this financially favourable situation.

Key Finding 5

The power to make decisions and employ strategies that could improve remediation projects is entirely with the client.

89% of respondents that offered suggestions on how to improve remediation projects focused on measures that could be undertaken by the client side as opposed to the builder. Furthermore, all of the suggestions were measures that the client could adopt in the pre-project or project planning stages. Whilst it is true that the decisions that ultimately influence the fundamental nature of a remediation project are made in the early stages of the project prior to the engagement of a contractor, the literature reviewed outlined a range of actions that the builder can take that have the ability to influence remediation projects, including cost control, procurement strategies and many others. Whilst this Key Finding highlights that the success of a remediation project can be greatly influenced by client decision-making, it also demonstrates a perception among builders that the client side of a project is invariably responsible for its shortcomings, whether that be accurate or not.

Key Finding 6

There is no consensus among interviewees in regards to the best way of procuring site contamination remediation works.

Whilst the review of literature suggested that flexible forms of contracts have been recently used with success to procure remediation work, there was no information available in regards to contractors' preferred procurement methods. The results of the interviews were essentially an even spread of four different procurement methods.

Managing Contractor main contracts and Schedule of Rates subcontracts were recommended by some because they provide the flexibility required to effectively undertake remediation when the extent or existence of contamination is unknown. An early works contract was recommended by 3 of 9 participants because the separation of remediation works from the construction contract reduced the scope for relationships that are strained during the remediation phase to have ongoing negative effects throughout construction. In contradiction, two participants responded that a variation to a lump sum contract as a latent condition is the best procurement method, seemingly because it is common, comfortable, familiar and profitable for builders.

Key Finding 7

Interviewees are completely confident operating in the usual practice of excluding the risk for site contamination remediation from contract works with the assumption that they will be entitled to additional time and money from the client if they are required to undertake any remediation.

When questioned about levels of confidence in undertaking remediation work, all nine participants expressed that there is generally confidence among builders. This came as the biggest surprise from the interviews, as the reviewed literature unanimously points towards elevated levels of overall risk to projects in the form of delays and budget blowouts. However, in giving their responses all nine interviewees justified their confidence levels on the basis that the builder is not contractually exposed to the direct risks of contamination remediation and that builders are entitled to additional time and money for undertaking any required remedial works.

Although this is true under standard forms of lump sum contracts, a greater level of caution or wariness amongst builders is expected. However, it seems that the “latent condition” function in construction contracts even transforms project risks into opportunities in the eyes of builders, due to the fact that additional works carried out as a latent condition are paid as a variation to the contract which might have a standard builder’s profit margin of 10% added – significantly more than works tendered competitively. This leads on to the next Key Finding.

Key Finding 8

Remediation phases of construction projects are generally profitable for the builder.

When questioned on levels of confidence among builders in undertaking contamination remediation, interviewees unanimously expressed confidence, due to the perception that the client is liable for all incursions and delays experienced as a result of the latent condition. Of the nine interviewees, six went further to express that under common lump-sum contract arrangements, the existence of contamination can even be preferable to builders because remedial works that are not tendered competitively can result in significant extra costs, of which the builder is entitled to claim a percentage mark-up on as a variation, making the remediation phase potentially quite profitable.

Key Finding 9

Interviewees are able to recognise the large risk posed by contaminated soils to clients, landowners and developers who are liable to remediate and how this can negatively impact the feasibility or profitability of brownfields development.

The flipside to the unanimously held perception that builders are essentially immune to the direct risks posed by land contamination is that these risks are entirely sided with the client. 78% of participants specifically highlighted the danger of finding unknown contamination on site during construction works and the potential that this has to throw out the entire feasibility of the project. The builders’ perception of this risk to clients reflects their response to other questions – that the client is generally liable for payment of remedial works and that the possibility for disputes is a significant residual risk to the builder – the perception being that the client may try and recoup the losses incurred by remedial works by becoming more combative and less reasonable when faced with decisions throughout the project.

Key Finding 10

Despite recognising the risk associated with the contaminated site remediation liability on projects, the majority of interviewees believe that clients, landowners and developers should be capable of mitigating these risks by such exercises as researching previous land-uses and undertaking appropriate investigations prior to committing to develop.

This Key Finding somewhat challenges the principles of the legislation surrounding contamination liability – that the person responsible for contaminating a piece of land should be financially responsible for its remediation. The finding reflects the reality in Australia, as discovered in the literature review, that the remediation of contaminated land is predominantly triggered by financial incentive of redevelopment, and that developers and land owners should be capable of recognising this reality and taking appropriate precautions to limit exposure to risk or of factoring potential contamination into investment and development decisions.

Only one interviewee expressed empathy for landowners and developers, stating that the risk posed to them is "unfair". The overall lack of empathy for clients and developers in this regard could be attributed to the history of disputes on remediation projects wherein the behaviour of clients in reaction to time and cost pressures of remediating has led to the breakdown of relationships with contractors.

Key Finding 11

There is no common consensus among interviewees to suggest that the standard or quality of remediation investigation, planning or documentation is considered inadequate or requires improvement for the purpose of performing the remedial works.

This Key Finding was another surprise from the interviews, as the literature reviewed seemed to point towards a sense of dissatisfaction in the quality and consistency of remediation investigation, planning and documentation. None of the respondents expressed inadequacies in this regard and only two offered suggestions for aspects that could be improved. The literature suggested that an overall lack of consistency in format and material is problematic to builders in comprehending and implementing remediation management, but no participants shared this view.

Key Finding 12

Some interviewees concede that there is a limited requirement for knowledge and understanding of specific technical aspects of soil contamination remediation among Head and Managing Contractors and that they often rely on the expertise of environmental consultants and subcontractors in overseeing the works.

This key finding was drawn from responses to a number of questions. When queried over the standard of remediation planning and documentation, three participants responded that the remediating subcontractor is more likely to have a valid opinion on the matter, whilst a further two offered no opinion at all. In addition to this, on the question of builders' confidence in undertaking remediation, three interviewees commented that builders rely heavily on remediating subcontractors during this phase, whilst a further three interviewees identified the importance of engaging a suitably experienced and qualified subcontractor when questioned on the best ways to mitigate risks on remediation projects. The overall impression left by this recurring theme is that at least "some" if not a majority of builders rely on specialist subcontractors in managing remediation phases of construction projects.

CONCLUSIONS

The overall perception of remediation projects received from the research undertaken with commercial builders in South Australia is one of confidence. The interviews revealed that, so long as diligence is shown when drawing up the contract to ensure that remediation works are not arguably included within the contract works, builders are completely confident that they will be protected under the contract against the risks associated with finding contamination on a project. Accordingly, the builders generally expressed that they would not tender on construction works that included remedial works unless a flexible form of contract that did not see the risk associated with the unknown scope of remediation contractually sided with the builder were adopted.

This confidence surprisingly extended to the general perception of remediation projects as an opportunity to make significant profits as a variation to the contract. What is more surprising is that despite this perception of profitability, in particular the opportunity to take advantage of remediation variations as a money-making exercise, the majority of builders would like to see a change in the way that site contamination as an issue is managed by the client. Specifically, the demand is for change in the way clients and developers choose to investigate contamination. The majority of builders expressed the belief that remediation projects could be improved if there were a greater emphasis on contamination investigation in the early stages of a project, prior to financial commitment to a development. The foreseen benefits of this included the ability to competitively tender remedial works, to undertake project planning based on true site conditions, and to provide realistic budgets and programmes with provisions for remediation that would presumably limit the scope for disputes with clients over unexpected delays and costs resultant of remediation.

This is reflected by the perceptions of risk articulated by the research participants in regards to disputes. With the direct risks associated with contamination contractually sided with the client, the chief remaining residual risk cited was damage to client-contractor relationships as a result of disputes. Whilst some other risks, such as those associated with payment lag, health and safety management and project resourcing, were identified by the research participants, these risks were all seen as secondary to the risk of disputes. In fact, the consensus among research participants was that the most important technique of mitigating risks to remediation projects is to develop and maintain good relationships with clients – to communicate well and make sure that the client is kept informed and on-side by implementing policies of transparency when dealing with additional costs or delays and making smart commercial decisions that display good faith with the client.

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DO SUSTAINABLE BUILDINGS AFFECT THE ELECTRICITY INDUSTRY? A PRELIMINARY STUDY

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ABSTRACT

The built environment contributes to approximately fifty percent of Australia's electricity consumption, and is a major contributor in fluctuating demand. The research aims to assess the physical differences in electricity consumption between green star office buildings and the general existing building stock. Green star office buildings hold 17.82% of the total office building stock and are predicted to increase over the next decade. Results revealed the building industry fluctuates by 23.2% between June and December, significantly worse than the electricity industry average of 16.3%. These fluctuations are contributing to high electricity prices and worsened by the building industry. Energy efficient buildings aim to reduce peak demand and electricity usage to better the electricity industry and reduce greenhouse gas emissions. An average non-green star building is consuming 166kWh per square meter per annum, significantly higher than the average green star building at 48kWh. To date green buildings have reduced Australia's electricity consumption by 0.1% per annum and could save a further 0.46% per annum by 2023. The change in peak demand due to energy efficient buildings could not be fully analysed due to a lack of data, but previous research suggests a reduction in peak demand will reduce the whole sale cost of electricity.

Keywords: sustainable buildings, electricity industry, sustainable development

INTRODUCTION

Sustainability is becoming more popular in Australia with 447 green star certified buildings, with 139 being registered in the last twelve months (GBCA 2013b). Considering The Green Building Council of Australia (GBCA) has been around since 2002 this shows a current trend towards sustainability. The National Australian Built Environment Ratings System (NABERS) (2013) are also contributing to this change with 111 established buildings using their rating tools. Both ratings systems promote a change in the built environment particularly in relation to energy, water and waste.

The increasing popularity in sustainability is being driven by social factors such as a responsibility for the environment. Economic forces are also being considered since the cost of electricity has increased by more than sixty percent in South Australia since 2007 (Chester L. and Morris A 2012). This increase is creating uncertainty in the future running costs of buildings, thus making the investment into sustainable solutions more economically viable.

The focus of this study is placed on the electricity industry and the direct effects that sustainable buildings are having on the network. The National Electricity Market (NEM) trades over ten billion dollars in electricity annually (AEMO 2010) which is sure to be impacted by efficient energy use and increasing solar feed-ins. Researchers such as McConnell et al. (2013) have already studied the effects of Solar Photovoltaic (PV) on the electricity network. Others such as Bazmi A., and Zahedi G. (2011) have studied the electricity network on its own to find methods of optimisation. Peak demand is mainly driven by the building sector, it uses over fifty percent of the electricity produced in Australia (AEMO 2010). This paper aims to provide a picture for the electricity industry of what a low energy building sector may look like.

LITERATURE REVIEW

In Australian context the National Electricity Market (NEM) is the transmission connections of electricity generators and distribution networks across all of Australia excluding Western Australia and the Northern Territory. The Australian Energy Market Operator (AEMO 2010) manages the NEM which trades more than ten billion dollars in electricity annually. AEMO's statistics show that the building industry used more than fifty percent of all generated electricity in 2010.

This strong relationship between energy usage and the building industry indicates a need to investigate the effects of a significantly reduced building energy output. Obviously a reduction in energy usage through sustainable building operations is going to have an adverse effect on the $10 billion electricity Industry which needs to be researched (AEMO

2010). The Green Building Council of Australia (2013c) released a report finding the 428 Green Star Certified projects already built use on average 66% less electricity than the average Australian building stock.

The Green Building Council of Australia (2013c) released a peer reviewed paper analysing the reductions on resources directly related to their sustainable rating system. Green Star buildings have reduced greenhouse gas emissions by 62%, reduced water demand by 51%, electricity usage by 66% and gas usage by 18%. Table 1 demonstrates this energy reduction in terms of comparison with the existing building stock. This information suggests if all buildings in Australia were built to green star design, there would be close to a 33% reduction in the electricity consumed in Australia.

Table 1 - Reduction of Electricity Usage due to Green Star Projects (Source: GBCA 2013a)

Energy benefits due to Green Star reduction in operational energy usage				
Green Star Rating	Electricity (MWh)	Electricity (%)	Natural Gas (GJ)	Natural Gas (%)
4 Star	201,000	61%	60,000	37%
5 Star	247,000	64%	34,000	13%
6 Star	132,000	80%	- 195,000	-139%
All Ratings	580,000	66%	- 100,000	-18%

A 580,000MWh reduction in electricity may be less than one percent of the annual usage through the NEM, but these 428 commercial and industrial buildings have removed an equivalent amount of electricity as 76,000 households (GBCA 2013c). The Green Building Council of Australia also noted that there have been 139 applications for green star in the last twelve months, indicating a growing desire for sustainability and an accelerated reduction on demand.

The green star rating model shows a strong benefit towards reducing electricity consumed from the grid. The six star buildings shown above indicate an average increase of 38% in gas usage which is due to the inclusion of natural gas fuelled co-generation or tri-generation systems which are being included to increase efficiency, reduce transmission losses and reduce network demand (GBCA 2013c).

Since sustainable buildings as a whole have not been largely researched it is important to consider the individual elements which make up sustainable buildings. Solar is one of the most common technologies used in sustainable buildings as a measure to offset the energy they use. In many cases this involves feeding excess electricity into the network when the sun is shining and retrieving it from the grid when it is not.

McConnell et al. (2013) investigates these effects on the electricity network and in particular the loss in revenue for generators as a result. The paper found that solar peaks in power output at the point when the NEM reaches peak demand. This critical timing allows spot pricing in the NEM to be reduced creating lower wholesale prices for electricity. This could create two possible outcomes for infrastructure. These are; (1) reduced peak loads will allow network costs to be delayed or (2) Stability issues with a two way network may result in a need for additional investment into infrastructure.

The economic effects of sustainable buildings on the electricity network are not the primary focus of this paper but still will be considered. If sustainable buildings continue to emerge in the building sector the effects of solar will be multiplied. Similarly the reduction in energy usage is envisaged to have a similar impact on the Australian NEM to cause significant drop in revenue for tradition large scale generation facilities.

As for efficiency in the network, generation of renewable energy sources such as wind and solar are unpredictable. Nikolakakis T., & Fthenakis V. (2011) discovers an increase in these technologies will require an increase in wasted energy to meet system stability requirements. Through an analysis for New York State an increase to thirty percent renewable base load power will result in about a three percent dumping of wasted energy. Whereas one-hundred percent wind alone would increase this wastage to twelve percent of all electricity generated.

These problems are where system optimisation tactics and overall demand balancing can be used to increase predictability and incorporate renewables with existing technologies to improve efficiency. Wind power has been focused on by Holttinen H., et al. (2011) since they generally operate on larger scale, impacting the electricity market far greater than solar. Holttinen H., et al. (2011) study the effects of wind power on the predictability, cost and infrastructure requirements in an electricity network. The Europe based study analysed the effect of wind integration supplying ten to twenty percent of base load requirements (year round) with the ability to supply up to fifty percent of peak demand at maximum capacity. One of the major problems with increasing the dependence on wind power is the increased uncertainty on performance.

RESEARCH METHODOLOGY

This research methodology aims to address the relationship between sustainable buildings and the electricity infrastructure network in South Australia. The information obtained and produced is aimed to provide electricity generators and forecasters with additional information regarding changing electricity usage patterns and what the effect is on the industry to help make the data more accurate. It will also serve the building industry as a reference point to how much impact sustainable designs are actually having on the electricity industry and how far there is to go before considerable results are achieved.

A green buildings average electricity demand cycle needs to be compared with the average building stocks demand. To properly compare buildings a few assumptions will need to be made to ensure we are comparing apples with apples. It can be assumed that the proportion of 4 star, 5 star and 6 star buildings will be approximately the same in the future while forecasting. The average building size will also be assumed as similar to current averages over the next ten years. With these two assumptions the two building types can be compared.

The demand cycle of green star buildings will be collected from the GBCA since demand is measured at design phase as part of their rating system. This means extensive data has already been collected for this component. As for the non-sustainable portion, AEMO, NABERS and energy retails will be contacted to gather existing data on energy demand. The ABS will also be required to gather data on the average building size in the existing building stock if it is unavailable from the Property Council of Australia. Average green star sizes will be collected from the GBCA.

As for sustainable buildings, building management systems have become an important resource in evaluating a sustainable buildings performance. As a result most modern sustainable buildings install an additional monitoring device which automatically collects data on electricity demand per time intervals as required for this papers research. Organisations such as GBCA and NABERS will be contacted to see if this information is being collected. If not, this data will need to be sourced from existing literature as well, since data monitoring will need to be over a full year. SA Power Network, AEMO and electricity retailers will all have relevant information on Australia’s current electricity consumption and demand cycles.

Once electricity demand information is collected, actual usage data for the general building stock, sustainable buildings and Australia will be collected on a kilowatt per meter squared of building area basis. This allows for accurate application of energy usage statistics onto forecasts.

FINDINGS

General Office Building Stock

By analysing the general building stock we can determine similarities between the existing built environment and the Electricity industry as a whole. Once this is identified the effects of green star buildings can be compared more accurately. The literature review identified the GBCA produced a report in early 2013 detailing the benefits to the environment due to Green Star Buildings (GBCA 2013c). This report estimates the current electricity usage of the existing office building stock and states the average energy consumption of standard practice new construction to a minimum standard of 2.5 star NABERS rating. Table 2 states the average energy usage of the Australian office stock as identified by the GBCA (2013c). The data provided in this report was clarified with the GBCA during email correspondents and were conducted by an external organisation. The data sample size was Australia wide and the accuracy of the data covers a reasonable sample size.

Table 2 - Average Energy Usage of Office Stock

Electricity Use kWh/ m2 (NLA)/ annum	**Existing Building Stock**	**Non-Green Star Building Stock**	**Standard Practice New Construction**
	145 kWh	**166 kWh**	**98 kWh**

The 47 kWh drop in electricity between the existing stock and standard practice is larger than expected, demonstrating the effects of energy efficiency policies implemented in Australia over the past decade. The Green Building Council of Australia were contacted to provide further details of the existing building stock in terms of monthly electricity usage above that shown in Table . The Head of Research ensured the data’s accuracy but could not supply monthly energy usage statistics since the research was conducted by another organisation on behalf of GBCA. This data would take a year to collect and is therefore out of the scope of this research, instead study in this area was sourced from the existing body of knowledge. K. Khan, M. Rasul & M. Khan (2004) has previously investigated the electricity usage cycle of office buildings in the NEM. This data was used as an indication of the existing stocks energy usage pattern as the research did not include buildings outside the NEM. Figure 2 demonstrates the electricity used by all office buildings in Australia on a monthly basis.

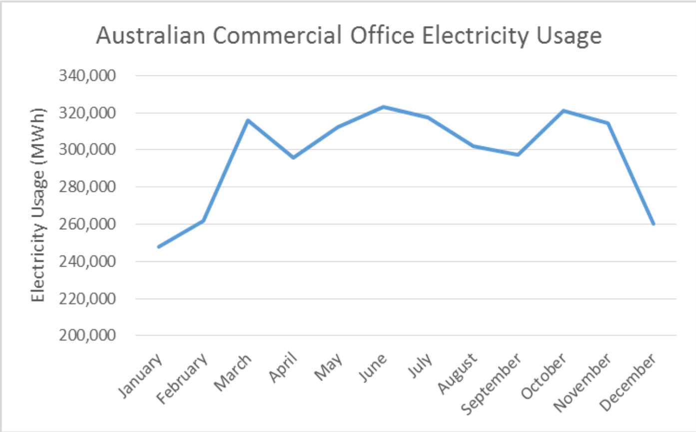

Figure 2 - Existing Office Building Stock Electricity Usage

The electricity usage pattern shown above is different to the author's original hypothesis. The significant reduction in electricity consumption in office buildings during the summer months is counter intuitive to the peak in electricity consumption in the overall NEM. It is therefore theorised that the dramatic reduction in electricity usage in December and January is due to the high number of businesses which close down over Christmas. Many businesses close from Christmas until the second week in January, contributing 1 week of reduced demand to both December and January. This two week break would significantly reduce the demand for all energy services over this period, hence causing the electricity usage to be only three quarters its usual operational consumption. Figure 2 also shows a peak in electricity use in March and October which is unusual, while the highest demand is in June as expected from the Australia wide electricity usage results. The minor troughs in April, May and August, September are also in character with Australia's electricity usage. Overall Australia's existing office space is consuming 3,568,898MWh of electricity per year which equates to 1.65% of all electricity consumed in Australia.

Green Star Buildings

The electricity usage of green buildings is required to find out the difference between normal and sustainable designs. It is the subject of research question number two and provides a crucial foundation for questions three and four. Unfortunately due to the relatively short research time frame a large enough sample could not be reasonably monitored to generate actual monthly electricity usage statistics for green star buildings. As a result the Green Building Council of Australia were contacted to provide the details, but only have credible statistics on an annual energy usage basis instead of monthly (Table 3). The data provided by the GBCA (2013) took into account all projects certified up until October 2012. Therefore the data represents a one-hundred percent sample size, allowing for very accurate results.

Table 3 - Green Star Electricity Usage

Electricity Use (kWh/ m2/ annum	All Projects (Ave 4.72 Stars)	4 Star	5 Star	6 Star
	48 kWh	**64 kWh**	**49 Kwh**	**24 kWh**

Table 3 was provided by green star in terms of energy usage per metre squared, per annum. This is a breakdown of all Green Star buildings which used the Green Star as built rating tool, since this is the only tool which measures actual energy usage. Therefore the table represents 28% of all green star buildings considered in this research, which is deemed a reasonable sample size to average out over all green star buildings and will be used for forecasted increases. The move from five star to six star shows a decrease in operational energy usage of 25kWh, whereas only a 15kWh decrease when going from four star to five star. This is not because a six star building is considerably more efficient than the others, the rating tools used by green star often require onsite co-generation or tri-generation to reach the reduction in CO_2 emissions needed for six star (GBCA 2013c). Therefore the buildings gas consumption increases significantly and the buildings actual energy usage is higher than that stated. Since this report is analysing the effects green buildings are having on the electricity industry the statistics in Table 3 are exactly what is required, since this only represents what electricity is taken from the grid.

As required for the existing building stock, secondary research was invested into finding other authors who have modelled energy use demand cycles for green buildings amongst the current body of knowledge. No credible data could be sourced for green building energy usage in Australia, let alone on a monthly basis. Therefore this shows a gap in the body of knowledge to study a topic which analyses the benefits of demand side electricity management of sustainable buildings for the electricity industry.

Since information is not available and will require more than one year to monitor, we has used the general building stocks demand cycle as a percentage and multiplied this by the energy usage of green star buildings. This assumes that energy usage patterns are not altered by energy efficient buildings, just simply reduced. It is envisaged this approach is relatively accurate for four and five star buildings, but will produce inaccurate results for 6 star buildings which are likely to be altered considerably during times of generator operation or solar activity. This means the differences in peak demand cannot be accurately discussed, leaving room for future research on the topic. This approach does not affect the annual results and still allows research questions three and four to be answered in a more general sense. Therefore Figure 3 displays the overall electricity used by all green star buildings if their energy usage pattern remains similar to the general building stock.

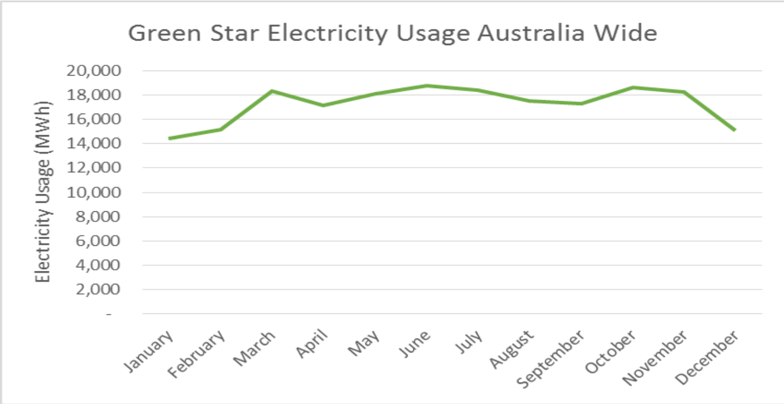

Figure 3 Green Star Office Building Electricity Usage

Figure 3 shows electricity usage fluctuating between 14,402MWh and 18,752MWh with a monthly average of 17,262MWh. The unexpected characteristics of January and December have already been discussed on Figure 2. However, it is interesting to note that the comparison of these two graphs shows that 17.8% of the office building area only consumes 5.8% of the electricity (207,147MWh). This shows the existing building stock uses 3.02 times more electricity than the average green building.

The energy usage statistics were found for all three areas required; Australia as a whole, the general office building stock and green star office buildings. Australia consumes approximately 216,877,125MWh of electricity per annum, 3,568,898MWh of which is consumed by commercial office space, and merely 207,147MWh of which is commercial green star office space. Peak demand was found for two of the three areas required revealing the NEM peaks in January and July with a maximum monthly load of 19,336GWh in 2013 and a yearly fluctuation of 2954GWh (16.3%) causing high wholesale and retail prices for electricity. The general office stock also has peak usage in June / July at 323,069MWh per month and a fluctuation of 74,943MWh (23.2%). Unfortunately the peak demand of green star office buildings was unobtainable due to lack of recorded and publicly available data.

CONCLUSION

This paper analysed the relationship between sustainable buildings and the electricity industry by determining the effect of green star office buildings on the electricity industry compared with the existing building stock. The findings show green star office buildings hold 17.82% of the total office building stock and are predicted to increase over the next decade to as high as 59.66% by 2023. The research found the building energy consumption fluctuates by 23.2% between June and December, significantly worse than the electricity industry average of 16.3%. These fluctuations are contributing to high electricity prices and worsened by the building sector.

Energy efficient buildings aim to reduce peak demand and electricity usage to reduce greenhouse gas emissions and wasted energy. An average non-green star building is consuming 166kWh per metre squared per annum, significantly higher than the average green star building at 48kWh. To date green buildings have reduced Australia's electricity consumption by 0.1% per annum and could save a further 0.46% per annum by 2023. The change in peak demand due to energy efficient buildings could not be fully analysed due to a lack of data, but previous research suggests a reduction in day time peaks will reduce the whole sale cost of electricity in the long run.

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PUBLIC PRIVATE PARTNERSHIPS: ENHANCING THE DELIVERY OF AUSTRALIA'S PUBLIC INFRASTRUCTURE

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ABSTRACT

In the midst of an evolving and tightening industry, are Public-Private Partnerships (PPP's) the best way forward for the successful delivery of major national and state level public infrastructure? Are they being developed and understood accordingly to ensure they are implemented with best practice methods, confirming that maximum efficiency is achieved with respect to project outcomes of Time-Cost-Quality. What can be learnt from global economic trends and how can they be used to create an innovative delivery system that is strong, financially healthy and effectively up to the challenge of bridging the $500-600 billion gap in Australia's public infrastructure network. This report will critically evaluate key market trends, current literature and related project performance to determine a set of functioning benchmarks for the partnership based system. The resultant outcomes and research findings will be used to formulate a robust strategy to develop and evolve the current PPP delivery model to a new level of maturity and sophistication.

Keywords: Public private partnerships, PPP, Australia's infrastructure, Project delivery, Project management

BACKGROUND

Public-Private Partnerships (PPP's) are a non-traditional delivery method which applies the combined efforts of the public and private sectors to design, construct, maintain and operate national and state infrastructure (Duffield, 2008). When an increasingly demanding public infrastructure network bread concerns regarding government debt levels during the macroeconomic disturbances of the 1970's and 80's, the PPP was borne out of a need to change the way in which public assets were procured within the global construction industry (Rakic & Radenovic, 2011). Governments sought the need to encourage private investment through the creation of a partnership that could allow the continued delivery of essential social services and public amenities that would otherwise not be possible (Donnelly, et al., 2015). The PPP model within the Australian construction industry has been extensively developed in recent years, with the Australian government actively engaging in increasing its effective use though the production and regulation of standardised frameworks at a national and state level (Donnelly, et al., 2015).

A strong PPP model will utilise the additional knowledge, experience, expertise and most importantly, the funding on offer from the private sector, to provide not just a building, but also a continued flow of vital public services over an extended period of time (Grimsey & Lewis, 2007). Through the formation of a stable, long-term partnership, the fundamentals of a traditional PPP promote a non-adversarial culture where resources are shared, friction between parties is lowered and the likelihood of disputes, delays and errors can be drastically reduced (McKeon, 2011). The appropriate allocation of risk and reward can maximise value-for-money while promoting a whole of life approach to the management of assets and services through the duration of the concession period (Australian Constructors Association [ACA], 2004). Through an effective increase in use, we can strengthen our depth of knowledge and level of understanding, fostering a resilient response to the delivery of multi-billion dollar projects.

PURPOSE

Effective and efficient public infrastructure is a critical driving component to sustained and secured economic growth and improved global competitiveness (Commonwealth of Australia, 2012). As we evolve and grow, we must continue to develop our infrastructure to provide enhanced community services and modern public amenities. The need for larger, more expensive public infrastructure of greater complexity will become increasingly prevalent within all levels of government. Governments, which are fast becoming unable to fund them outright (McKeon, 2011) and are simply ill equipped to consistently deliver them successfully (Infrastructure Australia [IA], 2015a).

Public investment in Australia's infrastructure decreased by 5.5% in 2014-15, the fifth consecutive year of fall (ABS, 2015a). Within a constrained economic environment, private sector investment is now a crucial element to the future finance, design, construction, maintenance and operation of major projects, placing increasing importance on identifying, establishing and implementing a flexible financing structure that can accommodate alternate and multiple funding sources. Traditional procurement methods are based on highly adversarial contracting principals that endorse quantitative selection techniques and cultivate unnecessary tension, rivalry and segregation (KPMG, 2010). In an extremely competitive industry, this form of delivery will usually sacrifice quality to save time and alleviate costs in an endeavour to hold of inevitable budget blowouts and schedule overruns.

Public-Private Partnerships (PPPs), while being one of the most heavily discussed procurement models of the last 10 years, are a proven vehicle for the provision of private investment in public infrastructure and are specifically designed to facilitate alternate funding scenarios from multiple sources (KPMG, 2015). It is within this context that this report has researched and reviewed the PPP market to identify a level of viability in the models performance before exploring potential avenues for improvement and innovation through which we can augment and advance the existing model. The knowledge and ideas derived from a combination of analytical report summaries, case-study outcomes and current market trends will provide an in-depth recollection of the Public-Private Partnership and its use within the Australian construction industry. Confirming the PPPs proficiency in consistently delivering complex infrastructure projects will place Australia in the best possible position to deliver an efficient and cost effective public network for the future.

ESTABLISHING THE OPTIMAL DELIVERY SYSTEM

You cannot view partnership based and traditional principle-agent based delivery models through the same procurement lens (Regan, 2012). Asset possession, decision-making authority and life-cycle costing responsibilities all lie with the contractor as the supplying agent in a PPP contract which in-turn offers an embedded incentive to perform through innovation and efficiency (Regan, 2012). A well-structured PPP can introduce a higher level of clarity with respect to the roles, responsibilities and obligations of each contracting party while also offering succinct assessment of project risk and a transparency of outcomes that are simply unobtainable through traditional models.

THE INFRASTRUCTURE MARKET AND PPP PERFORMANCE

Through an in depth analysis of the Australian and global PPP market we can identify essential data pertaining to local and global trends for consideration within the Australian context. Empirical data assessing the performance of PPPs is used to gauge the benefits to infrastructure delivery into the future while a detailed literature review offers an educated insight into the strengths and weaknesses of PPP’s that can be used to improve and evolve our current working knowledge of non-traditional procurement models. This study conducted the review of more than 15 pieces of PPP literature and delivery performance studies almost 500 projects consisting of 370 traditional projects and 130 PPP projects. It was found that 75-85% of PPP were delivered on schedule, compared to

30-40% for traditional. 70-85% of PPP were delivered on or under budget, under 30% for traditional. PPP had a total cost overrun of $58m on $4.8b worth of projects. Traditional were $673m over budget on $4.5b worth of project work. PPP projects were far superior in both time and cost.

Findings from the review suggested that tender costs involved in some PPP's need to be greatly improved, like full or partial bid cost reimbursement for invited/closed tenders. There is also a need to ensure that adequate preplanning and development is completed for all 'Full service' based PPP deliveries to avoid long-term performance issues. PPP also requires greater stakeholder involvement in the initial decision making processes. Furthermore, it is important to stimulate long-term investment, like 'user-pays' systems. This also includes national post completion reviews to increase future efficiency of PPP and a national approach to reform and to increase consistency in implementing PPP between states.

Emerging Trends and Global Influence

According to a recent KPMG report, a growing infrastructure deficit is challenging our ability to cater for the current and future needs of a modern society with fears that the simple task of keeping up with GDP growth could be out of reach within 15 years (KPMG, 2015). Population growths, demographic movements and an increase in urbanisation will continue to provide significant opportunities for social and transport infrastructure to enhance inner and intercity mobility and promote economic productivity while increasing social inclusion.

A snapshot of the Australian, and global trends, shows that the Traditional PPP model is evolving as a capacity-constricted market creates an opportunity for a variety of financing structures through an innovation driven delivery system. The emergence of mega projects is on the rise as governments push to address growing transport challengers, city and suburban congestion and commuter chaos. Significant opportunities therefore exist to develop, enhance and strengthen PPP outcomes by reviewing all stages of operational performance with particular attention on pre-planning, total risk management and relationship development. National reform from a strong and stable federal government is crucial in bringing consistency across all states. The need to improve productivity, service delivery, finance longevity and market stability being a pre-requisite to the future viability of PPPs. Opportunities exist for increased performance through mandatory project evaluations.

PPP Performance and Bridging the Gap

The last 10-15 years has produced a plethora of performance reports, case study reviews and academic opinions regarding the sustainability, feasibility and the overall success of partnership based procurement models. Because of such attention, there is enough publically available data to produce a set of rather conclusive performance outcomes (IA, 2015a) (Duffield, 2008).

PPP projects, currently, only account for between 20% and 30% of all major infrastructure delivery. 82% of Australian PPP projects are delivered on budget with 80% delivered on time. They are, on average, 40% more cost effective and 36% more time effective than traditional based delivery models. From the data collected, it is clear that partnership-based models provide an unmistakable increase to the cost benefits, schedule performance and contract execution of public infrastructure when compared to traditional models.

The Australian Outlook and PPP Opportunities

Table 1: Australian infrastructure outlook

Australian infrastructure trends till 2030:
• By 2031, Australia's population will grow by 37% to 30.5 million, our capital cities economic contribution increasing by 90% to $1.6 trillion (IA, 2015a). • $50 billion in the 2014-15 budget is to be dedicated to developing Australia's public infrastructure networks into 2019, which is estimated to combine with private investment to over $125 billion (Commonwealth of Australia, 2014a). • Up to $600 billion is required over the next decade to bring Australia's infrastructure back out of the dark ages (IA, 2015a). • Direct economic contribution will double to $380 billion by 2031 (IA, 2015a). • Mining exports currently generate over $180 billion a year (BREE, 2013). • Rail freight will increase by 66% with east coast freight growing to $230 million a year by 2030; Sydney networks will need upgrading (BREE, 2013). • Congestion currently costs Australian's a total of $15b a year with truck traffic forecast to increase by 50% to 2030 (BITRE, 2014). • South East Asian demand will double maritime exports by 2030 (DIRD, 2014). • Public transport infrastructure will need upgrading, with passenger numbers growing by over 30% by 2030 (BITRE, 2014).

In the face of unprecedented population and economic growth forecasts, establishing reliable and sustainable infrastructure will be critical to growing the economy and enhancing quality-of-life. The research data is testament to the PPPs abilities to ably implement a solution and drive the outcomes required. Significant increase in public investment is a valiant first step in pulling back the infrastructure deficit, Governments now only need to embrace balanced risk allocation and new funding and finance structures to respond to the changing needs of today's market and Australia's evolving social requirements. The development and establishment of a PPP performance standard will increase investor confidence while providing a means of establishing accountability for sub-standard performance through well-documented project benchmarks and KPI measurement.

ENSURING PPP PERFORMANCE AND VALUE

It has been reported that there is currently $500-$600 billion (estimated) in unfinanced work or work that has been identified as required (Australia Trade Commission, 2015) (IA, 2015a). Furthermore, the recent poor performance of key transport infrastructure projects has handed the private sector close to $5 billion in toll road losses, so understandably the private investor pool is starting to look a little dry. Some consortiums are resorting to a heavy-handed bidding regime to compensate for the risks they are being forced to accommodate (Australia Trade Commission, 2015).

Funding and financing – Evolving the PPP structure

PPP performance trends within the Australian market would suggest that after having secured quiet a strong and rightfully awarded spot at the top of the PPP ladder, recent performance outcomes only serve to showcase Australia's reluctance to heed advice from their global counterparts and evolve a rather prehistoric set of finance models (Infrastructure Partnerships Australia, 2013). Recent financially unsound outcomes like the Cross City and Lane Cove Tunnels, the Airport Link and Clem7 tunnels, the Adelaide-Darwin Railway, Waratah Train PPP and Melbourne's EastLink has resulted in decreased investor confidence and increased private sector borrowing costs.

By securing a level of minimum demand on user-pay systems within major transport projects or making use of a capital contribution model for the delivering of social infrastructure, we can maximise value and reduce the costs associated with private sector financing, providing the added confidence that is desperately needed. The government can also play a crucial role in reducing financial instability by simply encouraging private sector bidders to adopt a less aggressive financing structure. A task that can be achieved by testing the long-term viability of the funding model and including a minimum level of robustness within the tender selection criteria (Clayton Utz, 2013). This will dramatically reduce the likelihood of financial failure, which in turn will improve the credit rating of PPP projects and their attractiveness to private equity investors.

Re-Thinking Risk Management

Private sector involvement does not change the fundamental risks involved in major project delivery. However, it does inject important risk allocation and management issues into project success (Quiggin, 2006). Inefficient risk planning, inappropriate initial risk allocation and the inability to foresee and then adequately plan/mitigate long-term construction, demand and service risk has resulted in substantial cost and schedule blowouts, government repossession of assets and insolvency of private consortiums.

Failure of the private sector to account for risk and running cost resulted in the government repossession of the Metropolitan Women's Correctional Centre, Latrobe Public Hospital and the Port Macquarie Base Hospital. In addition, losses were reported by the contractor on the D&C aspect of the PPP contract for the Southern Cross Railway Station, Victorian Desalination Plant, the Brisbane Airtrain Project and the redevelopment of Ararat Prison. The Australian Government has taken the recent poor performance of several key transportation projects into consideration and as a result has sought to increase confidence within the financial element of the SPV by bearing a greater portion of demand risk within their recently released infrastructure projects (Clayton Utz, 2013). Some examples include the Gold Coast Rapid Transit, North West Rail Link, the WestConnex and the East West Link projects.

Service Delivery and Productivity Reform

In 2008, the Australian National Public Private Partnership Guidelines (ANPPPG) was finalised after 4 years of heavy reform, revision and development. The ANPPPG sets out to deliver improved services and better value-for-money through optimal risk transfer, relationship management, innovation and an integrated whole-of-life asset management approach (Commonwealth of Australia, 2008). This was the Australian governments push to provide an archetypal framework through which a unified approach to the development of the PPP model would bestow a much-needed level of consistency to the delivery of public infrastructure. The very nature of Australia’s federal system however, all but makes this act redundant and most certainly makes it impossible to determine if its creation had any real impact on PPP delivery.

In 2014, the Australian Government released a detailed report aimed at increasing the productivity of public infrastructure through the development and implementation of key reforms (Commonwealth of Australia, 2014c). The reforms tackle governance, project selection, value-for-money feasibility, project planning, risk management, financing, delivery costs and post construction evaluation (Commonwealth of Australia, 2014c). By addressing the need for short and long-term reform, the government has made a crucial step forward in developing a greater national consistency that will better enable the achievement of social and economic objectives. Strong leadership from a single entity will afford some much-needed stability to the built environment by providing a long-term infrastructure pipeline along with the clarity in project objectives that are key to their efficient delivery. A strong and transparent infrastructure pipeline is key to market success as it ensures a level of continued supply and demand of resources (KPMG, 2015).

Amongst the new reforms is the government’s intention to introduce a detailed benchmarking framework and a post-build evaluation processes (Commonwealth of Australia, 2014c). The complete inclusion and adherence to both will be compulsory on all government funded transport infrastructure projects. The benefits which can be gained from building a database of 'lessons learnt' through the systematic collection of project data will start by improving project selection and finish 35-40 years later when the asset is handed back.

When to Use

Ultimately, the fundamental rationale for PPPs must be based on the value-for-money drivers and the ability for a partnership based delivery system to provide positive outcomes given the key objectives of the project (Clayton Utz, 2013). Any project, which is perceived to have failed in the provision of value for money, will be instantly scrutinised by the public media, regardless of the projects eventual success (Raisbeck & Duffield, 2008). Amongst numerous questionable hospital and social infrastructure PPPs, the Cross City and Lane Cove Tunnels are two of the major transportation infrastructure projects that have found themselves in the middle of a media circus. Table 2 below represents key suitability criteria as it is detailed within the National PPP Guidelines.

Table 2: When should you use a PPP model?

When to use (suitability criteria) and value for money drivers
• Complex and long-term infrastructure projects with clearly defined outputs • Strong scope for innovation with the ability to attract a healthy interest from the market • Whole-of-life approach from integration of design, construction, operation and maintenance over the life of an asset, in a single project package which is both achievable and cost-effective • Opportunities for appropriate risk transfer and contract bundling • Complementary commercial development and/or Significant service component • Appropriate third-party use of facilities, reducing overall net costs • Efficiency of contract management

Source: (Commonwealth of Australia, 2008)

Over time, priorities will change and governments will seek alternative motivations for project delivery (KPMG, 2015). To ensure the value-for-money delivery of Australia's public infrastructure, the government must understand the trends that shape and control the procurement environment as this will help facilitate positive decision-making and the continued development of the PPP model.

CONCLUSION AND RECOMMENDATIONS

The need for reform within the planning and financing of Australia's public infrastructure is of significant importance. A major study conducted by Evans and Peck revealing that an inability to improve the way our infrastructure is financed, developed, operated and maintained will ultimately result in decreased growth rates and a declining standards of service (Evans & Peck, 2011). A damning sentiment which is further backed by Infrastructure Australia which concluded that a lack of efficient and effective infrastructure delivery will directly impact our standard of living, our transport safety and security and our capacity to invest in infrastructure which is capable of meeting future demands (DIRD, 2014). The recent recognition and subsequent action by the Australian Government will provide the industry with a consistent direction and a single benchmark framework from which a strong and robust system can develop.

The data above reads pretty consistently with general procurement theory which suggests that complex procurement contracts deliver better performance results when they are based on a contractual framework which incorporates non-adversarial principles (Regan, 2012) (Regan, et al., 2011) (Rakic & Radenovic, 2011). Through the development of a positive and sustainable relationship between contractual parties, a greater provision for the sharing of information, resources and co-operation can be created. This better aligns objectives with incentives, encourages innovation and productivity and adapts a relationship management approach to *ex post* contract administration (Regan, 2012). Australia must make crucial changes to the way it delivers public infrastructure if it is to remain a relevant and attractive global PPP player (Ashurst Australia, 2014).

The components that are vital to the ongoing success of the PPP model in Australia and internationally include political sponsorship and strong governance, consistent legal framework and stable industry environment, and long-term visionary infrastructure decision making. These also cover predictable and sustainable project pipeline, funding capacity with efficient finance, and adequate public sector delivery capacity (KPMG, 2015). In the wake of the Australian Infrastructure Audit, it is anticipated that opportunities within the Australian market will begin to grow and the combination of delivery and productivity reforms and significant government investment will only serve to bolster potential investment opportunities. The PPP model remains a critical constituent for the delivery of complex and high-risk projects that require innovation, value-for-money and alternate financing requirements. In a capacity-constrained market, Australia needs to once again, emerge as a global leader and take the PPP model to the next stage of development and sophistication.

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MOBILE TECHNOLOGY IN AUSTRALIAN INDUSTRIES

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ABSTRACT

Although the adoption of mobile technology is slow across industries, especially in construction, there is a gradual movement towards its use. Various implementation barriers exist to the adoption of new practices. This research investigates whether mobile technology usage in Australian industries is influenced by the same factors identified in previous research. A web-based survey and case study example were used to verify the conditions that currently exist in Australian industries. A range of issues were identified, including data security, system integration, return on investment (ROI), work procedures and device usage that specifically impact on the uptake of mobile technology. In overcoming these barriers, the potential benefits that exist are vast, with process efficiencies and productivity improvements available to those who implement systems that improve upon current practices. The research found that greater training and education is seen as one of the major areas in overcoming these barriers and assisting in achieving better process efficiencies through mobile technology use.

Keywords: Application, Barriers, Mobile, Productivity, Technology

INTRODUCTION

The construction industry is renowned for being slow to respond to change. With the vast technological advances of Building Information Modelling and other technological tools, there has still been a reluctance to adopt new practices. With Mobile Technology (MT) providing opportunities to increase efficiencies in the workplace for communication, safety, quality and a range of other tasks, barriers still exist that inhibit implementation. The aim of this research is to investigate the adoption of technological advances in the workplace and the factors that impact on implementation. This research consists of a literature review of MT usage in the construction industry and a research survey to determine whether the conditions in Australian industries reflect the existing body of knowledge.

This research is significant as it is necessary to gain deeper understanding of the factors present in Australian industries to unlock the full benefits of MT that are available. In fully appreciating the barriers that exist, strategies can be developed to overcome them. The expansion of suitable mobile technologies, means that there are improvement opportunities available to those who are able to tackle adoption issues.

MOBILE TECHNOLOGY IN THE CONSTRUCTION INDUSTRY

Technology in the workplace

Information and Communication Technology has been credited with making improvements in the construction industry by; making communication between stakeholders easier, increasing process speed and response times, and managing information more effectively (Harun & Bichard, 2015).

This has increased the effectiveness of various construction processes, with email and mobile phones facilitating efficient collaboration (Venkatraman and Yoong, 2009; Harun and Bichard, 2015). This does not mean to say that the industry has been quick to adopt technology as a method of improving systems or productivity. The construction industry still lags behind others, with it implementation of mobile Internet technologies remaining in the infant stages (Harun & Bichard, 2015). Opportunities exist with advancements in mobile technologies to increase productivity through the elimination of data re-entry, reduction of waiting times for responses and reducing the paperwork of field personnel (Kajewski & Alwi, 2006). There are a wealth of construction activities that can be improved through the use of mobile technology. These include tasks that require onsite access to information, viewing detailed drawings, and the inputting of data into forms (Saidi et al, 2002).

With the construction industry and work sites being plagued by paper systems, valuable time is expended and the opportunity to react quickly to changes are diminished (Harun & Bichard, 2015). While the current paper based systems for the transfer of information are robust, they are easily clogged and can become difficult to deliver necessary information in a timely fashion (Chen & Kamara, 2011; Harun & Bichard, 2015). Where personnel are unable to respond quickly enough to information changes, important issues can be overlooked. In severe circumstances, this can result in downtime, rework and cost overruns (Chen & Kamara, 2011). With such rapid changes in the availability and affordability of smartphones and the quality of telecommunication networks, the potential for improvement in information management is greatly increased (Chen & Kamara, 2011).

The opportunities that exist for MT to assist in improving the construction industry include instant access to project documentation and other project related systems (Szycher, 2014). It also improves the accuracy and quality of communication between parties, and provides the opportunity for workers to carry out more work remotely. With user-friendly systems, minimal effort is required in familiarising people with the applications (Venkatraman & Yoong, 2009). Mobile technology systems are found to be easier to implement than dedicated software programs based on customers own servers. This is because they are scalable to the customers needs, less expensive than other software, and are accessible through any Internet connection (Szycher, 2014).

Factors affecting implementation

The successful implementation of a new technology relies heavily upon its acceptance by the people who are expected to use it (Venkatraman & Yoong, 2009). Further investigation on this topic identified multiple factors that influenced adoption within an organisation. These factors were:

- The perceived benefits of adoption,
- The complexity of the technology,
- Managements enthusiasm for the new technology,
- The organisations competence and experience with the technology,
- External pressure to adopt, and
- The perceived cost of implementation.

(Williams et al. 2007)

As the construction industry needs to be able to respond to problems quickly, is highly competitive, and is often influenced by external parties, any new technology needs to assist in these areas (Williams et al. 2007). Mobile technology has the power to facilitate, but understanding the relationships between these factors can provide an insight into how best to approach implementation. Mobile technology is dependent on three things; the mobile device, the wireless network, and the mobile application. When applying this to a construction situation, one must also consider the end user, the construction site, and the information being analysed (Chen & Kamara, 2011).

Barriers

There are many barriers that exist for Mobile Technology in the construction workplace, however few are inherent only within this industry. As the availability and reliability of the systems are constantly evolving, there is progress in overcoming these barriers, but a thorough understanding is required to ensure there is continual improvement.

The mobile device itself holds some difficulties for implementation. The size, visibility and the ease with which users can input data can be a burden (Saidi et al. 2002). Adding to this is the harsh conditions and exposure to the elements that are experienced on a construction site, mean that the device must be able to withstand these factors (Saidi et al. 2002; Kajewski & Alwi, 2006; Chen & Kamara, 2011). Device usage is also a multi-layered issue, which will need to be resolved by the industry before widespread acceptance will occur. Whether a mobile device should be company or employee owned is a difficult conundrum. As the mobile device is being used to access privileged information, data security issues are encountered when a user is storing this information on their personal device (Szycher, 2014). The expectation of personnel to use their own personal device is also met with objection, with the majority of users refusing to use their own device (Harun & Bichard, 2015). This can be overcome by the purchase and supply of company owned devices. As one of the benefits of using MT in the workplace is the widespread ownership and usage of suitable devices (eg. Smartphones), the need to supply devices is not a favourable outcome. Mobile phone policy is also an emerging issue that is facing MT uptake (Harun & Bichard, 2015). Many workplaces are moving towards limiting or banning mobile technology usage in the workplace.

The highly competitive nature of the construction industry means that any opportunities that offer an edge must be investigated. It is important that any investment provides a quality return, especially when outlaying on a new technology (Harun & Bichard, 2015). The perceived high cost of implementation is one of the major barriers identified for mobile technology (Williams et al. 2007). Small organisations have particular need for a high cost to benefit ratio when implementing new systems (Venkatraman & Yoong, 2009). Organisational issues also deliver various obstacles for acceptance and implementation. The low risk tolerance that many organisations hold for trying new approaches means that there is often a reluctance to vary from their current practices (Saidi et al. 2002). For a new mobile technology to easily align with these current practices, they must be integrated or compatible with the existing systems (Chen & Kamara, 2011; Szycher, 2014).

How well users interact with the application will rely on their ability to use mobile technology, and the ease of use of the application. Intuitive design can assist, however, the users proficiency will still limit the effectiveness of the application (Chen & Kamara, 2011). This can be overcome through education and training, but will add additional costs to the implementation process (Williams et al. 2002; Harun & Bichard, 2015). The reluctance of older members of the workforce to accept changes that require greater usage of mobile technology may also create an obstacle (Harun & Bichard, 2015).

These barriers also culminate in delivering some obstacles for mobile technology, in developing construction ready solutions. Anumba et al. (2003) suggest that when developing a mobile technology solution for the construction industry, the following needs to be considered:

- The cost and complexity of developing mobile applications,
- The focus on the end users requirements,
- The need to be able to integrate with existing systems,
- Being adapted to multiple platforms, and
- What the most appropriate form of technology is.

RESEARCH METHODOLOGY

A literature review was conducted as a preliminary step in the preparation of the research survey. It was used to develop an understanding of the existing body of knowledge on the topic of MT implementation in the construction industry. While a substantial amount of information currently exists, it was intended that this research would be used to determine if the same factors influence Australian industries.

The basis of the research methodology employed two approaches. A survey was used to gather a broad understanding of the topic and understand the usage of mobile technology in the participants' workplaces. The case study was then used to gain an in-depth understanding of the participants' perspective of the barriers that would exist in implementing the specific mobile technology example. The web-based survey was developed to analyse responses in three target areas. It investigated the respondents; demographics, the level of implementation of MT in their workplaces, and how readily the case study example could be implemented in their workplace. These two research design methods were selected, as it was deemed more capable of determining factors affecting Australian industries. The survey gauged responses through both closed and open questions. Key parts of the research used open questions to identify implementation factors without providing any influence to the participant's responses.

The population being considered in the research were those people working in Australian industries who use mobile technology in their workplaces. This population was been used to determine whether the barriers that exist with mobile technology implementation in Australian industries are analogous with other regions and industries. A web-based survey was used to gauge the responses from Australians across a number of industries. The survey aimed to gather a random sample of responses, being made available through CQ University Built Environment forums, LinkedIn and social media. However, judgemental sampling was required after the initial survey failed to deliver a suitable number of responses. This meant that specific approaches needed to be made to industry personnel for their feedback.

A case study mobile application was identified to analyse how readily it could be implemented into workplaces, and identify any barriers that exist for its implementation. Safe Start Inspections is a mobile technology company based in Brisbane. Their product that was used is a free vehicle management mobile application, which has adapted an existing paper-based checklist into an electronic system. The application was deemed to be a suitable example, as it reflected many of the qualities identified in the literature review as being a marketable application.

DATA ANALYSIS AND DISCUSSION

The initial collection of survey responses was slow, insufficient responses being gathered at the planned close of the survey. At this point, key people were approached to participate in the research. With only 14 responses, statistical significance was not calculated. The data was used to determine anecdotally whether the same factors identified in the literature review influenced technological implementation in the analysed workplaces.

Demographics

A range of industries were engaged, with Construction, Mining and Electrical Infrastructure dominating the responses. All participants represented industries that would be able to respond to both the MT and case study aspects of the survey suitably. Generally, the education and employment levels of the participants, demonstrated adequate ability to respond in the decision-making process surrounding business decisions. The age demographic presented a potential limitation with a disproportionate amount of respondents aged under 40. As approaches were made directly to participants through social media platforms, their proclivity for technological usage may have also create a response bias.

Mobile Technology

The current landscape of technology usage was gauged through the survey. Gaining an understanding of the current implementation levels of MT usage was able to determine whether the factors influencing Australian industries would reflect the findings of the literature review. A Likert scale was used to understand how effectively workplaces were using technology and how effectively changes were being implemented. Graphical representations of the results are shown in Figures 1 and 2. Respondents believed that their organisations had a slightly above average effectiveness of utilising technology with a mean response of 3.36 ($\sigma = 0.72$). This was in contrast to a slightly lower response for their organisations ability to implement change with a mean response of 3.21 ($\sigma = 0.67$). Interestingly respondents' perceptions were lower of their organisations ability to implement change than utilising technology, which at some point would have required a change to be implemented.

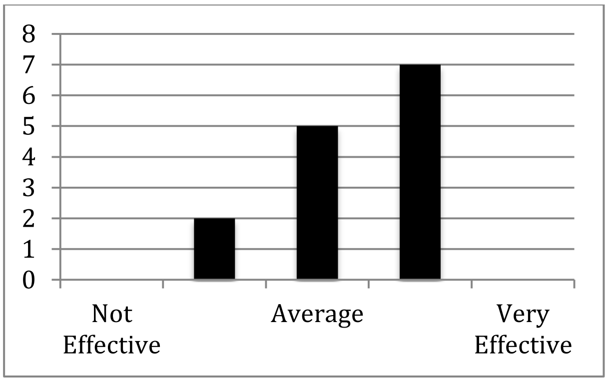

Figure 1- Effectiveness Utilising Technology

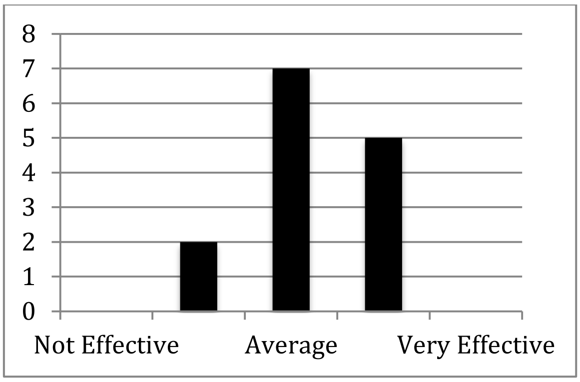

Figure 2- Effectiveness Implementing Change

The majority of workplaces had implemented some form of MT, with a number of examples being provided. Email, file-sharing and online systems for inspections, and incident reporting were being utilised. These types of activities represent the types of tasks that were identified within the literature review as being applicable for MT adaption. Device usage involved applications on multiple platforms and device types including mobile phones and tablets.

The results indicate that, while there has been some level of implementation of technology, it is still in its infancy, with only basic systems in place. The constraints that existed with previously implemented technologies, such as facsimile, are being reduced or eliminated through MT and its improving network infrastructure (Venkatraman & Yoong, 2009). With continuing improvements of affordable mobile devices, wireless data transfer speeds and the mobile applications, there is great potential to make improvements within the construction industry (Ferrada et al. 2014). The cost of simple processes can be reduced, by increasing the speed, quality and efficiency of information flow, with mobile technology applications (Chen & Kamara, 2011).

Case Study

Where participants were asked to respond to the case study example, the opportunity for improvement of an existing process was measured. Comparison between the effectiveness of the current vehicle management systems, and the ease of use of the mobile technology alternative was conducted. A Likert scale was used to determine the effectiveness of the current vehicle management system compared to the ease of use of the MT alternative. The effectiveness of current systems was average with a result of 3.15 ($\sigma = 0.77$), while the alternative provided a high ease of use result of 4.77 ($\sigma = 0.42$). Although the questions were not directly related, the ease of use responses highlight the potential benefits.

Table 2 Effectiveness of current vehicle management system

Effectiveness of Current Vehicle Management System				
Ineffective (1)	(2)	Average (3)	(4)	Very effective (5)
0	2	8	2	1

Table 3 Ease of use- Safe Start Inspections vehicle management system

Ease of Use- Safe Start Inspections Vehicle Management System				
Difficult (1)	(2)	Average (3)	(4)	Easy (5)
0	0	0	3	10

Through open questioning, the perceived benefits of the MT application were identified. These included:

- Ease of use (10)
- Efficiency of system (3)
- Instant access to information (3)
- Reduced paper (3)
- Accuracy of information (1)
- Mobility (1)

All participants responded that the case study mobile application would be readily implementable into their workplace.

Implementation Barriers

The barriers that have been identified through the survey reflect the existing body of knowledge. As shown in Table 4, industry respondents also detailed the barriers that were identified in the literature study. There were no new factors identified through the research, but the same influences were found to be impacting Australian industries.

Table 4 Barriers for implementation

New Technology Barriers	Case Study Barriers	References
Management reluctance (4)	Management authorisation (2)	Williams et al. (2007) Saidi et al. (2002)
Cost (3)	Cost (1)	Williams et al. (2007) Venkatraman and Yoong (2009) Chen and Kamara (2011)
System integration (2)	System integration (1)	Venkatraman and Yoong (2009) Szycher (2014) Chen and Kamara (2011) Anumba et al. (2003)
Computer literacy (1)	Computer literacy (1)	Harun and Bichard (2015) Anumba et al. (2003)
Procedural (1)	Procedural (1)	Harun and Bichard (2015) Venkatraman and Yoong (2009)
Mobile phone policy (1)	Mobile phone policy (1)	Harun and Bichard (2015)

Further investigation was used to identify how previous barriers had been overcome. This was useful in determining what steps would be required to encourage the adoption of new changes in the future. Participants identified a controlled implementation process and the use of training material as assisting in overcoming adoption issues. Training and education is a major factor in overcoming implementation barriers. It has been identified through survey responses and supported by previous research that increasing awareness of the benefits of MT will improve adoption in the future (Bowden et al. 2006).

When asked to make suggestions as to how the case study example may overcome implementation barriers, a range of different approaches were identified. It was suggested that barriers could be overcome by:

- Gaining management support,
- Further training and education,
- Integration with existing systems,
- Detailing the cost-benefit ratio,
- Encouraging cultural change, and
- Conducting trial implementation with smaller business sections.

Changing the mind set and initiating cultural change will facilitate greater implementation of MT and realise the full benefits of its usage. As stated previously, this will only be achieved through greater training and education. This will have effects on construction cost and schedules, operational and maintenance costs, defect management, safety and productivity (Bowden et al. 2006).

Research Limitations and Recommendations

This research was constrained by a number of factors. Firstly, the sample size is too small to develop any new conclusions from. A sample size of 14 industry personnel is inadequate when attempting to investigate new influences and identifying statistically significant relationships. This was offset by the use of a case study analysis, which provided the opportunity to assess the research problem within the scope of a detailed example. Although some factors that may be present in Australian industries may not be identified through this detailed approach, in-depth findings specific to the case study can be identified.

Another major limitation of the research is that the survey responses were based on the subjective judgement of the participants. With relaxed eligibility criteria for participation, the suitability of the respondents is virtually unknown. This limits the conclusions that can be drawn from the data, meaning they should only be used as indicators of trends that may be present. Regardless, the research has been useful in giving anecdotal support to the existing body of knowledge from current Australian workplaces.

CONCLUSION

The construction industry, like other industries, has shown some resistance to the adoption of mobile technology. Despite having many benefits, the endeavour to implement mobile technology in the construction industry is met with unique barriers. Data security, system integration, ROI, work procedures, and devise usage, present obstacles for organisations who desire a secure and easy transition to mobile technology. It is determined that greater education and training is needed to achieve better process efficiencies through MT use.

The survey conducted as a part of this research was able to provide anecdotal evidence that the factors identified in the literature study are currently present in Australian industries. Further research is recommended for greater understanding of the relationships between the identified factors in the specific Australian context.

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BELOW-GRADE WATERPROOFING AND THE NEED FOR STANDARDISATION

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ABSTRACT

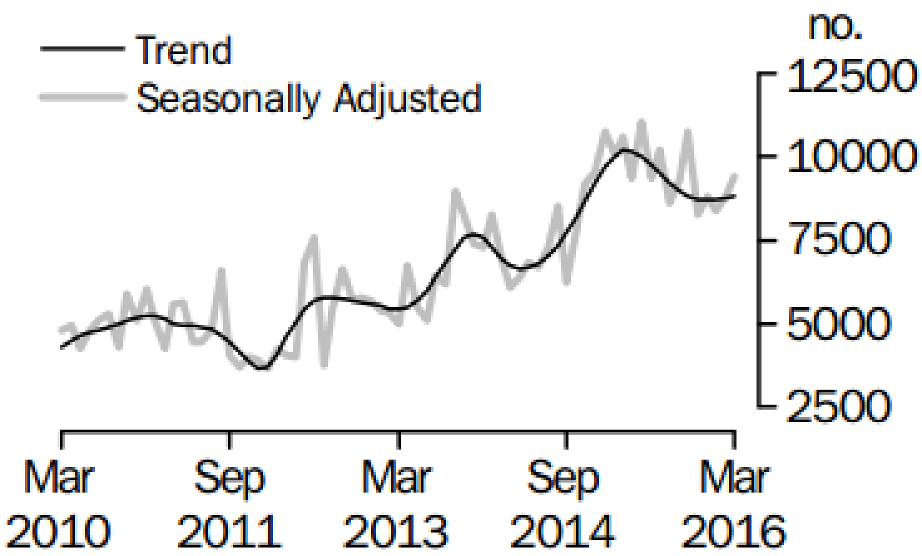
Waterproofing plays a major role in providing amenity throughout the lifecycle of any structure. The increasing demand for high density dwellings will prompt many construction industry professionals to redirect their focus on this sub-sector. However, a lack of published guidance for designers and contractors inexperienced with this structure type leaves building owners and occupants to problems resulting from water ingress over the life of the structure. This report focuses on the current state of below-grade waterproofing and the benefits associated with standardizing this component of structures. Common methods of below-grade waterproofing will be detailed along with risks associated with the insufficient use of appropriate waterproofing methods. Existing guidelines for waterproofing in Australia will be evaluated and the need for a below-grade specific standard will be identified. Findings include multiple existing waterproofing standards though none are directly relevant to the design and installation of below-grade waterproofing systems. This finding does not provide an immediate solution to the problem but identifies potential benefits required for development of this standard. Based on this a recommendation is made that a formal proposal for new standard be made to Standards Australia.

Keywords: Below-Grade, Design, Install, Standard, Waterproofing

INTRODUCTION

Due to the growing populations of Australia's major cities the development approval rate of high density non-house dwellings has increased significantly in recent years, from 5,000 to 10,000 (+100%) per month from 2011 to 2015 as shown in Figure 1, while private sector housing approvals increased from 8,000 to 9,500 (+19%) per month in the same period (Australian Bureau of Statistics (ABS), 2016). For the first time there is consistently more approvals to build new apartments than free-standing houses, driven by high demand for inner city housing among buy-to-let and buy-to-sell investors due to record low interest rates (The Sydney Morning Herald, 2015).

Figure 1: Approvals for Private Sector Dwellings Other Than Houses



(Australian Bureau of Statistics (ABS), 2016)

It is the nature of high density dwellings to be built both up and down from ground level to make efficient use of land area. Historically, structures have been built primarily above ground but the increasing popularity of high density dwellings means it is becoming more common for dwellings to have up to 20% of the structure situated below ground level. While the construction of below grade structures is not a new concept, it has been considered a niche skill due to its infrequency relative to above grade construction. How then are contractors and consultants developing below grade waterproofing systems and what guarantee of quality is there for the on structures with potential lifespans of over eighty years? This is particularly relevant as modern refurbishment projects can include existing basement carparks being repurposed into habitable space.

LITERATURE REVIEW

The primary factor separating below grade and above grade water management methods is the presence of hydrostatic pressure. Hydrostatic pressure drives water through small cracks and porous surfaces causing water ingress to areas that would typically not be susceptible in above grade locations. Ground water level and the consequential hydrostatic pressure can vary seasonally, daily or even hourly depending on tidal, rainfall or other events that provide large quantities of water (Henshell, 2000). There are currently four popular methods of preventing below-grade water and vapour ingress.

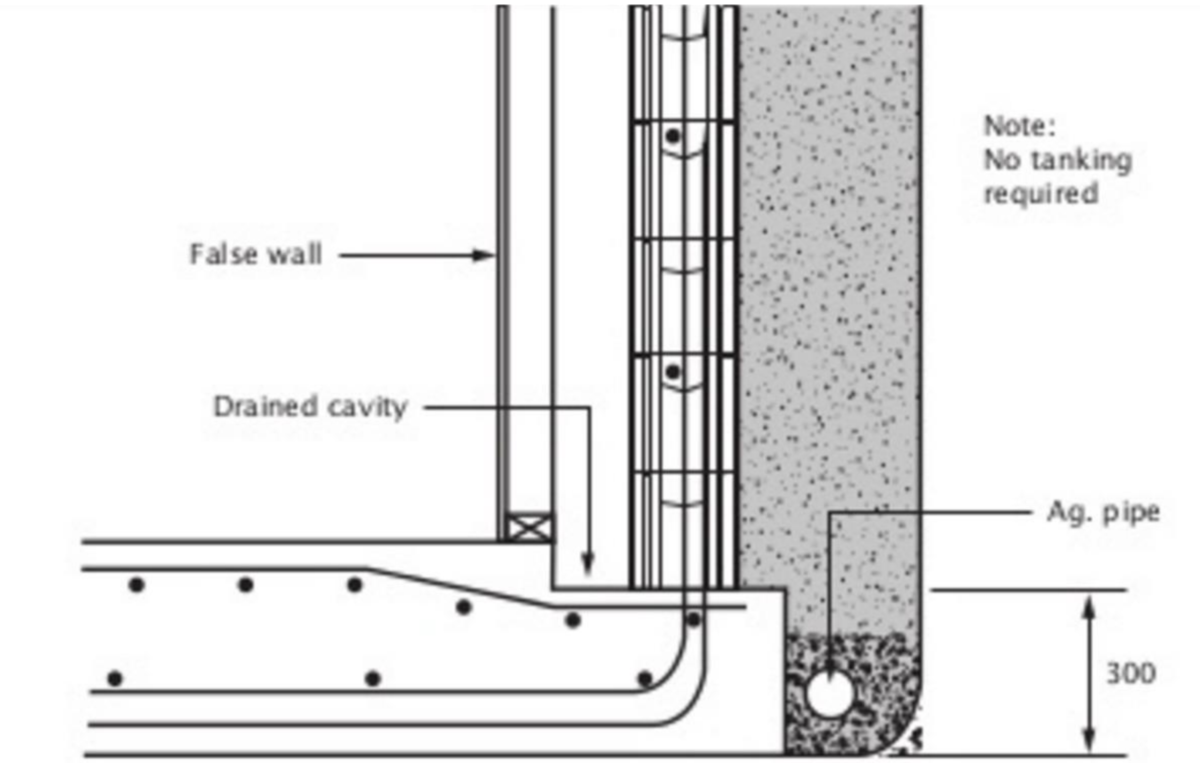
Positive side waterproofing refers to waterproofing membranes applied to the blindside or external surfaces that form an impermeable bladder preventing ground water from making contact with the structure. Coal tar pitch and bitumen systems were common prior to the introduction of volatile organic compound (VOC) initiatives and have since been replaced in popularity by prefabricated sheet systems. Sheet systems can be made from polyvinylchloride (PVC), rubber modified bitumen or bentonite mineral clay, applied to the basement envelope prior to the reinforcing and concrete works. (Henshell, 2000)

Negative side waterproofing is waterproofing membranes applied to the internal surfaces of the structure. These systems typically consist of a dense cementitious or crystalline coating that contains iron or aluminium filings which oxidise and expand to fill porosity during hydration. However, this method offers no protection to the structure from soil contaminants which may be corrosive to concrete, masonry or reinforcing steel (Haisley, 2001). Additionally, the lack of positive water vapour control may lead to condensation issues developing on the internal surface of the building envelope (Buccellato & Henshell, 2011).

Integral waterproofing systems include products added to the concrete mix during production to mitigate water transfer through the concrete. There are a range of integral waterproofing products, commonly known as admixtures, that all function by reducing the porosity of concrete to prevent water entering it. However, it is important to acknowledge that waterproof concrete does not equate waterproof construction as water and vapour can still bypass through joints, penetrations and cracking. (Waterproofing Magazine, 2010)

Water management methods are those where no waterproofing measures are applied and as hydrostatic pressure accumulates the water is allowed to flow through the external wall to be captured by a drainage network and pumped into a storm water system. Figure 2 shows a block retaining wall with no waterproofing system and a spoon drain in the cavity intending to catch the water and divert to a sump for pumping. The intention is that the cavity will be ventilated (also known as an 'air plenum') and water ingress through the wet wall will be ventilated out before penetrating the false wall.

Figure 2: Air Plenum Design Section



While ground conditions may be acceptable during design/construction it is possible that they may change over the course of the structures life and negatively impact its lifespan. It may be possible to mitigate some negative outcomes using remedial methods such as resin injection, though it is likely that ad hoc approaches will be significantly more expensive than installing an adequate waterproofing system during construction.

The Building Code of Australia (BCA) Volume 2 Part 2 includes performance requirements to safeguard occupants from illness or injury and protect the building from damage caused by surface water, waste water and/or moisture entering or accumulating in the building (ABCB, 2015). There are various risks worthy of consideration that may result from ineffective water management measures.

Amenity - The most obvious negative effect of water ingress is when it damages a property and renders it undesirable or unusable by its occupants. Figure 3 shows a basement carpark wall responsible for water ingress during rainfall periods, leaving the carpark with water throughout. Additionally, continued seepage of water through concrete results in efflorescence, the white powdery substance shown in Figure 3, as salts are leeched from of the concrete (Bannister, 2015).

Figure 3: Basement Wall Water Ingress in Liverpool NSW

(Previte, 2016)

Health - The most common health issues arising from wet or damp buildings is the fungal growth known as mould. The New York City Department of Health and Mental Hygiene released a document stating adverse health effects from the inhalation of airborne fungal spores in residential environments may include allergic reactions, toxic effects, irritation and infection. Internal mould found in existing structures can be minimised or prevented by actively maintaining, inspecting and correcting buildings for moisture problems and immediately drying and managing water damaged materials (New York City Department of Health and Mental Hygiene, 2008).

Building Lifespan - All structures decay over time, though it is plausible to suspect that a below grade structure exposed to water and moisture may decay at a faster rate. It has been proposed that a structure without positive side below grade waterproofing will have protection from soil contaminants which may be corrosive to concrete, masonry or reinforcing steel (Haisley, 2001). This is particularly relevant to wet wall systems that have a continuous flow of water with contaminants that are constantly being transferred into that wall. Figure 4 shows the early stages of decay on a block wall that is promoted by water ingress at the wall/floor junction.

Figure 4: Block Wall Water Ingress Causing Decay

(Forever Dry Basements, 2016)

Solutions designed by consultants and constructed by builders must be sufficiently compliant with the BCA for certification, but there is no guarantee that the methods used are actually capable of meeting BCA performance requirements for the lifespan of the structure.

Standards are published documents setting out specifications and procedures to ensure products, services and/or systems are safe, reliable and consistently perform the way they were intended to. Common sources include International Standards (ISO), European Union Standards (EN) and Australian Standards (AU). Standards make a sustained contribution to generating national wealth, improving quality of life, increasing employment, improving safety and health and using our national resources more efficiently. Both social and economic benefits of standards can be seen wherever they are implemented as demonstrated in these examples –

- AS 5100 for bridge design has improved public safety, guidance for engineers, reduction of design and maintenance costs and increased knowledge from committee participation (Standards Australia, 2015).
- The Green Building Council of Australia has produced a research study showing that Green Star guidelines have provided buildings with 62% fewer greenhouse gas emissions, 66% less electricity, 51% less potable water and 96% of demolition waste recycled on Green Star certified buildings (Green Building Council of Australia (GBCA), 2013).

- NOM-001-ECOL-1996 is the microbiological standard in Mexico that allows water reuse in to be more realistically policed, by reducing the amount of monitoring required (Peasey, et al., 2000).

- AS 3000 is the Australian Standard for Wiring Rules that has contributed to the protection of life and property, reduction of occupational health and safety risk, guidance for electricians, assists law-making, provides uniformity and benchmarks for safety (Australian Standards, 2015).

Based on the proven benefits of standardization in other sectors, it can be assumed that the benefits that may be achieved from developing a below-grade waterproofing standard include occupant health and safety, reduction in design and maintenance costs, guidance for engineers, consultants and contractors and improving consumer confidence in the quality and life expectancy of structures.

With Standards Australia so respected by Australian industries that the organisation's documents quickly become established as best practice and are often adopted voluntarily by corporations. Therefore, a waterproofing standard from Standards Australia has a high chance of achieving consensus and becoming the single point of reference above all others. The standards relevant to waterproofing structures currently available are -

- AS 3740-2010 is currently adopted by reference in the BCA Volume 1 Part F1.7 and Volume 2 Part 3.8.1. This standard sets out the minimum requirements for the materials, design and installation of waterproofing for domestic wet areas. AS4858-2004 includes criteria that, when met, ensure that domestic wet areas will achieve the required performance standard.

- AS 4654.1-2012 & AS 4654.2-2012 are currently adopted by reference in the BCA Volume 1 Part F1.4 and Volume 2 Part 3.8.1. These standards set out requirements for materials (Part 1) and design and installation (Part 2) of waterproofing membranes used in buildings and structures.

- ASTM D7832 is an international standard for performance attributes of waterproofing membranes applied to below-grade vertical surfaces enclosing interior spaces. Although it is an international standard that is not referenced by the BCA, it is able to provide useful guidance to contractors and consultant in the Australian construction sector.

As shown in Table 1, the standards currently available cover the waterproofing requirements for all elements of a structure with the exception of design and installation of below grade waterproofing elements. In fact, AS4654.2 specifically states that this standard is not intended for use in applications below ground level (Standards Australia, 2012). With no national or international standards available to provide guidance on this subject the option does remain available for the development of a standard to address current needs.

Table 1: Waterproofing Standards

	Materials Performance	Design & Installation
Internal Wet Areas	AS3740-2010 AS4858-2004	AS3740-2010
Above-Grade External	AS4654.1-2012	AS4654.2-2012
Below-Grade External	ASTM D7832/D7832M	

Newly proposed Australian Standards are reviewed and approved based on the ability to deliver a 'Net Benefit' that is assessed based on the following criteria

- Public health and safety
- Social and community impact
- Environmental impact
- Competition
- Economic impact

The proposed standards will be approved/denied and prioritised based on their ability to meet this criteria (Standards Australia, 2015).

CONCLUSION

The shifting demand from low density suburban to high density residential and commercial structures in Australia has required the construction sector to adapt to meet the new market conditions. Designers and contractors are deviating from their previous focus toward high rise structures that include below-grade elements commonly include car parks and plant rooms. The designers, contractors and consumers must be confident that methods employed for below-grade waterproofing will effectively maintain the amenity and health of the building for its anticipated lifespan as it is common to see basement spaces repurposed into habitable spaces that require much higher quality standards than the previous carparks. The intent of this report was to evaluate the need for standardization for below-grade in the Australian construction sector. This was achieved by analysing common below-grade water management methods, risks associated with inadequate waterproofing, current requirements for standards for waterproofing in Australia and the anticipated benefits based on standardization in other sectors.

It was determined that there is currently a wide range of below-grade waterproofing systems available although there is no guarantee that the appropriate system will be selected for any given structure as these decisions are not based on any information source consistently and are often motivated by aspects other than the long term performance of the building. It was found that while there are currently Australian Standard documents for internal waterproofing and above-grade waterproofing, none currently exist for below-grade waterproofing. This gap in guidelines for the design and installation of below-grade waterproofing membranes leads to discontinuity in the standardisation of waterproofing of structures in Australia. One limitation of this review is that it is unable to take into account any standards that are currently being developed and have not yet been published. For example, it should be noted that ASTM International does have an open work order labelled Guide for Design of Waterproofing Membrane Systems Applied to Below-Grade Walls Enclosing Interior Spaces (ASTM International, 2016).

Based on the findings of this literature review it is proposed that a rigorously developed standard, like those produced by Standards Australia, for below-grade waterproofing should be introduced to mitigate the identified risks to building amenity health and lifespan. This recommendation is supported by case studies of benefits achieved through standardisation to other sectors, providing potential benefits such as reduction in lifecycle costs, guidance to interested parties and an average improvement of health and amenity in below-grade structures. A proposal for a new standard should be made to standards Australia that would include a thorough 'net benefit analysis' appropriate for the size and impact of the proposed Australian Standard. Standards Australia conducts a formal submission, assessment and approval process twice each year that will determine if the proposal has merit and will move in development phase.

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INVESTIGATION OF HUMAN RESOURCE MANAGEMENT IN THE CONSTRUCTION INDUSTRY USING MOTIVATION-HYGIENE THEORY: A CASE STUDY

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ABSTRACT

Construction organisations are generally large and complex; strong internal and external relationships are often extremely difficult to develop and maintain. This research paper aims to better understand how the realities of organisation life affect human resource management of construction projects. Literature review of this study covers evolution of organisation structure, and factors influencing centralisation and decentralisation of power in an organisation. A main objective of this study is to investigate human resource management in the Construction Industry through a real-world case study using Motivation-Hygiene Theory. Findings from this study would be useful to both business owners and employees.

Keywords: Human resource, organisation structure, construction industry, success factors

INTRODUCTION

Significant skill is required to operate a successful organisation in the Construction Industry (Gary et al., 2000). Construction businesses are typically large and complex and strong internal and external relationships often extremely difficult to develop and maintain (Eriksson, 2013). The Construction Industry employs many hundreds of thousands people, thus it is critical to understand how people are organised, looked after, motivated and led. It is often suggested employees at project level (for example Project Managers and Contract Administrators) do not have the correct authority to carry out their job responsibilities successfully, however they are held accountable (Davidson Frame, 1988). Additionally, many Construction Industry professionals advocate Senior Management's desire for control is negatively impacting on the success of construction projects and tarnishing relationships (Davidson Frame, 1988).

A main objective of this paper is to investigate how the realities of organisation life affect human resource management of a construction project. The study began by reviewing evolution of organisation structure, as well as factors influencing centralisation and decentralisation of power in an organisation. The study then investigated human resource management in a construction project in Australia as a case study using Motivation-Hygiene Theory.

LITERATURE REVIEW

Evolution of Organisation Structure

An organisation structure defines the hierarchical arrangement of lines of authority, communications, rights and duties of an organisation; it determines how roles, power and responsibilities are assigned, controlled and coordinated. Additionally, organisation structures identify how information flows between the different levels of management. The organisation structure is unique to each individual company and is dependent on the organisation's objectives and strategies. There are four (4) types of organisation structures that are commonly adopted by companies today (Usmani, 2012; Wood, 2016):

1. Traditional (Classical) Organisation Structure

2. Functional Organisation Structure

3. Product Organisation Structure

4. Matrix Organisation Structure

Traditional Organisation Structure (also referred to as the Classical Organisation Structure) has existed for more than two centuries. Under traditional management the General Manager of the company is positioned at the top, with the chain of control descending through the levels of the company. All organisational activities are performed within the functional groups, which are headed by a Department (or in some cases, a Division) head. Additionally, levels of authority and responsibility are clearly defined due to each employee reporting to only one individual (Usmani, 2012; Wood, 2016).

A Functional Organisation Structure is best suited to smaller companies or those whose primary purpose is to produce standardised goods and services. Functional Organisation Structures are most effective in a stable environment where amendments and/or updating of company strategies are minimal. The functional units consist of personnel with various, however related, skills grouped by similarities. Each functional unit is responsible for one primary function of the organisation. Top management is responsible for coordinating the efforts of each unit and meshing them together into a cohesive whole. Usually the position of the Project Manager (or Project Leader) does not exist in functional organisations. However, if the position does exist, the role will be very limited and Project Managers/Project Leaders would have minimal authority (Usmani, 2012; Wood, 2016).

A Product Organisation Structure involves Managers reporting to Company Owner/Executive by product type. Large organisations, such as schools, universities, hospitals, governments, often divide their structure into product divisions. For example, schools consist of Science, English, Arts, Physical Education and Mathematics departments and hospitals divide their work into outpatients, accident and emergency, ear, nose and throat and so on (March, 2009). Additionally, construction companies may utilise this structure by dividing their business between types of work (i.e. civil engineering, housing and building projects) or procurement methods (i.e. Traditional, Design and Build, Private Finance Initiative (PFI)). There will be certain activities that will be undertaken centrally on behalf of the organisation, such as human relations management, public relations and marketing (March, 2009). The main advantage of adopting a Product Organisation Structure is that attention is focused on each division, which may have different requirements and expertise from the others (March, 2009).

A Matrix Organisation Structure is mainly used in the management of large projects or product development projects, using teams of specialists from different functional areas in the organisation without removing them from their respective position. The Matrix Organisation Structure is a company structure in which reporting relationships are established as a grid, or matrix in lieu of a traditional hierarchy. Essentially, employees have dual reporting relationships, to both a Functional Manager and a Product or Project Manager (Woods, 2016). Employees report on daily performance to the Product/Project Manager, whose authority flows sideways (horizontally) across departmental boundaries. The employees also report on their overall performance to the Department Manager whose authority flows downwards (vertically) within his or her department (Woods, 2016).

Centralisation and Decentralisation

Centralisation is defined as concentrating the power and authority to make decisions towards or at the top of the company. Alternatively, decentralisation is the delegation of power and authority to make decisions at the company's lower levels. No organisation is entirely centralised or decentralised, however will generally be primarily one or the other. There are five (5) main factors as shown in Table 1 that largely influence the degree of centralisation and decentralisation within a company (March, 2009).

Table 1 Factors that influence centralisation and decentralisation

Factor	Description
Management's philosophy	Some managers adopt Likert's exploitive and benevolent management styles: - Believe in strong central control and want to be in control. Build a close team around them of quality people and make all major decisions - Organisation's lower levels are instructed what to do. Believe staff at lower levels fit into Douglas McGregor's 'Theory X'. Other manager's adopt Likert's participative management style: - Delegate majority of decision making and accompanying responsibility and accountability to personnel that have appropriate information available to make the best decisions. - Believe staff fit into Douglas McGregor's 'Theory Y'.
Organisational growth	Companies that grow and remain centralised do so usually as a result of the way the company was set-up initially. Expanding or merging organisations as a result of further acquisitions generally become decentralised due to: - Different cultures of the businesses. Different products or services. - Geographical diversity of the businesses. - Management structures already in

	place (although likely to be radically changed as part of the merger and takeover process). - Size of the organisation.
Geographical diversity	Greater the geographical diversity of the company the more likely the organisation is to be decentralised (due to difficulty to control from distance). National companies set-up regional offices and employ staff who understand: The local market and supply change. In addition to above, International companies have further issues to deal with: -Time differences between the different parts of the organisation. -Customs and practices of different countries.
Quantity and quality of managers	Decentralisation requires sufficient qualified and competent managers to take responsibility and make sound decisions.
Diversity of products and services	Many organisations move from centralised to decentralised (and vice versa) approximately every two decades to cope with the diversities of the industry in which they operate.

(Source: March, 2009)

CASE STUDY

Project A began in mid-2010 and was completed in late 2012. The redevelopment consisted of four stages with nine separable portions. The main components of work included a new 2-level 12,000m2 MYER Store, 4,200 m^2 Woolworths supermarket, 750 seat food court and 3-level car park. Tier 1 construction company, Contractor B was engaged to complete the works under a Design & Construct Contract.

The Project Team of the Contractor B experienced multiple issues throughout the project, consequential to decisions made by upper management and the delegation of authority. Two major issues included programme delay due to the exclusion of wet weather allowance and Force Majeure from the Contract Agreement and strained subcontract relationships consequential to delayed approval of variation orders.

In the final contract negotiation stages, Contractor B executives agreed to no wet weather allowance and removal of the Force Majeure Clause from the Contract Agreement. On Thursday, 3rd February 2011, Cyclone Yasi (category 5 system) made landfall on the North Queensland Coast with damaging winds and heavy rainfall. Cyclone Yasi was one of the most powerful cyclones to have affected Queensland since records commenced (Australian Government Bureau of Meteorology, 2011). The construction works were severely delayed due to the natural disaster: The site was flooded, the two cranes had to be re-erected (were dismantled prior to the cyclone). This delay in conjunction with significant Liquidated Damages/per day put immense pressure on the project team from the very beginning of the project. Site visits from upper management were never positive; one particular visit Upper Management advised the Project team they were not able to take Annual Leave for a significant period of the project and would have to work Saturdays to make up the time. As a result, the Project Team lost motivation, resented upper management and left the company.

Frederick Hertzberg 'Motivation-Hygiene Theory'

Frederick Herzberg's 'Motivation-Hygiene Theory' (also known as 'Two-factor Theory') states an individual has two sets of needs: First to avoid pain and second to grow psychologically. Herzberg's 'Motivation-Hygiene Theory' distinguishes between two factors (Chartered Management Institute, 2003):

1. Motivators: For example, responsibility, involvement in decision making and sense of importance to an organisation that provides positive satisfaction, arising from intrinsic conditions of the job itself.

2. Hygiene: For example, job security, work conditions and vacations that do not provide positive satisfaction or lead to high motivation, however dissatisfaction results from their absence.

According to Herzberg there are four (4) possible combinations:

1. High Hygiene + High Motivation:

- Employees are highly motivated and have little complaints.

- Ideal situation.

2. High Hygiene + Low Motivation:

- Employees have few complaints, however are not highly motivated.

- The job is viewed as a pay check.

3. Low Hygiene + High Motivation:

- Employees are motivated; however have a significant number of complaints.

- Job is exciting and challenging, however salaries and work conditions are poor.

4. Low Hygiene + Low Motivation:

- Employees are not motivated and have many complaints.

- Worst situation.

The working environment of Contractor B’s Project Team aligns with the worst possible outcome of Hertzberg’s ‘Motivation-Hygiene” theory: “Low Hygiene + Low Motivation”:

Low Hygiene:

- Work conditions were poor (long hours and six day working weeks).

- Vacations were scarce (no annual leave allowed to be taken for a period of time).

Low Motivation:

- No involvement in decision making.

- Poor sense of importance and responsibility within the organisation.

CONCLUSION

The study investigated human resource management of the construction project as the case study using Motivation-Hygiene Theory. The theory highlighted a number of key considerations for managing human resource in the case study. These include workload management, vacation management, involvement in decision making, and sense of ownership. This study therefore points out the areas that an organisation should pay more attention in its human resource management. A main limitation of this study is that there was only one case study conducted. As such, future research may apply Motivation-Hygiene Theory to study other cases and find ways to mitigate human resource management problems found in each case.

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REVIEW ON BID OR NO BID DECISION FACTORS

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ABSTRACT

Recent economic indicators globally tend to suggest cautious behaviours amongst businesses. There is a wealth of resources on bid or no bid decision in literature. However, as things are changing, extant models need some revamping if they are to keep pace with current economic conditions that are challenging our industry. The purpose of this review paper is to explore extant frameworks for developing bid or no bid decision models and to point out possible variables that future research studies can focus on. Such contributions are important: current economic conditions are affecting the various sectors of the construction industry differently. When the key decision factors are elicited, future research can further analyse them to point out the factors that support specific elements of the construction business space e.g. small, institutional, major and mega building construction; civil and resource engineering construction, and; specialist projects [such as space and terra projects].

Keywords: bid decision factors, construction business, economic climate, procurement

INTRODUCTION

Bidding processes are complex. It is not often a simple decision for contractors to bid or to decline to bid after invitations to bid have been received. First, it is paramount that contractors understand clients' requirements. Many studies have reported this as ambiguous, ambitious and incoherent (Kamara et al., 2000; Kamara et al., 2002; Shen et al., 2004; Singh et al., 2011). The best of contractors' intervention on this (e.g. helping to define clients' own requirements) may not reduce contractors' own exposure to risks such as disputes and complication to commercial interests (see Kometa et al., 1995 and Younis et al., 2008). More importantly, the commercial reality of contractors' involvement in project development processes is also susceptible to many soft factors. For example, on the one hand, it is not sufficient that a contractor has calculated his cost accurately, clients are at liberty to pick from a pool of alternatives that are within close range. Skitmore and Patchell (1990) have captured this scenario more aptly. The authors argue that the challenge before a contractor when bidding may not go beyond the desire to win, rather than being realistic about project success. A plethora of strategic models is available around this phenomenon (Baloi and Price, 2003; Cattell et al., 2007; Skitmore et al., 2007).

On the other hand, cost is a dynamic phenomenon. Bidders must know how to deal with the multiple attributes of cost. Baloi and Price (2003), and Olatunji (2010) have all reported a wide range of factors that could impact cost performance. These include macro-economic factors such as inflation, cost of finance, national income, resource availability, project complexity, government stability and the state of national economy. Each of these factors affects different sectors of the construction industry, and business sizes, differently. Analysing extant knowledge on bid or no bid decision factors in line with these factors will help to construct new tools that can help construction bidders in current and future tough times.

BID DECISION FACTORS

A research by Skitmore et al. (2000) has explained the ideal focus of bidders when considering their options as to whether to bid or not to bid for new projects. The authors indicated the need for contractors to always consider bidding as a comprehensive and intensive process of data collection, involving investigation of endogenic and exogenic factors. Endogenic factors relate to organisational capabilities and contractor's own resource strength. Exogenic factors relate to external conditions and project characteristics which are often exclusive to contractors' control. The specific elements of these factors are shown in Table 1.

Table 1: Bid or no bid decision factor of contractors

	Bid-no-Bid Decision Factors	Bagies and Fortune (2006)	Bagies and Fortune (2009)	Lemberg (2013)	Ma (2011)	Jarkas et al (2014)	Lowe and Parvar (2004)
A	*Project operation factors*						
1	Availability of equipment	x	x	X	x	x	x
2	Availability of qualified staff	x	x	X	x	x	x
3	Difficulty in obtaining finance	x	x	X		x	
4	Previous relationship with client	x	x	X		x	x
5	Availability of other projects	x	x	X	x	x	
6	Availability of qualified subcontractor	x	x	X		x	
7	Resource price fluctuation	x	x				
B	*Construction business environment generally*						
1	Nature of project	x	x	X	x	x	x
2	Size of project	x	x	X	x	x	x
3	Cashflow arrangement required	x	x		x	x	x
4	Client type	x	x			x	
5	Project location	x	x			x	x
6	Type and number of equipment required		x		x	x	
7	Consultants' interpretation of client's requirement	x			x		
8	Safety hazards	x	x			x	x
9	Identity of owner/ consultant	x	x			x	x
10	Proposed timescale and penalty for non-completion	x	x		x	x	
11	Degree of technological difficulties				x	x	
12	Site space constraints	x	x				
13	Amount of work subcontracted via client nomination		x		x		
C.	*Contractors' organization*						

1	Expected rate of return on investment	x	x		x		
2	Ability to self-finance project	x					
3	Contractor's ability in specified construction technique	x	x				x
4	Contractor's reputation	x				x	
5	Competence of estimators					x	
6	Experience in similar projects	x	x		x	x	x
7	Involvement in design and innovation		x				
8	Strength of business partners/ subsidiaries	x	x		x	x	
9	Desire for continued employment of personnel				x		
10	Adequate information on resource market	x		X			
11	Expertise in management and coordination	x	x				
12	Current workload		x		x	x	x
13	General office's overhead recovery	x	x				
14	Familiarity with site conditions	x	x			x	x
15	Share of market	x	x	X		x	
16	Reliability of subcontractors	x	x			x	x
D.	*Bidding requirements*						
1	Required bond arrangement	x	x			x	
2	Accuracy of contract documents		x			x	
3	Prequalification requirements	x	x		x	x	
4	Categories of contractors expected to bid		x			x	
5	Time allowed for bid preparation		x		x	x	

Extant literature on bid or no bid decision factors is robust. Internals factors, which are largely controllable by contractors have been well documented (see Akintoye and Fitzgerald, 2000; Chan et al., 2004; Chua, et al., 2001).

- Project Operation factors: It is important for contractors to consider basic risk factors relating to a proposed project before they bid. In essence, before contractors bid for a project, it is crucial that they possess, or are able to hire, the required equipment at reasonable costs (Ma, 2011). It is also important that they have the staff to that will facilitate the success of the project. Finance is important too: finance pre-conditions must be project-friendly (Bagies and Fortune, 2009). To these, Jarkas et al (2014) added previous and current relationship with clients, volatility in resource price regimes, whether other projects are available for bidding at the time of bidding for a particular project, and whether there are capable sub-contractors around to help with the project.

- Contractors' Organizational factors: Bagies and Fortune (2006, 2009) have argued that contractors' decision to bid often have strong correlation with their business intendment and 'weight' (e.g. market share) within the business space. For example, some project are likely to promote the reputation of the contractor, some are not. Thus, it is easier to bid for a project that promote a firm's reputation; and this is much easier if the contractor has had substantial experience in similar projects in the past, and has had (or still have) considerable expertise in managing and coordinating resources relating to the proposed project. According to Bagies and Fortune (2006), other key elements of contractors' organizational factors include whether the project meet the contractor's expectation regarding rate of return expected, contractor's current workload at the time of bidding and whether there are partners/subsidiaries and reliable subcontractors to help with the project. The authors also think that contractors are incentivised to bid if they are able to self-finance the proposed project, if they are able to recover their general overhead costs, and if they have considerable knowledge and information about the local resource market. Jarkas (2014) also added competence of estimators to prepare a competitive bid for the project and familiarity with site conditions. Ma (2011) also added contractor's desire to keep staff in continued employment.

- Contractors' business environment: According to Ogunlana (1988), construction firms are registered by government to undertake specific types of projects e.g. it is illegal for building contractors to bid for civil works unless they are legally registered to work in both domains. In addition, firms that do not have the requisite capacity to bid and succeed on a mega project should simply not bid for super-large projects. Bagies and Fortune (2006, 2009) also identified cashflow, client types and project location as key factors that contractors consider whether to bid or not to bid. For instance, small firms may choose not to bid unless they are paid in advance at least once during the life of their contract. It is also their prerogative to choose to work for either public or private clients, or both. In addition, small firms will only reduce their overhead cost (hence they have competitive advantage) when their project sites are within close proximity to their offices. They are also likely to reconsider their decision to bid if they have constraints in sourcing appropriate types of equipment at the right time and in the right number – they will incur loss on their projects if equipment is not available abundantly and persistently. Ma (2011) and Jarkas (2014) have added consultant interpretation of client requirements in developing contract documents. This is because contractors are more likely to have pragmatic approaches to their work than contractors, whose standpoint could be unnecessarily wasteful. Another important dimension to this is the identity of the consulting firms (and the reputation and the relationships they have add with the contractors). Small firms are also not likely to bid where projects are overly unsafe and the technological requirements are highly complex. Similarly, they are not likely to bid where site conditions are difficult, and penalties for delayed completion are high. Bagies and Fortune (2009), and Ma (2011) found that construction firms are not likely to bid if their portion of the work will not fulfil their business objectives.

- Bidding requirements: Small contractors are only able to bid if they meet the specified bidding requirements. This often involve several qualification pre-conditions such as financial stability, occupational health and safety requirements, corporate social commitment, technical strength and general information about a contractor's firm (and its owners) (see Aje, 2012). According to Jarkas (2014), the decision to bid or not to bid is often shaped by length of time allowed for bid preparation, the categories of contractors invited to bid, accuracy of contract documents and the required bond arrangements.

Combining endogenic and exogenic variables involves complex protocols, as the construction economy is susceptible to frequent shocks within the larger economies. As Chua et al. (2001) suggested, a decision to bid or not to bid requires a comprehensive evaluation of risk elements in line with bidders' own competitive advantages as well as competitors'. This observation is consistent with extant studies on the subject of bid-no-bid decision making e.g. Krasnokutskaya and Seim (2007), and Wanous et al., (2003). The studies identified factors that affect contractors' bid or no bid decision, however the studies are not consistent in terms of the importance of the factors. More importantly, construction business environments are sufficiently distinguishable (e.g. by the uniqueness of their inherent attributes). The decision factors are not likely to be the same both in identity and level of importance in different parts of the world.

INSIGHTS FOR FURTHER RESEARCH

There are over 330 thousand construction businesses in Australia presently. Most of these, about 98 percent, are small and medium size business outfits that have no more than 20 permanent employees on their payroll. Certainly, small and medium sized construction business outfits in Australia contribute more to the economy of the construction industry than large and super-large firms. Although neither of these may be less important, there are three dimensions to the nuanced challenges facing each of the different sizes of construction businesses in Australia. First, most new construction business outfits are more likely to start as small firms than as large firms; existing small firms have had to feel comfortable in their skins, then increase in size. A key factor in a construction business outfit's survival is their ability to take appropriate decisions when it matters. This includes when to bid, how bid and the projects to bid for; relative to the contractors' business environment. The second dimension to this is that businesses of different sizes are unlikely to have equal knowledge depth. Large firms should have had more robust experience and support resources that could help in their decision making, than smaller firms. The third dimension is that normative literature has elicited a long list of factors, most times between 50 and 80 factors. It is difficult for bidders to consider these many factors within the short time window they operate under during bidding. In addition, inferential evidence on the relationships between the factors, and how they impact bid success, is understudied.

It is important that future research focus on these dimensions. For example, research on bid or no bid decision factors will impact construction businesses more effectively if research efforts are focused on business sizes, specific business environments, project types, and the legislations under which the businesses operate. It is also vital that the many factors that are available in literature are narrowed down into a smaller number that businesses are able to relate with. For example, by using scoring factor and reductionist methods, it is possible to elicit the top 10 factors that explain the most variances amongst the many factors that are available in literature. Such analysis will also make it easier to understand the statistical relationships between the factors, and how they impact bid success either collectively or individually. The overarching importance of these is that such further research outcomes will improve decision making processes of construction businesses through simplified objective instruments that are specific to their environment and problems, rather than global indexical suggestions.

CONCLUSION

Bid decision is important to construction businesses, and construction businesses are significant contributors to national growth. However, Success of construction businesses is relative to the appropriateness of the decision they take during bidding. Extant studies are a little short on this. Only a few studies have focused on specific business environments when developing their bid or no bid decision tools. In a lot of instances, research frameworks are broad and analysis are rarely conclusive. For example, it impossible to know from the scores of factors that are available in literature on bid or no bid decision protocols, which factors relate to specific business sizes, environment or culture. It is also not clear how the factors are likely to affect bid outcomes, or the relationship between them. Current challenge before construction research community is in considering advance inferential techniques that will help businesses develop new decision tools that apply to current challenges. The multiplier effect of this is overwhelming: theory will become closer to practice, business confidence will improve during decision making, and the economy will accrue more growth.

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A MODEL FOR DESIGNING GROUP TASK ASSESSMENTS

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ABSTRACT

This study uses quasi-experimental method to develop a framework for peer assessment in group tasks. A total of 94 students who completed a first year CM undergraduate unit were analysed. The 10 criteria used in the peer assessment framework ensured all students within a group are mutually accountable to their individual commitment to learning in the group. In addition, the framework can be used to predict group success. A Cronbach Alpha's reliability estimate of 0.968 was obtained when the criteria were tested for internal validity. Principal component and scoring factor analyses were used to elicit the relative importance of each peer assessment criterion: the most significant were 'Timeliness of contributions', 'Reliability of individual's inputs', 'Value of individual's contributions' and 'Individual's motivation to succeed'; 'Communication' is least important item. Correlations between the variables were also obtained. Results showed a strong relationship between peer assessment success and the overall success in the unit i.e. students were able to learn genuinely in their teams and were able to succeed in the unit.

Keywords: academic unit, construction management education, group task, pedagogy, team work.

INTRODUCTION

Teamwork is a vital skillset, essential to an appropriate education in disciplines that prioritise knowledge in industry practice and professions. As elicited by Azmy (2012), employers within the construction industry take employees' teamwork ability very seriously. Other studies have also shown that the commercial reality of today's construction education is such that it is insufficient for potential employees to distinguish themselves only on the basis of individual excellence. Rather they must demonstrate instinctive ability to situate themselves in the organization as team players (Carnevale, 1990; Casner-Lotto and Barrington, 2006; Morgeson et al., 2005). Apparently, like a coin, there are two sides to the personality traits of graduates willing to make a career in the construction industry. They are either 'lone-rangers' or efficient team players. 'Lone-rangers' are individuals who may be able to exhibit individual brilliance, however possess minimal capability or self-expectations regarding the thrust to work well within teams. On the other hand, team players have strong inter-personal skills and are boundary spanners – see Bossink (2004). Boundary spanners are able to extract and diffuse knowledge beyond their disciplinary boundaries and organizations. None of these attributes is mutually exclusive; a proficient graduate should be able to demonstrate individual excellent and teamwork ability.

Deficiencies in students' teamwork ability has been a considerable challenge that has remained largely unchanged in construction management education for a long time (Ayarkwa et al., 2012; Harris and McCaffer, 2013; Latham, 1994; Noel and Qenani, 2013). Why this remains so is a complex argument project. Imagine this: pedagogists think interactivity within the teaching and learning space is the best framework for knowledge co-evolution in students i.e. cooperative and collaborative learning; not situations in which students are made to learn independently, with absolute intendment to compete against each other perpetually, and the integrity of their learning is measured only in terms of individualism (see Beauchamp and Kennewell, 2010; Wagner, 1997). The work of Springer et al. (1999:22) resonates this robustly: "The message is clear: what students learn is greatly influenced by how they learn, and many students learn best through active, collaborative, small-group work inside and outside the classroom". The reality is: if students learn best in active collaborative groups, study and assessment designs must be made to make the best of this. How are students supposed to grow their teamwork ability when the trainings they receive focus mostly on individuals' competitiveness?

The purpose of this study is to report on an assessment design in a construction management unit, in which the correlations between students' group task assessment, individual assessments and students' overall outcomes were explored. In particular, it reports on the validity of a peer assessment structure (for the group task), and explores the correlation between students' individual abilities, the peer assessment mechanism, group task performances and students' overall success in an academic unit.

RESEARCH METHODOLOGY

This study used quasi-experiment research design, a method used to estimate the causal impact of an observed phenomenon (Dinardo, 2008). DeRue et al., (2012) elicited the advantages of this method to include being a true and natural experiment that does not require random assignment of study population (in this study, students' study groups are self-selected). According to the authors, the method also minimises threats to ecological validity – as data are obtain from real natural observations, problems of artificiality such as in controlled experiments do not surface. The outcomes can also be generalized, just as they apply to longitudinal observations efficiently (e.g. findings will apply to different construction management units, and to different levels of students' study). In particular, the method is used in this study to predict the success of a cohort of first year construction management students (N = 94), both in their group tasks and their overall performance in the academic study unit, by combining the ten elements discussed above as a peer assessment framework. Further to this, the method is used to explore the relationships between students' individual academic ability (by using individual assessment items), students' individualised performance in group work (by using peer assessments) and students' overall performance in a construction management unit.

The unit has three assessment items: one group task, one assessment item (a quiz) which students must complete individually (weighted 20 percent of total unit mark), and a terminal examination that tests the students on the entire content of the unit (weighted 50 percent of total unit mark). The group task, weighted 30 percent of total unit mark, asks students to research into the macro-economic importance of the Australian construction industry. Each group will make a presentation before a 50-member audience and submit a 5,000 words report jointly on the assignment problem showing how the feedbacks they received from the audience have been considered in the final report. 70 percent of this is the singular mark awarded for each group's effort, 30 percent for individualisation i.e. by considering students' peer assessments. In the peer assessment, each student must submit a reflective journal on the learning activities within the group, detailing his or her contributions to the success or failure of the group. Each student must also assess other members of the group using the ten variables indicated above using a 5-point scale. 1 represents "Unsatisfactory", 2 represents "Meets requirements sometimes", 3 represents "Meets requirements", 4 represents "Exceeds expectations consistently", whilst 5 represents "Exceeds expectations greatly". As students were allowed to self-select their group members (five in a group) and each student was required to submit his or her assessments of other members of the group confidentially, it was possible to obtain four perspectives on the performance of each student in a group against the ten peer assessment variables. These were calculated into averages and were extended for further analysis.

RESULTS

First, the internal validity of the peer assessment framework was established. Cronbach's Alpha reliability estimate is obtained as 0.968, whilst the Hotelling's T-Squared Test value is 38.108 (p=0.000), and the Kaiser-Meyer-Olkin Measure of Sampling Adequacy is 0.919. As shown in Table 1, there were no exclusions in the outcome of the analysis. All the ten items used for the peer assessment are statistically significant, and will explain 96.8% of possible variances in the outcomes of a phenomenon they may be made to predict (e.g. group performance and success in the group).

Table 1: Item-Total Statistics (N = 94)

	Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha
Value of individual's contributions	0.881	0.843	0.963
Attendance	0.802	0.838	0.967
Timeliness of contributions	0.911	0.855	0.962
Problem solving	0.855	0.841	0.964
Technical knowledge of group member	0.880	0.891	0.963
Flexibility and Availability	0.860	0.829	0.964
Motivation to succeed	0.879	0.808	0.963
Reliability of input	0.903	0.869	0.962
Team Spirit	0.861	0.831	0.964
Communication	0.702	0.660	0.969
Explanatory Indicators			
Hotelling's T-Squared		38.108	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.919	
Bartlett's Test of Sphericity (Approx. Chi-Square)		1174.844	
Sig.		0.000	

Second, relative importance of the peer assessment variables were obtained using principal component and scoring factor analysis. Results show the first function accounts for 78.147% of variance in initial Eigen values and in sums of squared loadings (see Table 2 – Appendix). In addition, Table 3 shows the relative importance of the variables are relatively close. The most significant variable is 'Timeliness of contributions', followed by 'Reliability of individual's inputs'. 'Value of individual's contributions' and 'Individual's motivation to succeed' are next. The least important variable is 'Communication' (i.e. students seem unconcerned about other members of their groups who are less able to communicate efficiently – as long as the group succeeded). Correlations between the variables were also obtained (see Table 3). All the 10 variables correlate against each other significantly ($p<0.01$). The correlation analysis was further extended to individualized marks from the group task, the marks awarded to each group for their collective efforts and number of students in a group that finished the tasks (this is because some of the groups had their members reduced due to turnover issues – average number of students per group at completion was 4.798). Of these three variables, individualised marks correlate most strongly with the peer assessment frameworks and with number of students in a group and the marks awarded to each group for their collective efforts. In essence, a group that started with five members but completed the tasks with three did not perform as well as those who started and finished as five members.

Table 3: Scoring Factor and Correlation Analysis of Peer Assessment Variables

	Scoring Matrix	Component Score Coeff.	Inter-item Correlations											
Var 1	0.907	0.116												
Var 2	0.841	0.108	0.749**											
Var 3	0.930	0.119	0.825**	0.805**										
Var 4	0.886	0.113	0.792**	0.627**	0.814**									
Var 5	0.907	0.116	0.851**	0.641**	0.819**	0.897**								
Var 6	0.886	0.113	0.762**	0.871**	0.830**	0.712**	0.734**							
Var 7	0.904	0.116	0.771**	0.764**	0.831**	0.737**	0.805**	0.802**						
Var 8	0.923	0.118	0.865**	0.832**	0.830**	0.755**	0.777**	0.831**	0.810**					
Var 9	0.890	0.114	0.776**	0.657**	0.816**	0.769**	0.759**	0.706**	0.802**	0.824**				
Var 10	0.753	0.096	0.597**	0.466**	0.627**	0.720**	0.717**	0.566**	0.653**	0.613**	0.754**			
Var 11			0.180	0.262*	0.272**	0.263*	0.213*	0.222*	0.292**	0.269**	0.219*	0.168		
Var 12			-0.040	0.038	-0.006	0.013	-0.035	0.018	0.042	0.023	-0.010	-0.024	0.711**	
Var 13			-0.184	-0.149	-0.144	-0.173	-0.181	-0.179	-0.077	-0.128	-0.131	-0.149	0.374**	0.660**
			Var 1	Var 2	Var 3	Var 4	Var 5	Var 6	Var 7	Var 8	Var 9	Var 10	Var 11	Var 12

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Legends

Var 1 = Value of individual's contributions, Var 2 = Attendance, Var 3 = Timeliness of contributions, Var 4= Problem solving, Var 5 = Technical knowledge of group member Var 6 = Flexibility and availability, Var 7 = Motivation to succeed, Var 8 = Reliability of input, Var 9 = Group member's team spirit, Var 10 = Communication, Var 11= Individualised mark from group work, Var 12 = Group mark, Var 13 = Number of students in a group

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization and Component Scores.

Also, individualised marks did not show a considerable correlation with two of the peer assessment variables: individual's ability to communicate effectively and value of individual's contributions. This means those who were less able to communicate effectively were given tasks in areas where they were best able to contribute (e.g. proof read, collate data, manage ethical issues regarding the data contributed by every member of the group). It also means as long as final submissions were satisfactory to the Instructor, students did not worry about the value of their peers' contributions.

As shown in Table 4, this study also obtained the statistical relationship between the peer assessment framework and students' performances in all the assessment items in the unit. Findings showed no correlation between performance in individual tasks and peer assessment. For example, those who performed very well in the examination (an individual assessment) also performed very well in another individual assessment (a quiz) in the unit. Analysis did not show any considerable evidence to conclude that students' study activities within their groups were sufficient to facilitate their overall performance in the unit – this is because the strategy used to individualized students' marks ensured all students were held accountable for their group contributions as well as to their overall learning experience in the unit.

Table 4: Correlation between the peer assessment framework and other assessment items

Peer Assessment Total	0.263*			
Examination	-0.004	-0.011		
Quiz	-0.016	0.020	0.298**	
Final Unit Mark	0.012	-0.032	0.851**	0.619**
	Individualized Group Mark	Peer Assessment Total	Examination	Quiz

One of the ultimate goals of this study was to obtain a structural explanation to the relationships between the assessment items in the unit and student's final outcome. A regression model was obtained (see Equation 1); $R = 0.956$, $R^2 = 0.915$ and Adjusted $R^2 = 0.909$. This particular finding supports the strong correlation between Student's Final Grade and the End of Semester Examination (an individualised assessment), Peer Assessment Total and the individualized assessment (the quiz). However, Group Mark shows a negative correlation with Student's Final Grade. The underlying statistics for this relationship is insignificant: the coefficient Group Mark in the equation is less than 0.01, and the Sig. value is 0.732 (Sig. values are best when they are between 0.05 and absolute 0).

$$\text{Final Grade} = 12.316 + 0.299Gn + 0.100PAT - 0.082GM + 0.528Exm + 0.251Qz \qquad \text{Equation 1}$$

Gn = No of students in a group; PAT = Peer Assessment Total; GM = Group Mark; Exm = End of Semester Examination, and; Qz = Quiz

Similarly, another regression model was obtained to elicit the relationship between the peer assessment criteria and students' group mark (see Equation 2). The model's descriptors are: R is 0.689, R^2 is 0.475 while the Adjusted R^2 is 0.404. Explanatory descriptors of the model are not absolutely strong because student are awarded marks on the basis of their final deliverables (presentation and report), not necessarily on the basis of the social relationships within the groups. Yet, the model shows the performance of a group is reasonably predictable by the peer assessment factors. Results show a strong positive correlation between marks awarded to students within the groups and number of students in a group, attendance, problem solving skill of group members, flexibility and availability, and the ability of a group member to communicate own ideas.

These variables explain the model most significantly (R = 0.677, R^2 = 0.459, Adjusted R^2 = 0.428). The other six variables that show negative correlations are not statistically significant. For example, contributions during presentation and to the report is not assessed in Group Marks individually (Sig. = 0.748). In addition, timeliness of contribution may be underrated if groups are able to make submission by due dates or can be granted additional time to deliver their assessment items. As students are all of the same study cohort, it is not very important whether some students are overly better than others (Sig. = 0.614); equal opportunity for value sharing and continuous support provided during tutorials sufficed. Results also indicate student's self-motivation to succeed (Sig. = 0.966), reliability of team member's input (Sig. = 0.983) and team spirit (Sig. = 0.872) showed negative correlation with group mark. As shown in Table 6, these variables are not statistically significant. Although, the ability of a group member to communicate own ideas correlates positively with the group mark, evidence also suggests this is not significant statistically (Sig. = 0.996). This is because the assignment deliverables only expect students to put forward their peers with the best communication skills – student's individual communication skills were not assessed in the group mark; and others would have made contributions to the group 'quietly'.

$$\text{Group Mark} = 6.371 + 2.081Gn - 0.214VoC + 0.435Att - 0.568Tim + 0.920PS - 0.414TKn + 0.354FlA - 0.028Mot - 0.015Rel - 0.108TS + 0.002Com$$

Equation 2

Gn = No students in a group; VoC = Value of individual's contributions; Att = Attendance; Tim = Timeliness of contributions; PS = Problem Solving; TKn = Technical Knowledge of group member; FlA = Flexibility and Availability; Mot = Motivation to succeed; Rel = Reliability of team member's input; TS = Team spirit, and; Com = the ability of the group member to communicate own ideas

DISCUSSION ON FINDINGS

It is to the greater benefit of all stakeholders in students' learning that assessments are designed to be truly fair and genuinely inspiring. However, certain challenges have made this nearly impossible (see Cohen, 1994; Cohen and Lotus, 2014; Gunderson and Moore, 2008 and McKeachie, 2002). Some methods of group task assessment do not ensure students are accountable for their commitment to learning activities in their study group i.e. such students are rewarded even when they have only committed themselves poorly to group's learning activities – where such academic unit relies mainly on group work, students might pass even when they have not participated in learning. Being rewarded for outcomes students did not achieve genuinely is not the only issue, poor group task design allow some students to be burdened or penalized for outcomes they should not have been held truly accountable. Studies have argued that there is no best way to resolve these (see Hansen, 2006). Models to help optimise genuine team building in students' group work and mutual accountability are not very popular in normative literature on construction management education. Bridging this gap is the ultimate goal of this study. Key evidence from the results elicited in this study include:

- The 'dinkum' concept: Peer assessment mechanism helps to instil 'dinkum' in group tasks. This is because it enables students to see through their assessment processes and be sure that mutual accountability in group tasks can be rewarded. The study also shows coevolution of knowledge in group learning also helps students to do well in individualised assessments (Table 4). This is consistent with the findings of Springer et al. (1999) and Gunderson and Moore (2008).
- Peer assessment criteria: 10 peer assessment criteria have been analysed, and they were found to be reliable statistically. Davies (2009) and McLaughing and Simpson (2012) identified the need for some form of peer assessment criteria in construction management education, however were not able to elicit what these should be. The current study has closed this gap; the criteria have been identified, and so were their weighting and the relationship between the criteria and other assessment outcomes – in groups, in individual tasks and the overall success in the unit.
- Relationships between assessments: The peer assessment played a significant role in students' final outcomes. Those who were mutually accountable to their peers learnt from their groups and were able to do well in all assessment items in the unit. Results also showed group marks is predictable by the number of students in a group, attendance, problem solving skill of group members, flexibility and availability, and the ability of a group member to communicate own ideas ($R = 0.677$, $R^2 = 0.459$, Adjusted $R^2 = 0.428$) – also see Table 6.
- Longitudinal study: Quasi-experimental research method has been used in this study. One of the justifications for this study is that it open additional study opportunities in longitudinal studies. The students whose performance were analysed in this study were first year undergraduate students, studying a construction management unit for the first time. The strength of the internal validity of the study is an indication that the criteria could be re-studied as the students develop even further in their study career.

CONCLUSION

Workers in the construction industry must be able to work well in teams. Construction trainees need to be trained in this adequately. However, existing framework to provide such training is soft: there is limited definitive framework on how to design group task assessments that are truly fair to students' learning expectations. Evidence from this study has shown that this is indeed possible. 10 peer assessment criteria have been elicited. The criteria support equal opportunities, co-evolution of knowledge and mutual accountability. Assessment items were considered significant, just as the processes leading to their development. The study also found that those who work well in teams were able to achieve good outcomes in individual assessment items in the unit, although the group task and the individual assessment items were not entirely related. Success in the group task was predicated by the peer assessment criteria. Nonetheless, the limitation of the study is that the criteria have only been tested with first year undergraduate students who are studying an academic unit in construction management for the first time. The models have not been tested longitudinally. Outcomes may be different in other units, if the expected learning outcome are different.

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A HISTORICAL PERSPECTIVE ON THE EPISTEMOLOGICAL EVOLUTION OF EDUCATION FOR OCCUPATIONAL LICENSING IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

In New South Wales, Australia, there are prescribed educational requirements for occupational licensing within the built environment. An important consideration for the government in this regard is the underlying need to provide consumer protection. Therefore mandated occupational licensing and continuing professional development are key components within government policy. This research paper reviews the literature for continuing professional development within the built environment. Concurrently, data under the Home Building Act 1989, relating to enforcement and prosecutions during the last decade in New South Wales are examined and discussed. Issues such as the purpose and intent for education, complexity of skills required and industry experience and an appropriate course curriculum are embedded within the discussion. It is argued that whilst improved CPD requirements best serve the needs of the consumer and prescribed education should be maintained, there is also the consideration that consumer protection cannot be solely addressed though an educational curriculum.

Keywords: consumer protection, curriculum, education, industry experience

INTRODUCTION

For many years, the various states within Australia have regulated the licensing of practitioners in the construction industry. Initially, legislation delivered a loose assemblage of educational requirements for the diversity of skills necessary for the construction industry to carry out the appropriate discharge of their duties. Occupational licensing was not accompanied by compulsory education but this has gradually changed to increasing requirements in this area. In parallel there has been an increasing awareness of consumer protection, thus demanding the tightening of licensing requirements including its sub-parts.

At present licensing is managed under the auspices of individual state and territory Fair Trading Offices and these individual regimes have followed historical patterns reflecting the *ad hoc* and inconsistent development of the regime. Historically, during 1971, New South Wales introduced mandatory licensing for all home builders, under the Building Licensing Act; and licences for associated trades was introduced in 1977 and onwards. Mandatory formal education was later introduced, although in the earlier years, a long history of industry experience was considered the equivalent of formal education. The Office of Fair Trading (2011) summed up the need for occupation licensing by stating that compulsory licensing "ensures unqualified or inappropriate people do not undertake work in the areas of residential building and specialist trades". To this end from the inception of occupational regulation in New South Wales there was an expectancy for builders to be accountable for the quality of their workmanship and transparency for the stakeholder. Additionally apart from licensing, there are other ways the government intervenes to protect consumers.

For instance, the Home Building Act 1989 provides for insurance warranty and the establishment of a dispute resolution process for the purpose of providing assistance to the stakeholders. Therefore, defective building work and disputes regarding the satisfactory completion of the contract, is considered an important consumer protection mechanism and is a key feature of the regulatory system. Even so, it is notable that in order to get this protection, consumers have a duty of care to select a licensed contractor or otherwise they are not entitled to insurance protection – hence they must be active in acting according to a continuous chain set up by government consumer protection protocols.

Life-long learning is critical to the development and commitment of all professions. This ensures the maintenance and proficiency of the professional to competently carry out their duties and maintain consumer protection and accountability. The introduction of compulsory CPD in 2004 also raised questions with regards to the relevant and important topics, content and delivery of the educational syllabus. Fair Trading introduced a point system to monitor the compliance requirements. The introduction of compulsory CPD was aimed at "....maximising consumer protection outcomes, maintaining public confidence....raising the quality of building and construction standards, improved safety....". (Office of Fair Trading 2009).

Currently the revised CPD program is a simplified method, with the introduction of a broader range of topics, and includes the involvement of industry experts and training providers. Additionally, many professional bodies mandate CPD as part of their ongoing membership renewal process and it is possible to have CPD requirements for professional membership crossing over to meet the requirements for Fair Trading.

The first part of this paper discusses the literature for CPD for occupational licensing. The review is complemented in the second part of the paper with statistical and descriptive data relating to prosecutions and enforcement procedures under the Home Building Act 1989. The purpose of this research is to identify if parallel trends exist between CPD and consumer protection. It is argued that whilst improved CPD requirements best serve the needs of the consumer and prescribed education should be maintained, there is also the consideration that consumer protection cannot be solely addressed through an educational curriculum.

LITERATURE REVIEW

The learning environment for education in Australia has been identified as an important consideration when engaged in CPD activities (Boyd 2005). Suggestions include integrated problem based workshop activities and industry engagement as a practical option for the development of multi-skilled professionals. Many researchers acknowledge the importance of updated information for technology combined with the development of decision making skills as a worthy outcome. Indeed literature is quick to state that CPD broadly encompasses a life-long learning process, and is for the benefit of all stakeholders and society in general.

During this last decade many professions and professional bodies have introduced compulsory CPD with an underlying aim to help serve public interest and strengthen the individual image for the professions. CPD includes a "lifelong learning function" (Collins & O'Brien 2003) and is the "maintenance of knowledge, expertise and competence of professionals throughout their careers" (O'Sullivan 2003). This is further reiterated by Cervero (2001) who stated that "...incorporation of continuing education into accountability systems for professional practice" has increased. Equally political agendas have been cited (Young 1998) as the motivation for compulsory CPD however arguably with the increase in consumer complaints within the construction profession it can be stated that the Australian government is well justified with their intent to introduce compulsory CPD. Furthermore Young (1988) stated that the public were concerned with the professions and the employers inability to police and train their staff adequately. A survey undertaken in 1988 (Young 1998) supported mandatory CPD for many reasons including "protection against liability". Indeed many insurance companies consider the non compliance of CPD a contributing factor to the high litigation claims.

In America, CPD is now serviced by the professional associations, professional practices, the licensing agencies, non-profit organisations and commercial firms (Monograph 2006) for the licenses and certificates of registration. This is very similar to Australia also, where CPD can be carried out by Universities, Registered Training Organisations and relevant professional associations. Similarly, research for CPD for secondary school teachers (Knight 2002) recommended the involvement of Universities for the delivery of CPD arguing that this would enhance a "stronger intellectual substance than commonsense and hard manageralism." There has been a widespread introduction of compulsory CPD in the accountancy, legal, medical, and engineering etc (Cervero 1988) professions worldwide. Research undertaken in 1990 (Cervero & Azzaretto 1990) reiterated compulsory CPD as a popular choice for licence and certificate renewals. This reasoning has also been reflected in the South African real estate industry where the government has introduced training and entry requirements for their sector to promote knowledge, ethics, a professional image and improve communication between all stakeholders (Robinson 2008).

The real estate market in New Zealand is considered to comprise a "more sophisticated, better-educated profile of vendors and purchasers"' hence the demand for advanced real estate qualifications in New Zealand (Crews 2004). For these reasons salespeople participate in CPD and are offered a variety of delivery methods, such as block mode delivery, and an interactive, learning environment enhanced and cemented with the contents and academic rigour combined with industry input. Research indicates in some cases an unwillingness to participate in CPD programs citing the costs and value for money as some of the reasons (Crews 2004). However, it is very important that knowledge is current and constantly up-dated.

In the 1980s various professional bodies started to introduce their own policies for CPD (Crews 2004). However because construction professionals in Australia require a licence through a legislative structure, it was not until the early 2000's that discussions commenced for compulsory CPD, which were eventually introduced in 2004.

As we enter into a new decade there have been varied schools of thought to justify the need for CPD. For example does CPD enhance existing knowledge? Where is the benefit for the different stakeholders? Were there problems in professional practice prior to compulsory CPD? Is the benefit aimed at a financial reward for the training provider only? i.e. is there a notion that training providers have a vested interest? Interestingly, research and literature indicates professional associations, universities and governments have a "clear responsibility" for the development and introduction of courses and methods for CPD in the general professions (Cervero 1988).

The importance of "interprofessional skills" where a professional taps sources from other professions is highlighted (Barr 2009) with suggestions of activities via journals, or to join a reading group, distance learning and e-learning. However, the argument presented also expressed concern with the importance for "grounding in practice" and "quality of interaction". A popular suggested education method appears to be the inclusion of workshops which include problem solving techniques, seminars, conferences, courses, self directed learning etc to provide a blended learning environment (Brown & Uhl 1970; Green et al 1984; Houle 1980; Knox 1974; Miller 1967).

Various sources of literature continues to express concern with methods available to assess the measurement of performance, and various approaches such as observation, oral examination, self-report, peer evaluation, and the use of consultants are recommended (Gonnella & Zeleznik 1983). This difficulty to measure performance was reiterated by Botticelli and Anderson (1981); Goran, Williamson and Gonnella (1973); Levine and McGuire (1970); Payne (1978). Whilst education for licensing can provide the students with a foundation course of study, the knowledge and the skills and opinions acquired rapidly date (Farmer & Campbell 1997; Roberts 1991; Watkins & Drury 1994). The richness of the CPD must ensure that education is not just a mass production of accumulated hours or points to satisfy merely the licensing requirements.

It is generally accepted that CPD can bridge the gap between formal education and practice through professional socialisation (Page 2007; Farmer & Campbell 1997; Roberts 1991) and the using of problem-solving skills to perform effectively (Cross 1969; Escovitz 1973) and the introduction of specialisation will enhance "education and training beyond the basic professional degree of license" (Lowenthal 1981;Ball 1991; Pritchett 1994). This is further summarised by researchers (Regehr & Mylopoulos 2008) who favour CPD from practictioners own personal experiences such as problem solving by reflection and self assessment, recognition of the gaps in knowledge, undertaking appropriate learning activities, and translating these new skills into daily professional practice and the continuous reassessment of performance.

The introduction of CPD also raises questions with regards to the relevant and important topics and content of the educational syllabus; documented studies in the property sector support this notion (Hovell 1999; Newell & Eves 2000; Fischer 2000; Boyd 2000; Avdiev 2000; Yu 2001; Oloyede & Adegoke 2007). Ideally, the CPD should be structured within a framework to monitor and record the relevant topics included as a component of the educational system. The next section of the paper discusses the research method approach followed by the analysis and discussion.

RESEARCH METHODOLOGY AND LIMITATIONS

As stated previously the aim of this research paper is to examine and undertake a textual analysis of the current CPD mandated for the construction industry. The first stage of the research discusses the literature for CPD for occupational licensing. The second stage of the research identifies data relating to prosecutions and enforcements under the Home Building Act.

Therefore, the paper will focus on the following research questions:

1. Why have prosecutions and enforcement procedures in the construction industry continued to prevail and increase during the last few years.

2. Are there recommended topics/subjects which should be incorporated in CPD so as minimise this risk, and therefore improve consumer protection. In other words, are there any subjects which are considered core and essential in the life-long learning process for the individual.

Because each jurisdiction in Australia has varying licensing and educational requirements, the second stage of the research was limited to the state of New South Wales, Australia, as it is beyond the scope of this paper to include all states and territories. Furthermore, only data relating to prosecutions and enforcements under the provisions of the Home Building Act 1989 are considered. The reason being, that occupational licensing is regulated by this legislation under the auspices of Fair Trading NSW. The data has been extracted from the annual reports issued and published by the Office of Fair Trading NSW and is recapitulated in both statistical and descriptive formats.

DISCUSSION AND ANALYSIS

Over the last few decades regulation and educational requirements for the building industry have increased, driven by the desire and need to improve consumer protection. Formal education and CPD is aimed to provide new knowledge, information, meet legislative requirements for licence and certificate applications and renewals, maximise consumer protection, maintain public confidence and reduce disputes in the building industry. Specialist topics are also included for the different licence and certificate categories, where the OFT considers this to be a high risk area. For example, some of the current recommended risk areas for CPD include sustainability, compliance responsibilities, safety, building technical issues, communication techniques, dispute resolutions and business management skills. This section of the paper provides data relating to compliance activities and prosecutions.

Penalty notices are an enforcement tool, which is available in a range of statutes, including the home building legislation. The entity served with the notice is able to pay a fine rather than to have the alleged offence dealt with in a court. If the detected breach in the legislation is straightforward to detect without any questions of intent, then the penalty notice is issued, otherwise the matter will need to be dealt with in court. Therefore, penalty notices are also issued for minor breaches and these are included in table 1 below. The table shows the penalty notices and successful prosecutions for the financial years commencing from 2002 to 2014. An analysis was undertaken of the total penalty notices issued and the successful prosecutions. (In the financial year 2013/2014 the success rate for prosecutions was approximately 95%- Fair Trading 2014).

Trends recently indicate a decrease with penalty notices issued and a leveling of the value associated with this infringement; likewise successful prosecutions have decreased in numbers and also in value. However, from 2002 there was a steady increase of compliance enforcement, which peaked during 2006 to 2008. It is not possible at this stage to predict whether the decline will continue, as previous records also showed a peak during 2003 to 2005, followed by a decline and then yet again another peak. Since the introduction of compulsory CPD in 2004 the figures do not appear to indicate any steady improved trend, rather the indication in the table below favours cyclic increases and decreases.

TABLE 1 - COMPLIANCE ENFORCEMENT

FINANCIAL YEAR	PENALTY NOTICES	VALUES $	SUCCESSFUL PROSECUTIONS	VALUE $
2002 - 2003	246	104,250	47	71,547
2003 - 2004	664	293,650	115	134,225
2004 - 2005	703	270,150	86	161,160
2005 - 2006	341	159,500	88	204,460
2006 - 2007	813	595,800	141	313,583
2007 - 2008	561	502,000	173	269,561
2008 - 2009	676	611,150	124	299,482
2009 - 2010	426	383,050	106	171,882
2010 - 2011	500	413,700	37	66,983
2011 - 2012	458	484.800	125	384752
2012 - 2013	327	322,750	116	313,962
2013 - 2014	377	365,000	130	296,850

Source: Office of Fair Trading Annual Reports each year from 2002

However, government policy is to reduce red tape and compliance costs and to maintain an appropriate level of consumer protection. Policy makers will continually implement strategies to improve consumer satisfaction and protection. There are varying learning activities suggested by government, all aimed to develop the required skill set and knowledge and competencies for relevant topics. Learning activities are measured in a variety of methods such as the time allocated for the activity, journal entries for time spent on reading published materials such as journals and professional articles. The implementation and monitoring of CPD appears to be a reflection of the quality of the training and the adoption of the National Training framework and concerns arise over these educational requirements and perhaps also the better monitoring of CPD topics.

Currently, the data which details the type of complaints leveled at the building industry has listed poor workmanship at the top of the list. Therefore, it would be an obvious choice to select CPD topics along these required skill-set. If workmanship could be improved, this would lessen the complaint burden from consumers, and reduce penalties and prosecutions. Therefore, the question arises why these cause of complaints have not been addressed by Fair Trading and industry. However, at times there might be a perception from the building industry that the professional bodies have a vested interest to support compulsory CPD. Some courses are very expensive and there has been an attitude of "tick and flick" to enter the applied hours into the log book, and not concerned with acquiring knowledge and participating in the training sessions. Some professionals perceive that there is little value attached to CPD and upgrading their skills and knowledge. Whilst the OFT does not limit quality assurance only to the CPD learning environment, their investigators also carry out random inspections and examinations for individual CPD compliance. As indicated earlier in this paper, the Home Building Act provides for severe penalties and disciplinary action for misconduct and falsely declaring CPD compliance. Therefore, with a cyclic increase in penalty notices and prosecutions, together with the increase of complaints lodged against the building industry, ongoing research into this problematic area is required before rendering definite conclusions.

CONCLUSION

The research paper set out to evaluate CPD and consumer protection. Therefore, with the obvious increase in penalty and prosecution proceedings and issues relating to workmanship, it is recommended that compulsory CPD is aligned to the appropriate skills sets for the various licences. For instance a correlation between job responsibilities, title, and job description undertaken will enhance the quality of the workmanship and eventually lessen the need for consumers to lodge complaints with Fair Trading.

However, it is very difficult to prove a link between an improvement in consumer services running parallel with CPD. The reason being that poor workmanship cannot necessarily be improved by CPD, rather this might require additional on the job training in a similar way to an apprentice learning the trade.

FURTHER RESEARCH

The cyclic increase in prosecutions and consumer complaints, as identified earlier in the paper, requires further analysis, to demysify if in fact a correlation exists with the consideration of the following additional data:

1. The value of total building work carried out.
2. The total number of building approvals undertaken, completed and the scale of building work.
3. The cause and type of defect.
4. The total licences held in the relevant categories.

It is envisaged this further study will provide the opportunity to explain the cyclic trends and implement recommendations aimed to improve the consumers experience in the construction industry; which will lead to a decrease in consumer complaints lodged at Fair Trading NSW.

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THE ADOPTION OF MODERN OFFICE WORKSPACES BY TERTIARY EDUCATION INSTITUTES: A CASE STUDY OF UNITEC

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ABSTRACT

Modern office workspaces, and particularly activity-based workspaces (ABW) are emerging in the education sector. The primary reasons for making changes to workspaces vary from institute to institute. Yet, there is limited research on the objectives, the overall value of making these changes, the strategic plans used, the types of workspaces being implemented and the issues faced by higher education institutes, which can potentially affect their users and their associated work practices. Semi-structured in-depth interviews within a case study approach were carried out with three groups of participants: staff that have had previous experience in new types of workspaces, staff that have not worked in such environments, and institutional key decision-makers. Field observations and a review of supporting documentation complemented the interviews. The findings indicate that there are wide-ranging organisational changes occurring within Unitec, and not just simple changes to existing workspaces with the aim of increasing collaboration, reducing facility costs and creating sector alignment. Additionally, ABW are being implemented throughout the organisation based on prototype office spaces in one campus building heavily influenced by commercial workspace design. However, higher academic work practices make unique demands potentially creating tension between the aims of the institution for increased collaboration and interaction and established work patterns. The inclusion of more private quiet spaces is suggested by the interviewees to help staff adapt to these new ways of working. Furthermore, keeping the lines of communication open and regularly updating all staff on the redevelopment of the new workspaces ensures an overall smoother transition.

Keywords: academic work, activity-based workspaces, organisational change, tertiary institute

1. INTRODUCTION

Tertiary education institutions with their collective knowledge have a major impact on the national economy and society as a whole. Yet, there is limited research exploring the changing nature of academic office environments and the potential effects on the users and their associated work practices. Some tertiary institutes have adopted in recent years modern flexible workspaces with the aim of facilitating cooperation and knowledge-sharing through informal interactions. These changes are primarily influenced by technological advancements and driven by economic factors. However, the users of these new spaces and management often have different views on the value and potential benefits of modern office environments. This is mainly due to the current dominant culture of individual research in academia. Despite apparent tensions, academic work practices are evolving and progressing towards change, even though being drawn-out.

This study examines the characteristics of well-designed modern workspace environments at Unitec Institute of Technology and ascertains whether they meet the requirements of all stakeholders involved. Unitec is New Zealand's largest Institute of Technology, with more than 20,000 students studying over 150 work-oriented programmes at three Auckland campuses. Unitec is currently undergoing a complete transformation of its organisational structure, academic culture and physical environment. At the core of this transformation is a commitment to providing world-class learning and teaching opportunities that are integrated with industry. The support of these learning and teaching models requires: the creation of new spaces for students to learn and work; a reshape of the existing services; and a drastic upgrade of technology. The physical redevelopment, focused mostly on the Mt Albert campus currently with 177 buildings spread over 53.5 hectares, aims at developing it as a more compact and lively campus at the southern end of the existing site. In addition, the research investigates the challenges during the transition period.

2. BACKGROUND

2.1 The nature of academic work

Academic work is predominantly individual, concentrated, autonomous and without distractions. Occasional meetings and collaborative working are an exception rather than the norm (Lansdale et al., 2011; Pinder et al., 2009). Academia has its own cultural norms and rules that individuals must follow and learn through interaction with others to be accepted by the fraternity (Lansdale et al., 2011). Despite academic work's mostly independent nature, informal face-to-face communication proves to be the preferred method of information exchange (Lansdale et al., 2011; Toker and Gray, 2008).

Commercial and higher education work environments have very similar attributes. However, it is also important to note that there are distinct differences (Lansdale et al., 2011). Firstly, postgraduate research, in particular, is conducted over a long period of time, independently, with minor collaboration, little supervision and insignificant interaction. Secondly, open-plan layouts prove challenging for academic research which is cognitive, non-routine, requiring a high degree of application and minimum distractions. Thirdly, workspaces are highly individualised through the display of personal items such as qualifications, photos, etc.

In recent years the impact of information and communication technologies on academic work within the higher education sector has been profound (Watson et al., 2014). Laptops and portable technology provide the flexibility for researchers to work away from their dedicated workplaces and collaborate in various locations. Consequently, this has changed the space requirements of campus-based workplaces. Additionally, wireless technology has allowed new and existing workspaces to be flexibly configured to respond to the demands of new work practices (Pinder et al., 2009).

2.2 Benefits of modern workspaces

A number of studies in the literature argue that open-plan office designs with non-territorial workspaces create flexible quality work environments and offer additional savings in the form of reduced occupancy costs. This approach has been considered as an acceptable strategy to resolve low occupancy rates usually associated with traditional academic spaces (Haynes, 2008; Lansdale et al., 2011; Värlander, 2012). Flexible workspaces utilise standardisation and design norms, achieve more efficient use of space by incorporating new technologies that are constantly decreasing in size, and have space-saving storage solutions (Pinder et al., 2009).

Well-designed modern workspaces do stimulate frequency of interactions amongst occupants. Both the ‘flow model’ and ‘serendipitous communication’ model state that the layout of a workspace environment can influence interaction and hence improve productivity (Peponis et al., 2007). Effective communication is best achieved when occupants are located in close proximity and when they congregate in common areas known as ‘interaction nodes’ - main circulation corridors, hallways and lounges. Good spatial design with the added benefit of technology, can compensate for the loss of privacy, as well as the loss of workspace personalisation, territory, and expression of one’s status. Creating a communal workspace with its own qualities, thus generating a ‘group territory’ atmosphere and own collective identity is suggested as a way to offset the loss of territory and personalisation (Voordt, 2004).

2.3 Disadvantages of modern workspaces

Often despite the willingness of organisations and a well-thought out strategy, intentions and desires differ significantly from resulting outcomes (Pinder et al., 2009). In some instances this has led to unanticipated outcomes such as the establishment of new rules, routines and procedures being learnt by the occupants (Värlander, 2012). The lack of privacy in open-plan workplace environments is a major issue for both the commercial and education sectors despite design provisions (Eisinger, 2002; Gorgievski et al., 2010; Lansdale et al., 2011; Värlander, 2012; Voordt, 2004, 2008). Due to the very nature of academic work with a high degree of concentration and creative thinking, minimal detractions are paramount. In comparison with individual cellular offices, open-plan academic environments have a tendency to decrease psychological privacy and increase noise and distractions, which ultimately affects negatively the occupants' productivity and motivation (Gorgievski et al., 2010; Parkin et al., 2011). There are also claims in the literature that instead of promoting informal interactions, open-plan workspaces reduce the spontaneity of interactions (Pinder et al., 2009) and encourage superficial conversations due to concerns of being overheard or interrupted (Fayard and Weeks, 2011).

For academics, the loss of privacy is associated with the loss of independence due to the loss of control over their personal space. This loss of independence is particularly severe during a transition to non-territorial workspaces (Wells et al., 2007). On average 10% to 20% of employees are unable to cope with a non-territorial work environment as they miss their personal workspace and the opportunity to personalise it. The hot-decking policy does not prove as effective as initially thought as employees still prefer their own decks (Gorgievski et al., 2010). Taken to a very extreme, some occupants perceive the inability to display own personal items as a loss of their own individual identity. This gives rise to negative behaviour such as squatting and colonisation of space in desirable unassigned areas (Värlander, 2012).

3. RESEARCH APPROACH

A case study of Unitec Institute of Technology was used to explore how the organisation embraced modern office workspaces, the approaches used and the progress made thus far. Document analysis, field observations and semi-structured interviews were used as data collection methods within the case study research approach. Unitec has a number of strategies and plans to help it achieve the goals set by the Unitec Council and government. Of particular relevance to this research were a number of specific strategies regarding Unitec's Transformation Programme: the Sector Alignment, the Property Strategy and the Student Services Blueprint. The document analysis, which took place first, helped in formulating the questions for the face-to-face interviews that followed.

The interview questions were exploratory and qualitative in nature. The first stage of the construction development on the Mt Albert campus began in late 2014 and primarily focused on developing and testing prototype learning and office spaces with the intention to use them as models for future development. The on-site observations of the new prototype office workspaces were conducted in building 48 before and at the time of the interviews and resulted in the collection of image data. The refurbishment of the existing building was completed in mid-2015 to showcase a much more open plan office environment which features no offices, two quiet rooms, three bookable meeting rooms, and no set desks. The observations provided further evidence of the physical transformation of the existing workspaces particularly with regard to their suitability based on workspace design strategies; the progress being made; and the goals that had been set.

Twenty five semi-structured in-depth interviews were carried out with three groups of participants: ten with staff that have had previous experience in adopting modern office workspaces; ten with staff that have not worked in such environments; and five with institutional key decision-makers responsible for the management of Unitec facilities. The interview participants were from a number of departments located on the two levels of building 48: Accounts & Finance, the Corporate Office of the Chief Executive, the International Office, Marketing & Communications, the Pacifica Centre, Te Puna Ako and Te Waka Urungi. Their background was primarily admin work, student learning support and curriculum development. Five interviewees were also engaged in teaching. The interview data captured the participants' attitudes, opinions and experiences in relation to modern workspaces and associated work practices. A matrix of responses was created to analyse the collected data from the three groups of participants and the reviewed documents.

4. FINDINGS AND DISCUSSION

4.1 Broad organisational changes taking place

Unitec is in a process of widespread organisational changes, it is not just undergoing a simple transformation of its existing workspaces. Unitec has adopted various strategic plans for the implementation of these institution-wide organisational changes and for the upgrade of its physical environment. These changes include new work practices, new programme design, the disestablishment of exiting roles and establishment of new ones in a flatter organisational structure where desk-sharing in modern ABW environments will become the norm. According to the research data, interdisciplinary collaboration, co-creation, innovation and community culture are at the core of the proposed organisational model with the aim to meet the expectations of employers, students and government (i.e. sector alignment).

Official documents state that the existing workspace facilities at Unitec are inflexible to changing technologies, hamper the institute to deliver contemporary teaching and learning models and saddle it with unsustainable financial costs. The main reasons for the physical transformation of the institution's existing workspaces are: to facilitate the sector alignment as part of the new organisational model; to encourage more interaction and cooperation within its academic fraternity; to enable the introduction of advanced teaching technologies; and to reduce facility costs. Although the reasons for having new workspaces vary across institutes, there are some common threads such as fostering interactions, collaborations and creativity or reducing facility costs (Pinder et al., 2009). However, the interviewed staff were of the opinion that new workspaces alone would not be enough to make substantial changes to existing work practices. This finding is similar to other studies where the physical workplace environment is not considered as the sole factor able to alter the culture of an organisation and facilitate change towards a more collaborative environment (Lansdale et al., 2011; Pinder et al., 2009).

4.2 Workspaces mirroring user's requirements

The decision-makers provided conflicting information regarding user's workspace requirements. On the one hand they indicated that all users had the same universal requirements and there was no specific workspace design. On the other hand, a decision-maker elaborated on the various strategies focusing on proposed new spaces tailored to the specific needs of individual users. Furthermore, the decision-makers pointed out that the ABW concept implemented in the prototype spaces in building 48 would be a template for all new workspaces at Unitec, which will be flexible enough to adapt to the changing requirements of each individual user. These prototype spaces have been modelled on typical commercial office use. The industry influence on new workspaces within higher academic institutions and the inclusion of non- territorial spaces as part of work areas has become a pervasive trend in recent years (Pinder et al., 2009).

The majority of staff that have had experience working in modern workspaces before felt that the new workspaces did facilitate the different needs of users. However, some thought that such spaces focus more on the tasks at hand rather than on individual user's preferences. Staff that lacked such experience were not convinced that the new spaces would cater for individual working styles. Some privacy is required especially in the cases of quiet concentrated work (Haynes, 2008; Parkin et al.,2011). A site visit to building 48 revealed readily available workspaces that met the specific needs of the admin staff and executive team. However, these spaces were not suitable for individual work styles, if required, due to the uniform workspace design for a uniform approach to work.

4.3 Workspaces facilitating work collaboration and interactions

There was a general agreement across the three interviewed groups that the proposed ABW do support work interactions, and facilitate collaboration and knowledge sharing among various groups that normally would not have regular contact. Even the group of staff participants who have never worked in modern office environments expressed a more optimistic view that these shared spaces could be beneficial to all, especially in combination with the new flatter organisational structure. An example of such spaces fostering collaboration and informal interactions among staff are the non-territorial workstations located in a 'neighbourhood zone'.

Various institutional documents also emphasise the importance of collaboration among Unitec staff within the proposed organisational model. By upgrading its physical environment and creating new modern workspaces with the purpose of encouraging cooperation and knowledge sharing, Unitec is following in the footsteps of other tertiary institutions (Cole et al., 2014; Pinder et al., 2009). However, the question still remains how shared spaces are going to support individuals who need to work in isolation. Such sentiments were particularly prevalent in the group with no experience in modern office environments. These findings are similar to other studies which highlight the tension between the need for concentrated individual work and the requirement to share information within modern workspace environments (Haynes, 2008; Parkin et al., 2011). Furthermore, some interviewees were sceptical as to whether or not collaboration could be achieved in these new non-territorial spaces between disparate disciplines within Unitec and between staff members and their respective superiors.

The interviewees also described their own personal experience working in an open space office environment and identified an inherent weakness in the design, where the distance between users determines the frequency of collaboration. A communal area design approach undertaken in building 48 has allowed for centrally positioned purpose-built spaces to compensate for such distances. Such common areas or 'interaction nodes' stimulate frequent interactions (Peponis et al., 2007) and encourage separate groups of staff that do not normally work with each other to interact (Fayard and Weeks, 2011; Jaitli and Hua, 2013). A decision-maker described these informal interactions facilitated by the new workspaces as 'bump culture'. In Unitec's case although staff tend to congregate and socialise in these common spaces, the general perception of the interviewees was that that was not very effective.

4.4 Staff engagement

Meetings, workshops and ongoing discussions with Unitec staff over a long period of time aimed at clarifying the concept of ABW and developing an awareness of what management was trying to achieve. According to the decision-makers, staff from across the campus were also encouraged to test the work environment in building 48. There were some inconsistencies in the interview data collected from the different participant groups regarding direct staff engagement, input and feedback. The decision-makers thought that staff whose workspaces were directly affected by the changes were approached for feedback on the overall design and the definition of their new sub-culture. However, the affected staff felt that they were left out and had only been made aware of the existence of these prototype offices after they were built; they were never involved in any discussions revolving around desk-sharing with others within their department. Interviewees that have had past experience working in modern office environments mentioned that feedback regarding workspace design was sought only from selected user groups. If other discussions of any kind took place, they must have been with the department heads. Similar cases in the literature with a lack of engagement in the planning and design process have resulted in a negative impact on staff's satisfaction from their new workspaces (Gorgievski et al., 2010; Parkin et al., 2011).

In relation to staff being engaged in discussions regarding the changes to the Unitec organisational structure and work practices, it appears that staff were well informed of what was happening at Unitec. Various institutional documents, campus-wide discussions, presentations and departmental meetings in 2014 and 2015 helped in that regard. A number of staff were also involved in the 'new ways of working'. However, staff that have never worked in modern workspaces before claimed that they had no knowledge of any structural changes occurring within their department, similarly to the lack of consultation regarding new workspace design. Situations were described where departmental heads within Unitec 'would only pass on selected information of their own choosing'. Staff were only privy to general organisational changes. This claim is acknowledged by an organisational document, outlining staff's concerns about being adequately heard, openness and transparency, and a lack of communication in the engagement process. The breakdown in communication lines between the decision-makers and general staff members was apparently an issue. It is also possible that the decision-makers did not intend to include every staff member in the decision-making process. Most institutions still have a silo decision-making process when it comes to facilities planning which does not involve all stakeholders (Groat and Stern, 2002). Interviewed staff felt that for a 'complete buy-in' of what management is trying to achieve by both general staff members and middle management (i.e. heads of departments), they all have to be fully engaged with the process from early on to accept these widespread changes.

4.5 Privacy, distractions, loss of personal territory

The view of the decision-makers was that there are no distinguishable differences in work practices and work areas between industry and academia. Although commercial workplace environments and tertiary institutions do have similar characteristics, there are also distinct differences (Lansdale et al., 2011; Pinder et al., 2009; Voordt, 2008). Designated spaces will be available to staff as part of the ABW design for reflective and quiet individual work. Interviewed staff who had worked in modern office workspaces before were more perceptive to the suggested changes in comparison to the staff who lacked such an experience. The latter group were concerned that there would be peripheral noises, distractions and inadequate privacy, although were prepared to work in these new environments as long as there were sufficient workspaces for individual work. Such private spaces that provide full audio and visual privacy are available in building 48.

Some contrasting views were expressed with regard to ‘protecting personal territory of each individual user’. Staff who had never worked in modern workspaces were particularly passionate about this concept and felt that it could be incorporated into the new design. This view was questioned by the decision-makers who thought that the need for personal territory was unjustifiable. Currently, academic staff have their own office, lecture theatre and tutorial space. On average only 35% of the time these spaces are utilised making the current use of space inefficient. The decision-makers’ opinion was that ‘the workspaces are Unitec spaces and not the individual users’. The loss of personal territory is clearly illustrated at building 48 in the common central core area and the main workstations within the ‘neighbourhood zone’ with the desk-sharing. However, this loss of personal territory is partially compensated by a ‘group territory’ atmosphere when the team personalises their communal work area within the neighbourhood zone, for example, through the use of graffiti on the storage lockers.

5 CONCLUSIONS

The current organisational changes taking place at Unitec range from the introduction of activity-based workspaces and associated new work practices to changes in the academic culture and management structure. The principal aim is to reduce facility costs, create an environment for more interdisciplinary interactions and collaborations, and better meet the needs of both the commercial sector and students. The ABW prototype spaces in building 48 at the Mt Albert campus have helped the increase in collaborations and informal interactions among staff. These spaces, whose design has been heavily influenced by the commercial sector, will be used as a template for future workspaces within Unitec. However, there appears to be tension between the management’s objectives of space utilisation and the staff’s workspace requirements for concentrated individual work. Work practices and work styles in academia are distinctly different from industry despite decision-makers insisting otherwise. A level of uncertainty remains whether these proposed spaces will be adequate and fit for the intended purpose.

There have been genuine attempts on the part of the decision-makers to fully engage staff with the change-management process. However, this process has had limited success so far according to staff surveys and interviews. The lack of engagement could have a negative impact on staff's satisfaction from their new workspaces. The particular approach which was adopted during the workspace design process involving a few selected staff does not help either. It only contributes to the perception of a silo decision-making process occurring within the organisation.

The planned implementation of non-territorial workspaces at Unitec will lead to a loss of personal territory for all staff. Strategies are put in place to compensate for this loss by creating a team culture within staff groups. Workspaces need to be viewed as a valuable resource, which has an influence on strategic style, organisational culture, work practices and employee performance. Likewise, workplace strategy should primarily be focusing on the users of the workspaces; hence these areas should not be considered just as a facility issue to ensure their successful implementation by the organisation.

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EXPLORING THE INTERACTION BETWEEN AGED CARE POLICY AND BUILDING REGULATION: DISPARITY BETWEEN POLICY INTENT AND OUTCOME

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ABSTRACT

Nationally, one of the most significant demographic challenges confronting society concerns our ageing population. In 2002 it was reported that persons aged 65 and over contributed to almost 2.5 million; yet, by 2042 this is set to exceed 6.2 million. Similarly, with the age group 85 and over the growth rate is significant from approximately 300,000 to an estimated 1.1 million by 2042. Given such growth, the availability of appropriate housing is a prime consideration. With this in mind, the Australian government through the Aged Care Act and the National Construction Code established the means by which to achieve housing demands of the ageing population. Although the Act promoted ageing in place, the Code has formerly been restrictive requiring multiple classifications for different building uses. Changes in 2002 brought conformity: the introduction of a new classification designed specifically for aged care buildings: aligned with ageing in place criteria. However, this solution presents a predicament. Typically the Act moves beyond care provisions and into the realm of the built environment stipulating requirements possibly contrary to the Code. Furthermore, in an attempt to achieve ageing in place requirements of the Act, unintentional breaches of the Code may occur particularly with fire safety. The new classification introduced by the Code became mandatory in 2011 and the ability for older facilities to comply with contemporary Code requirements for ageing in place remains questionable. This paper reports on the current policy state of affairs, highlights the policy disparity concerning fire safety and identifies future research.

Keywords: aged care, ageing in place, building classification, building regulation, policy

INTRODUCTION

Within Australia, one of the most significant demographic projection trends concerns our ageing population (Australian Bureau of Statistics, 2015; Commonwealth of Australia, 2013; Giesecke and Meagher, 2008; Miller, Donoghue and Buys, 2014). In 2010, 13.5% of the Australian population was over 65 years with 5% of that group in residential aged care; however, the size of the cohort is anticipated to rise to 20% of the Australian population and the number of residents in RAC is predicted to show a 54% increase by 2023 (Australian Bureau of Statistics, 2010). Therefore, it is imperative that society addresses the increase in demand for aged care facilities with the ability to support ageing in place.

The ageing population will increase the need for aged care facilities and subsequently presents a range of challenges for the industry (Miller et al., 2014). Much research has been undertaken into the quality of life for residents in these facilities in areas such as place attachment (Heisler, Evans and Moen, 2014), attitudes towards adjustment (Hjaltadotir and Gustafsdottir, 2007), social interactions (Tsai and Tsai, 2008), cultural values and systems (Carr, Biggs and Kimberley, 2015) and ageing in place in the home (Horner and Boldy, 2008). However, the built environment in terms of policy requirements and outcomes specific to fire safety requisites require further attention.

During 1997 the Commonwealth established the Aged Care Act 1997 (Commonwealth of Australia, 1997). This new regulatory policy acknowledged the ageing population and promoted the concept of ageing in place and was subsequently adopted by all States and Territories. The Act further specified accreditation and certification requirements for aged care facilities that are aligned to government funding. In many instances the Act moved beyond care provisions and delved into construction standards where the potential for policy conflict evolved (Commonwealth of Australia, 1997). Furthermore in an attempt to achieve compliance with the Act and ageing in place requirements, it is possible to unknowingly and unintentionally breech construction standards.

The National Construction Code (NCC), formerly the Building Code of Australia which encompasses technical building provisions, remained restrictive. Facilities associated with aged care were nominated as class 3 low level care, or class 9a high care level. A facility may consist of one class or be awarded multiple classifications for various parts. Essentially, this restricted the type of use due to different construction and fire requirements associated with each classification (Australian Building Codes Board, 2015). Eventually it was acknowledged that there was a need for national regulations that allowed for multi-used residential care buildings. Subsequently, in 2002, the ageing in place concept was recognised with the adoption of a class 9c specific to aged care facilities (ABCB, 2015). Although the new classification resolved future construction concerns, those structures erected prior to 2002 remain exposed to ongoing challenges and where used for ageing in place, the ability to comply with contemporary NCC conditions remains questionable, particularly in relation to fire safety requirements.

METHODOLOGY

The aim of this paper is to report on the current policy state of affairs concerning the Act and NCC, discuss the interaction between these policies highlighting issues related to fire safety. First, a review of the literature concerning ageing in place as related to the built environment and fire safety was undertaken. Governing policies for these specific areas were then identified. They were reviewed in terms of their requirements for fire safety and any issues noted and explored. This paper focuses upon policy environment with a discussion on the governing aged care policy, the NCC and interactions between these policies outlining potential areas of conflict.

THE RESIDENTIAL AGED CARE SYSTEM

Residential Aged Care governance has changed significantly since the commencement of the Act in 1997 and the subsequent adoption of the Department's 'ageing in place' policy. Most notably, assessment and funding mechanisms changed considerably and this resulted in another raft of challenges for the facilities given new criteria to be achieved (Commonwealth of Australia, 1997).

The Aged Care Act

The Act describes residential care as personal care or nursing care, or both, that:

(a) is provided to a person in a residential facility in which the person is also provided with accommodation

(b) meets any other requirements specified in the Residential Care Subsidy Principles (Commonwealth of Australia, 1997)

Initially the Act required residents to be assessed and allocated a status against the Residential Classification Scale (RCS): dependent on the level of care required. Care level increased as RCS approached 1. RCS determined the level of subsidy the Commonwealth Government provided for the resident. In 2008 the RCS was replaced with the Aged Care Funding Instrument (ACFI): 12 areas of care needs that mostly affect the cost of care. The 12 questions are spread over 3 categories of care being, Activities of Daily Living (ADLs), Behaviour; and Complex Health Care. In comparison to the RCS, a high score in any of the 3 categories defines the resident as requiring high care with others delegated low or medium care

(Australian Government, Department of Health and Ageing, 2008). For a facility to provide aged care services, charge accommodation bonds or charges and receive grants it must be certified. Furthermore, the aged care services must be accredited. Whilst certification relates mainly to quality of buildings and their fabric, accreditation mostly assesses quality of care (Commonwealth of Australia, 1997). There are areas of overlap with the built environment throughout these processes as multiple criteria relate to construction areas having the potential to impact fire safety.

RAC Certification

The Act is quite succinct in regard to certification and division 38.3 part 1 (a) and states that there must be regard to:

> "...*the standard of the buildings and equipment that are being used by the residential care service in providing residential care; and' (Commonwealth of Australia, 1997)*

The "…*standard of the buildings*..." is set out by the Australian Government Department of Health and Ageing in a number of documents primarily "Building Quality for Residential Care–Certification' and is assessed across 7 categories and 33 parts of which the first overarching theme is 'Safety' with a focus upon 'Fire Safety' as shown in Table 1.

Table 1 The certification assessment instrument score summary

Category	Overarching Theme	Parts	Weighted Score	Theme/s
1	Safety	7	25%	Fire safety
2	Hazards	3	12%	Maintenance
3	Privacy	5	26%	Room allocation
4	Access/OH&S	6	13%	Mobility/OH&S
5	Heating/Cooling	4	6%	Heating/Cooling
6	Light/Ventilation	4	6%	Light/Ventilation
7	Security	4	12%	Security

(Source: Australian Government Department of Health and Ageing, 2006)

RAC Accreditation

Accreditation is undertaken to promote quality of care and is carried out by the Aged Care Standards and Accreditation Agency Ltd, a company appointed under the Act with the Minister for Mental Health and Ageing as the sole member. Accreditation is dependent on 4 "Standards" which cover 44 outcomes that have to be met achieved in which Standard 1 makes reference to 'Safe and Comfortable Living' that impacts upon fire safety elements (Aged Care Standards and Accreditation Agency Ltd, 2011). Where the emphasis of accreditation is slanted towards quality of care there are direct outcomes related to the built environment. As an example, Standard 3, Outcome 3.6 Privacy and Autonomy could have influences over building elements like the type of windows (operable or not) and air conditioning system and controls (Aged Care Standards and Accreditation Agency Ltd, 2011). The criteria controlled by the Standards are important as a minor change to achieve compliance, may in fact be detrimental to life safety from a NCC perspective. For example, Standard 3 may result in changes to openable windows or air condition systems (Aged Care Standards and Accreditation Agency Ltd, 2011). Such alterations may produce an impact upon fire services (e.g. smoke exhaust and ventilation systems) installed to ensure rapid and safe evacuation during an emergency. In attempting to achieve compliance at one level may result in an unintentional breach to another policy (NCC). In reality, it is not reasonable, nor feasible, for employees of such facilities to be familiar with facility policies and also those associated with other professions to ensure conflict is eliminated.

NATIONAL CONSTRUCTION CODE

In 1988 the first edition of the Building Code of Australia (BCA) was produced as a result of the Local Government Ministerial Council seeking to provide a uniform building code for the Nation. This first edition was revised in 1990 and progressively adopted by all states and territories in the early 1990s. In October 1996 a performance based BCA was adopted by the Commonwealth and subsequently the states and territories in 1997 and 1998. From 2003 annual revisions and amendments to the BCA were produced on May 1 each year (ABCB, 2015). On May 1, 2011 the first stage of the National Construction Code (NCC) was released for adoption by the states and territories and comprised the BCA and the Plumbing Code (ABCB, 2015).

Originally, the BCA identified 2 classifications related to aged care: class 3 and class 9c. With the challenge of an ageing population and the development of comprehensive aged care facilities, it was acknowledged that great flexibility was required within the Code and an ability to offer ageing in place. Subsequently, a new classification was introduced during 2002: class 9c. However, the class relates to aged care facilities approved for construction after May 2011 (ABCB, 2012). Table 2 illustrates the differences between the 3 primary classifications.

Table 2 NCC classifications relating to aged care

NCC Classification	Definition
Class 3	A low care level facility: hostel
Class 9a	A high care level facility: nursing home
Class 9c	A multi-care level facility: aged care building

(Source: Australian Building Codes Board, 2015)

Class 3

A class 3 is not necessarily purpose built for aged care but refers to a building where unrelated people reside long or short term. Given the building type, it reflects a shared accommodation style: residents are fully cognitive with a high degree of mobility. Class 3 buildings, or parts of, have been used in RAC for residents who have a degree of independence and require minimal support (ABCB, 2015). The NCC provides a range of examples for this classification as follows:

> '*a boarding house, guest house, residential part of a school, accommodation for the aged..*.' (ABCB, 2015).

Class 9a

A class 9a building traditionally represents a health care building where occupants require a degree of assistance to evacuate during an emergency situation. Prior to 2011 the definition of a Class 9a included:

'…*a nursing home or similar facility for sick or disabled persons needing full time care*…' (ABCB, 2005).

Subsequently, the classification covered the high level care portion of an aged care facility. Within the current NCC context, a class 9a reflects:

'…*a health care building, including those parts of the building set aside as a laboratory*.' (ABCB, 2015).

A health care building refers to a structure in which occupants and patients undergoing medical treatment require assistance to evacuate during an emergency. In the current context, this extends to hospitals and day surgeries but also the nursing homes (ABCB, 2015).

Class 9c

The 9c buildings were included in the BCA from 2002 as an ageing in place option and for facilities with Class 3 and Class 9a uses. From 2011 Class 9c is the requirement for an "aged care building" where residents require "personal care". The NCC sets out 5 parameters to define "personal care": the provision of nursing care; the need for assistance or supervision in relation to areas such as bathing; the need for physical assistance to a person given limited mobility; assistance with management of medication; and the provision of rehabilitation or development assistance (ABCB, 2015). Today, the class 9c building may be considered a comprehensive aged care facility that importantly, makes provision for ageing in place. Regardless of the adoption of a comprehensive classification, the situation exists where buildings of all 3 classifications or a mixture of these remain in existence. All classifications have specific construction requirements stipulated within the NCC and minimum fire safety requirements: however, characteristics including building height and floor area dictate additional controls such as the need for higher fire ratings of building elements and fire compartmentation. In general, the class 9c has more onerous conditions given the range of residents accommodated within the building.

INTERACTION BETWEEN THE NCC AND ACT

Stated objective (j) of the Aged Care Act 1997 is:

> "*to promote ageing in place through the linking of care and support services to the places where older people prefer to live*."
> (Commonwealth of Australia, 1977).

The class 9c became mandatory for aged care buildings from May 2011. Prior to July 2002 RAC facilities comprised Class 3 and Class 9 buildings dependent on use and between July 2002 and May 2011 a dedicated Class 9c aged care building was an option. Although the Act gave residents the ability to age in place, the building codes only provided an option to meet this objective in 2002. As a result a mix of buildings and classifications were used for many years (1997 – 2011) to meet the requirements of the Act. Figure 1 indicates the building classifications overlaid on the health care requirements at the time of the Class 9C amendment (2002). Low care and high care ends of the scale are also indicated. Although the RCS (Resident Classification Scale) used in this system was replaced by the Aged Care Funding Instrument (ACFI) in March 2008 (Australian Government Department of Health and Ageing, 2006), the overall graphic provides a good indication of the relationship between the level of care and the class of building in the NCC. An RCS 8 classification indicates the minimum level of care and an RCS 1 classification indicates the highest level of care. Government funding of aged care was also pinned to the RCS.

The ageing in place component of the Act enables residents to fluctuate between low, medium and high care, dependent on circumstances, and remain within the same familiar home environment, preferably the same room. Previously when residents required a higher level of care they were transferred to another facility or another part of the facility or from a

Class 3 building, or Class 3 part of the building to a Class 9a building, or Class 9a part of the building. Class 3 buildings, or portions of buildings, have fire systems that, while adequate for ambulant residents of a Class 3 building, are not adequate for residents who require assistance to evacuate. For many RAC facilities built prior to 2011 the NCC and the direction of the Australian Government Department of Health and Ageing are not congruent on this point.

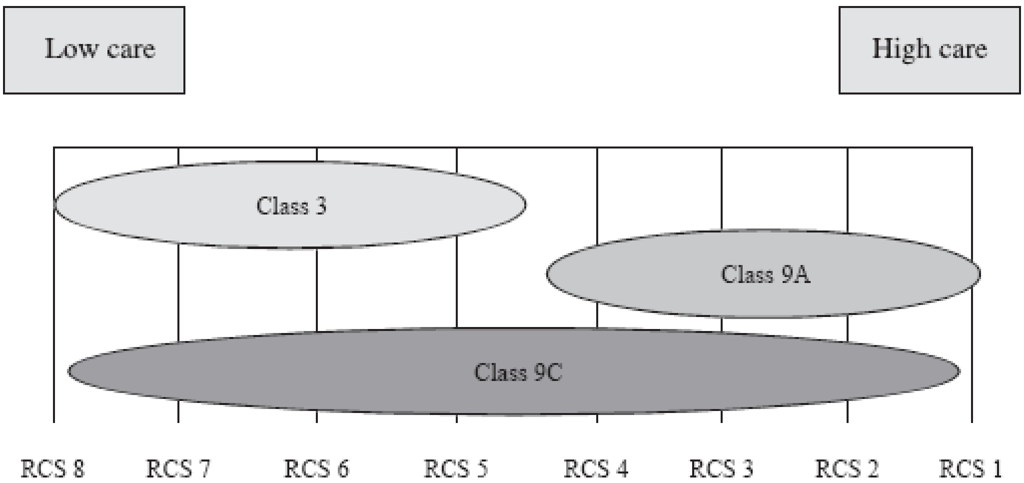

Figure 1 Residential Classification Scale vs Class of Building

(Source: Australian Government Department of Health and Ageing, 2006).

Currently where there is a mix of the three classes of building (Class 3, 9 and 9c) in a RAC facility, it is possible for management to meet the requirements of the Act but unknowingly and unintentionally breach the requirements of the NCC. For example, a resident in low care may be established in a Class 3 section of a facility, as the resident ages and requires higher levels of care they remain in their home room environment and the care is provided in accordance with the Act. However the NCC requires that resident to be moved from the Class 3 building to a Class 9 or 9c building to receive higher levels of care. Managers of RAC facilities are not specialists in types of construction, fire ratings, fire compartmentation, sprinkler systems and so in complying with the Act they can unknowingly contravene the requirements of the NCC. A large component of the classes of building for RAC in the NCC are based on evacuation of impaired residents and therefore the morphing of use in a Class 3 to higer levels of care could put the residents at risk.

Conversion of class 3 to a class 9c is not a straightforward process and presents a range of issues and generally is not a process that can be undertaken due to economic feasibility and physical limitations of the building. Typically the fire and smoke compartment size is incompatible. Smoke reservoirs above smoke doors may not be provided, anxillary areas would not be smoke separated. Similarly, external hydrant coverage and location would not be compliant nor the mandatory requirement for a fire sprinkler system. Additional areas associated with access and egress (disability acress) would not be compliant.

DISCUSSION

The Aged Care Act and the NCC establish the means by which to achieve the housing demands of the ageing population. Although the Act has promoted ageing in place, the Code has formerly been restrictive requiring multiple classifications for different building uses. Changes in 2002 brought conformity through the introduction of a new classification designed specifically for aged care facilities: aligned with ageing in place criteria. Even with highly specialised policy the system remains fraught with difficulty. The intent of the Act relates to care provisions; yet, it is shown that it often affects issues regulated by the NCC, particularly those associated with fire safety. In achieving the goals of one policy another may be inadvertently breached. The current situation portrays a range of different aged care facilities within operation that have different classifications: each with their own specialised construction requirements under the NCC. However, the ability of the older class 3 and class 9a buildings to appropriately achieve classified aged care facilities within operation. Although the more modern class 9c are suitable for ageing in place and have fire safety provisions to accommodate a range of residents, the ability for older facilities to comply remains questionable.

CONCLUSION

One of the most significant demographic challenges confronting our society concerns our ageing population and the need for appropriate housing. With the introduction of the Commonwealth Aged Care Act, 1997 and amendments to the National Construction Code consideration has been given to ageing in place and future housing needs. However, within this policy system there is a range conflicts that potentially impact upon life safety. Parameters of one policy appear to impact upon another causing non-compliances and the ability for existing facilities to achieve high fire safety standards remains questionable. Given the potential disparity between policy intent and outcome, it is proposed that research will be undertaken to explore existing facilities to determine compliance against governing policies. In this manner, barriers and enablers to policy implementation and the true extent of policy conflict can be understood to help guide future policy directions to ensure appropriate accommodation for the elderly that maintains the highest fire safety standards.

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SCANNERS AND PHOTOGRAPHY: A COMBINED FRAMEWORK

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ABSTRACT

Latest Lidar scanner technologies have great potential to contribute to construction processes by capturing accurate data in a convenient way. In particular, handheld Lidar scanners have the potential to provide real-time data from insitu buildings that are under construction or will be redesigned during construction. Focusing on the advantage of handheld Lidar scanners and photogrammetry technologies, this paper presents an integrated framework to revise digital drawings based on updated data from construction objects. The data was collected using handheld scanners for two floors of a building. Additional data was collected using terrestrial scanners including point clouds and photos in order to compare different Lidar technologies and update the data.

The findings show how handheld laser scanners differ from terrestrial scanners: efficient for updating data to assist designers to revise digital construction drawings, easy to use without high-skilled labour required, and less expensive than terrestrial scanners. The procedures of creating models from different tools, namely handheld and terrestrial Lidar scanners, are compared to evaluate the feasibility of semi-automatic data acquisition for creating Building Information Models (BIM). It was found that the framework using handheld Lidar, potentially enables designers to quickly revise drawing of complex objects. The proposed study is a step towards semi-automated modelling and drawing revision of construction objects.

Keywords: Lidar, Challenges, Digital drawings, Laser scanner, Photography

INTRODUCTION

Future trends for construction revolve around the utilisation of digital technology. There is a desire to convert all construction documentation to electronic edition compatibility. However, the possibility of acquiring accurate data from complex objects in both indoor and outdoor settings, as well as the skill to work with captured data needs to be improved for as-built documentation purposes (Giel and Issa 2011). Therefore, a tool capable of detecting objects and collecting accurate coordinates, colour and texture in a timely manner would have significant value for contractors. This tool could contribute to the flow of information and increases the quality of technical communication on construction sites.

Given the above, a procedural framework for utilisation of scanners is proposed which aims to assist contractors to utilise a chosen laser scanner and incorporate 3D Lidar point cloud data captured into a BIM. The main objectives of this paper are: 1) to implement advanced technologies to create as-built drawings; 2) to examine the feasibility of new scanners to capture data for digital drawing modelling for different purposes such as progressive monitoring during construction; and 3) to investigate the possibility of developing an integrated system to collect new information and building mature models from different tools. The originality of this paper lies in implementing a novel framework to use different scanner technologies for rich data acquisition for creating digital drawings. The presented framework enables contractors to update a BIM and use it for different purposes on the construction site.

The paper first identifies technology gaps and barriers to the automated modelling process. Second, a novel procedural framework for creating as-built drawings using scanner technology is implemented. Third, the process is put into action via applied experimentation using three competing Lidar technologies. This included comparison of terrestrial and handheld scanning technologies and experimentation with supplementary photography to improve colour and texture recognition of scanned objects. Finally, future pathways of investigation are suggested.

DIGITAL DRAWING TECHNOLOGY

The process of scanning for the purposes of real time enhanced digital drawing modelling can be divided into three main phases: 1) point cloud data acquisition (Sepasgozar et al. 2014, Sepasgozara et al. 2015); 2) photo shooting, and 3) building information modelling.

Recently, researchers have been using photogrammetry techniques to produce digital and parametric data for as-built information modelling. Photogrammetry refers to geometric information derived from photographs (Zhu and Brilakis 2009, Klein et al. 2012). However, this method has limitations (Bhatla et al. 2012, Klein, Li et al. 2012) and in particular, difficulties in extracting object points from close but wide angled situations (Klein, Li et al. 2012). This approach cannot produce the required information about the topography of irregular shapes in detail and cannot provide the details of curves and irregular shapes, whereas Lidar scanners can capture such details easily. Photogrammetry usually cannot be used independently in creating as-built models, therefore, it is not a holistic or ideal solution for capturing a progressive understanding of the actually built building (Markley et al. 2008).

A few recent studies attempted to integrate digital photogrammetry with Lidar scanners (Jeyapalan 2004, Liu et al. 2012). Lidar is a laser imaging technology that is increasingly employed for capturing scenes with millimetre to centimetre accuracy (Sepasgozar et al. 2014, Sepasgozara, Limb et al. 2015). It provides fast, accurate, comprehensive and detailed 3D data about the scanned scenes at the rate of hundreds of thousands of point measurements per second. Laser scanners collect data in the form of point clouds which make it possible to define shapes and dimensions of objects in real space, converted and represented as a collection of points in a 3D digital space (such as a BIM). However, there are two main problems for utilisation of these technologies. Firstly, the geometric information such as lines and surfaces cannot be easily extracted from the millions of data points associated with the captured object environment (Arayici 2007). Secondly, only a limited number of scanners such as terrestrial scanners (which can use LIDAR technology) are suitable for BIM (Xiong et al. 2013). Therefore, Lidar scanners have yet to mature in terms of usage with BIM. This sets up the need to examine the state-of-the-art concerning the technologies mentioned above.

RESEARCH METHOD

In order to investigate the capabilities of different advanced technologies, a combination of two data acquisition techniques, photography and Lidar scanner were adopted. Previous work shows that Lidar scanners provide dimensioning data in an accurate manner and within a short time frame (Sepasgozar, Lim et al. 2014, Sepasgozar, Lim et al. 2014, Sepasgozara, Limb et al. 2015). However, the drawback of such scanner technology is that they are not very helpful in defining objects in terms of texture and colour. In this paper, photos are collected to cover the deficiency of the previous studies by providing supplementary information. Therefore, the process of data acquisition is divided into sub-processes of ‘scanning’ and ‘shooting’.

The sub-processes of the data analysis are presented in the next section as the procedural framework consists of scanning, shooting and creating 3D models. Field experimentation using the scanner/photography technology was undertaken in a real world data capture scenario, using a sample building. A number of competing approaches were tested including: a handheld mobile scanner (HMS) which was used in conjunction with a contemporary handheld digital camera; and two stationary terrestrial Lidar scanners (TLS) with different range including a multi-station and scan station model. The feature set of the competing technologies was analysed with respect to onsite application and subsequent data conversion processes. The intention was to compare the performance of the Lidar scanners with camera combination, and their compatibility with photography approaches.

The utilized HMS included a 3D sensor system that consists of a rotating and trawling 2D Lidar and an internal measurement unit mounted on a spring mechanism. This scanner was utilised because in contrast to the stationary TLS models tested. For instance, the HMS does not need a tripod or a vehicle and skilled operator. The handheld scanner utilised an algorithm for data collection that takes advantage of recording points against a trajectory route and other reference points. The HMS was transported through a loop in the corridor of an existing building on the third and fourth floors. The area represented a lot of detail such as doors, windows and stairs. This study area was selected as it was complex enough to explore the accuracy of the different scanner technologies. The TLS options were used at two locations from less than three metres distance from the objects being measured. The maximum distance measurement and the maximum range were 50 and 1000 metres respectively for the TLS units.

PROPOSING A COMBINED PROCEDURAL FRAMEWORK

This section presents a procedural framework for acquiring data for producing construction drawings (e.g. as-built drawings). The innovative framework is called Drawing Assistance Modelling (DAM). Based on our previous work, the overall process for as-built creation is proposed consisting of scanning, processing and creating (Sepasgozar, Lim et al. 2014, Sepasgozar, Lim et al. 2014). This process is being developed as a part of an on-going study in order to create drawings that can benefit from the advantages of the Lidar technology and photography. Figure 1 shows that DAM consists of four phases as follow:

Phase I – TLS and HMS were used for data capture, data processing, polygon extraction, making volumetric models and creating initial information models. The implementation of this phase was reviewed and the challenges of implementing the procedure are discussed in the following sections. This phase refers to the process of data collection using the scanners. The data was registered and obvious noise was removed. The main elements including openings, walls, floors and ceilings were segmented in the next step. Then, the extracted elements were combined to define as-built elements. Fieldwork was conducted to assess and verify the level of accuracy obtained using the Lidar points to define as-built objects.

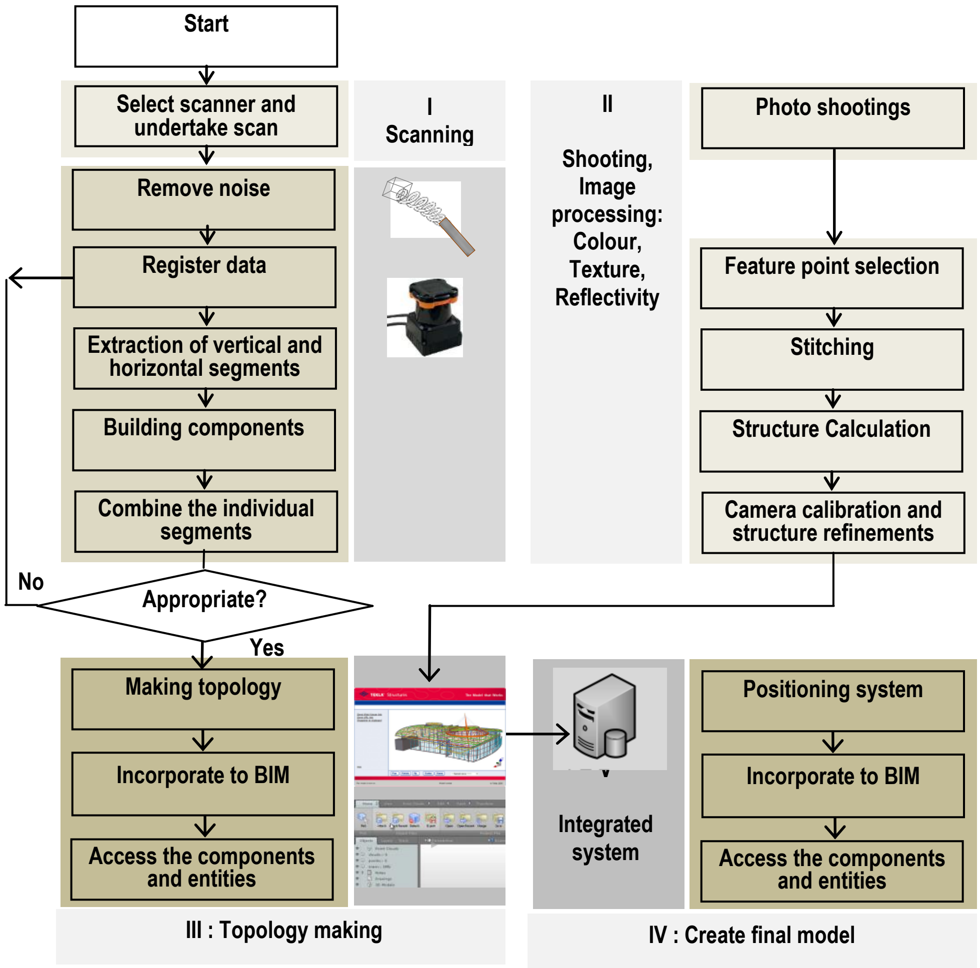

Figure 1. The developed procedure for creating drawing modelling

Phase II – A contemporary handheld digital camera was used in conjunction with the HLS technology for collecting complementary information about the texture and colour of objects. Similar functionality was also available for the Multi Station TLS as it incorporated its own on-board digital camera.

Phase III – The information collected from previous phases including point clouds and photos were used to make the topology for information modelling. In this phase all data was then incorporated to produce a rich model (for each Lidar technology).

Phase IV – The modelled objects and other information such as scheduling and positioning systems were collected in an integrated system to examine the feasibility of measuring construction progress. This part of the algorithm needs to be implemented in the second stage of the study.

CHALLENGES AND SUGGESTIONS

Experimentation via implementation of the above procedural framework allowed insights into the challenges of using the different Lidar technologies i.e. for collecting data used in as-built drawings. Particularly, it focuses on practical challenges of using scanners. Table 1 presents findings from the abovementioned field experimentation plus related specification data about both TLS models as well as the HMS and camera combination.

Table 1. Comparison matrix of Implementation of TLS, HMS and Photographs

	Item	TLS (both models)	HMS	Digital Camera
Spec	Max. Range	300 m to 1000 m	20 m	50 m
	Equipment cost	$60,000 to $75,000	$25,000	$200 to $1000
	Portability	7 to 8 kg	510 g	500 g
Field	Operating	Careful adjustments required thus it is time consuming	No adjustments required	No adjustments required
	Skill required for operation	High	Low	Low
	Practical output accuracy	+/- 3 to 15 mm	+/- 5 to 30 mm	cm
	Spatial data speed	Real-time retrieval possible	Processing required	Manual
	Operation time	Approx. 11-30 mins	Approx. 5 mins	2 mins
	Geometry of the object (shape)	Influences the work	Strongly influences the work i.e. noise is harder to remove	Influences the work
	Weather condition	Influence the work if outdoors	Influences the work if outdoors	No influence on the work

Some of the key challenges of with respective technologies are outlined as follows:

1) There are many construction objects which must be surveyed and then selectively separated for use in the drawings. The objects vary from a large wall to fine openings to stairs. Due to the fixed setup location of the TLS technology, visibility of the intended objects is often obstructed by other objects that get in the way. For example, constant movement from people and machines throughout construction contribute to more noise in the data during the operation process, because the scanning process

takes longer than other approaches and subsequently captures more unwanted artifacts (see Table 1).

As shown in Figure 2, TLS requires a tripod to setup and then it must be moved multiple times to capture the same information that is captured via single pass of the handheld HLS scanner. Of further note, it can be seen from Table 1 that the HMS is much more portable, cost and time-efficient. Even so, Table 1 also indicates that the TLS is significantly more accurate where fine dimensional detail is required for the likes of fine grain positional or setout work. Therefore, recommended use may ultimately be dependent on the purpose and situational circumstances.

Based on the above, the field experimentation shows that a mix of TLS and HMS should be used in order to update the documentations of construction objects so it is more helpful for the drawer/draftsperson to create a mature model and easily updates the documentations for ongoing activities during construction.

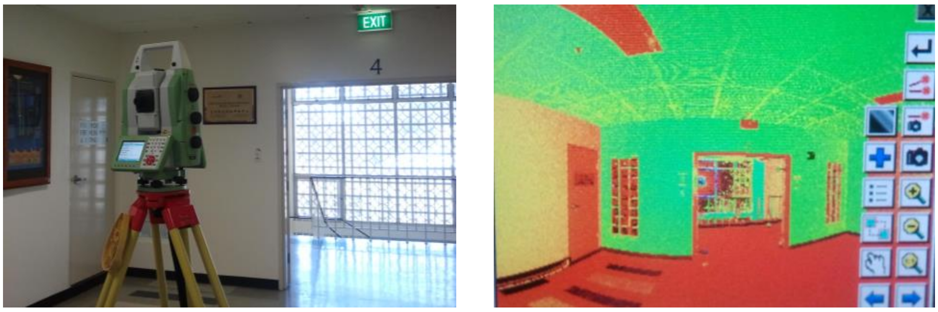

Figure 2. Collecting data from different objects such as walls and openings

2) The scanners were incapable of capturing the texture and colour of each object directly. Particularly in construction, many materials had a similar colour scheme. So, using photography as a supplementary tool can help the contractor to enrich the information in BIM by adding the information collected from photos. However this task is ostensibly a manual one and needs further research to develop an automated procedure to decrease the errors in data entry. Park et al. (2011) generated texture information of a building using a commercially available Canon camera. They showed that texture mapping of the 3D model should be done in two layers: walls; and roofs. They suggested that using the pictometry data reduces the processing time, but the accuracy would be about 1 cm.

3) Since the process of integrating Lidar with photogrammetry needs much work to be automated. Thus it is imperative that challenges and barriers for an automated process of collecting and processing data, be identified.

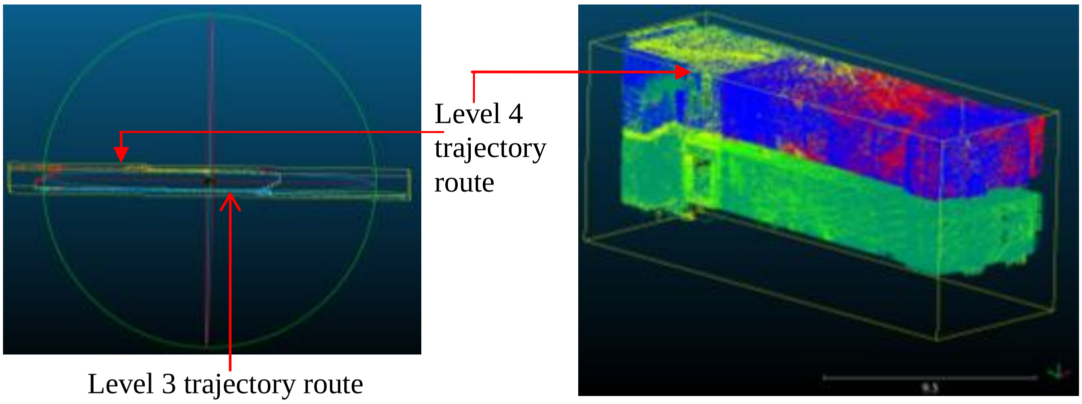

Figure 3. Trajectory of the HMS for scanning level 3 and 4.

4) Moving the TLS and making adjustments is time-consuming and not particularly cost-efficient. In contrast, the experiment showed that using HMS enabled construction engineers to capture indoor data without any setup requirements. Figure 3 shows the trajectory of HMS, which illustrates the route the scanner travelled in the indoor area of the building, and mapped inside the building. The operation time also is very quick and does not require skilled operators to capture data (see Table 1). It seems that such technology is well suited for use in construction for updating as-built documentation and drawings.

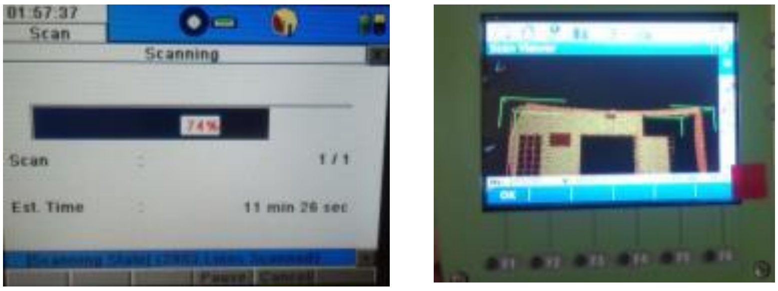

Figure 4. The scanning time and the model view

5) The scanning time for the test area (covering approximately 100 m2) was fast compared to the likes of traditional hand held measuring (such as a measuring tape). For instance, Figure 4 shows the TLS total station used only 11:26 minutes to capture a dense point cloud of the entire area but of course this relies on fast post capture processes in order to ensure true efficiencies are properly realised. The scan viewer also provides the possibility to see the scanned area during the scanning process. However, HMS cannot easily provide a view at the time of scanning. In addition, the communication between any of the tested scanners, TLS and HMS, and office computers, is not real-time. As operators need to collect data from different objects using different scanners and a camera, it is a concern how they would be able to communicate in terms of time and

compatibility. In addition, a Wi-Fi system is also required to make the real-time communication possible. As the data needs post-processing, it was not possible to directly transfer all data to BIM.

CONCLUSION

The aim of this paper was to investigate the feasibility of using different scanners and photography in order to develop a framework for rich digital modelling. The data from the experiments with different types of Lidar scanners was analysed in order to examine the feasibility of creating drawings of as-built construction. The framework presented in this paper is different to previous studies as it shows some possibility for recognising texture and colour for each object that are required to complete digital drawing modelling. Object dimensions were cross-validated using different Lidar scanners and manual survey measurements with photography. The modelling results provide accuracy to millimetre level.

Field experimentation shows that a potentially cost-efficient way of creating a BIM from scanned site data is to use HMS with a simple point-and-shoot camera, because a photo can capture the colour and visual texture of the object which cannot be achieved by Lidar scanner only. This of course will still require off-site processing of the two data sources to assign colours and texture to the captured objects which will have a secondary impact on cost effectiveness. It is also less applicable where high level dimensional accuracy is required.

The presented framework is a valuable tool that assists practitioners to create digital drawing models in BIM. However, there is much work to be done to implement this framework in different fields and to develop a semi-automated drawing tool. There are many different complex objects in construction so future studies should examine different objects in terms of complexity, size, volume, location and in extreme weather conditions in construction.

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LIFTING AND HANDLING EQUIPMENT: FROM SELECTION TO ADOPTION PROCESS

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ABSTRACT

Advanced technologies are increasingly being introduced to the construction industry. Several studies in the literature have examined the diffusion of advanced communication technology, however the adoption process for handling and lifting equipment (e.g. advanced cranes and lift trucks) from an organizational/project perspective has received very little attention. This paper presents the handling and lifting equipment adoption model including key stages of the process from seeking a potential solution to utilisation. The paper also intends to identify whether different construction companies follow the same procedure or have different technology adoption behaviours due to the differences in their organization characteristics. In doing so, a total of 22 in-depth interviews were conducted to investigate how contractors make decisions to adopt a piece of handling and lifting equipment, and to gather information about their feedback on technology implementation. The findings show that the model consists of six main stages (i.e. required activities) such as 'seek potential solutions', 'comparisons', 'evaluation', 'negotiation', 'evaluation', and 'assemble and operate', which are navigated by customers and vendors as they pass through the adoption process. It was also found that there are three main groups of decision makers in the sample which are called 'leader corporations and large firms', 'mid-sized leaders' and 'followers' which pass through the adoption process differently in terms of being either innovative, developing new market technologies, or exhibiting conservative behaviour. Future study should evaluate the model in different contexts and market settings.

Keywords: handling and lifting equipment, Technology Adoption, Cranes, Lift Truck

INTRODUCTION

Building construction is becoming increasingly modernized and industrialized. There is an interest in shifting from traditional and in situ construction to modularized and off-site prefabrication methods. Consequently, handling and lifting equipment (HLE) such as cranes and lift trucks will be critical for improving productivity and safety in modern construction. However, the current crane literature focuses on the process of crane selection but there is virtually no published work explaining the holistic crane adoption process.

Several technology adoption studies focusing on information technologies show: consensus on the importance of understating the process to ensure successful uptake; and the need to investigate the market place where technology diffusion and adoption occurs (Kale and Arditi, 2005; McCoy et al., 2010; Sepasgozar and Bernold, 2012 ; Sardroud, 2014; Sepasgozar and Davis, 2014; Sepasgozar and Davis, 2015b). According to Arts et al. (2011), understanding the whole process gives a critical insight for managers involved in marketing innovation. However, an open question concerns consideration of the range of key factors influencing adoption decisions by which construction companies select and operate new HLE for their projects. According to Manley (2008), many construction companies are not aware of the best practice approaches to implementing innovations and whilst this comment is primarily for Australian projects, the same is thought to be true of many other countries as well. Therefore, the need to study technology adoption topics in construction is particularly important as it has been generally slow in uptake across the construction industry (Sepasgozar and Davis, 2015a; Sepasgozar et al., 2016).

Previous studies have provided different models for crane selection, such as Adaptive Probabilistic Neural Networks (Sawhney et al., 2000) and geometrical characteristic based algorithms (Al-Hussein et al., 2001). However, these current studies only consider project specific variables as distinct from the broader based organisational needs that clearly impact on customer decision making. There is therefore, a need to investigate the industry practice of crane usage in a local area to better understand organisation level adoption strategies.

The present paper develops a framework for HLE adoption in three main steps. First, the relevant literature was reviewed to identify the key area where current knowledge is lacking in HLE adoption and to distinguish between selection and adoption processes. Second, the research method to investigate the adoption process in the HLE industry is presented. Third, presentation of findings which includes an HLE adoption framework consisting of three main themes; and three customer groups who pass through the process in different ways. This is followed by a comparison to understand differences between each customer group in the adoption process.

FROM CRANE SELECTION TO CRANE ADOPTION

The contextual complexity of the construction industry coupled with the uniqueness of the crane business in terms of sensitive technology and safety, compel us to seek a more comprehensive framework to assist in HLE adoption decisions. The existing studies present crane selection models such as Decision support for tower crane selection (Marzouk and Abubakr, 2016), Adaptive Probabilistic Neural Network-based (Sawhney et al., 2000) and a geometrical characteristic based algorithm (Al-Hussein et al., 2001), predominately relying on crane geometry and technical factors. For example, Al-Hussein et al. (2001) presents an algorithm that takes into account the lift dimensions, weight capacity, and the location distance (that should be covered), all technically feasible lift settings. These attributes should satisfy all specified clearances between the crane, the lift, and all adjacent buildings.

An extensive research exists in the construction technology literature, which attempts to empirically understand the adoption process of information technologies through an analytical exploratory process in construction projects. For example, Mitropoulos and Tatum (1999) and Peansupap and Walker (2005) investigate factors affecting 'information systems' adoption in construction. These studies often investigate new factors (e.g. availability of skills; site engineer and foreman involvement in the process) but the differences between information technology and HLE adoption processes differ in attributes, hence limiting the ability to simply apply the same contextual variables. Therefore, a more specific framework for HLE, which is purpose built, forms the key aim this study. The equipment adoption literature is an under development area, and the current paper follows the general method of construction technology adoption model (CTAM) developed by Sepasgozar et al. (2016). CTAM shows that other factors such as down time, quick operation, ease of repair and automatic control influence the decision processes (Sepasgozar and Davis, 2015b; Sepasgozar et al., 2016).

RESEARCH METHODOLOGY

A qualitative research was conducted in order to explore the HLE adoption process in construction. It utilised thematic analyse and cluster analysis make possible using NVivo software. As mentioned, this method was employed because of the lack of understanding about HLE manufacturers and their customers' business behaviour, in regard to the adoption process. A total of 22 participants in Australia and the United States were recruited using a combination sampling strategy of 'criterion-chain' from the crane business. Some examples of the unstructured questions which were designed to allow the respondents to explain their experiences of the technology adoption process are: Give me specific examples of technologies in your company, how many purchase decision procedures do you have in the company, how different they are. Criterion chain sampling makes use an initially identified participant who can provide additional participants via a network of supply chain contacts. For example, a crane use in Sydney can provide participants involved in crane manufacture and crane distribution.

This method of sampling was designed specifically for this study because the investigators aimed to become immersed in the construction technology market community, and also aimed to elicit facts rather than individual behaviour (Schultze and Avital, 2011). Based on chain sampling method, 22 experienced participants were purposely recruited from two regions Australia and North America. Participants from two developed countries were chosen as their feedback on technology adoption is critical to vendors before disseminate the technology in the rest of the world. Table 1 shows the participants profile.

Table 1. Selective participants' profile and business

Participant position	Experience (years)	Crane type
Dispatch manager	25	Mobile crane
President	50	Mobile crane
Safety director	12	Mobile crane
Sale manager	20	Mobile crane
Owner	28	Mobile crane
Owner	28	Mobile crane
Operator manager	20	Mobile crane
Operator management	30	Mobile crane
General manager	42	Mobile crane
General manager	22	Tower crane
State sale manager	4	Two mobile cranes
Senior project manager	10	Tower crane
Managing director	43	Mobile crane (55 and 250 ton)
Project manager	12	Tower crane
Project manager	10	Tower crane
Project manager	10	Tower crane
Managing director	12	Rail crane and tele-handler
Director	30	Rail crane and tele-handler
Managing director	27	Tower crane (310 and 330 ton)
Contract manager	16	Tower crane
Project manager	14	Tower crane
Managing director	40	All terrain and crawler crane

ANALYSIS AND FINDINGS

Themes constituting the adoption process

This section presents key themes representing the HLE adoption process observed in the interview data. For instance, Figure 2 presents the key themes and subordinate structure of parent nodes, child nodes and indicative comments which lead to three key themes of customer decision-making processes identified by the research including: Investigation (T1), Acquisition (T2) and Utilisation (T3).

Investigation (T1): T1 represents activities that a customer carries out to identify potential solutions and make comparison between competing options. This includes seeking understanding about newly available handling and lifting solutions and gaining confidence about whether or not the solutions will meet their needs. This theme shows that customers are looking for safer solutions to lift more weight. In addition, they are interested in machine control and monitoring technologies to increase performance efficiency. When the customer seeks new solutions, the local standards and road conditions and traffic legislations are mainly considered. This makes the crane industry different from other technologies such as concrete pumps or information technologies. Further, previous crane selection studies have not mentioned these factors.

Acquisition (T2): T2 represents activities that a crane customer carries out to evaluate, select and purchase a new crane. This theme represents HLE evaluation steps including functionality (e.g. Outriggers) and financial (e.g. Cost analysis) and recommendation criteria. In addition, customers negotiate to get their crane from a vendor who is trustworthy. Here, trust and relationship with the vendors are important and are intimately linked with other aspects such as negotiating lead times and the terms and conditions of contract.

Utilisation (T3): T3 represents activities that a customer carries out to operate, maintain and ensure the HLE works appropriately on their projects. The interviews show that this theme was very important to customers and formed a key part of their purchase decision process. Customers were concerned about crane tests including safety test, HLE maintenance and spare parts availability. In this sense, they look for simple technology and not complex HLE. They are also mainly concerned about down time (i.e. how long and how frequent), particularly where the likes of a small sensor on a complicated HLE becomes burnt-out or broken, and can cause significant delays. Customer feedback was crucial for new customers. As they talk to each other using different communication channels (e.g. industry workshops), networking and word of mouth affect HLE diffusion in the longer term.

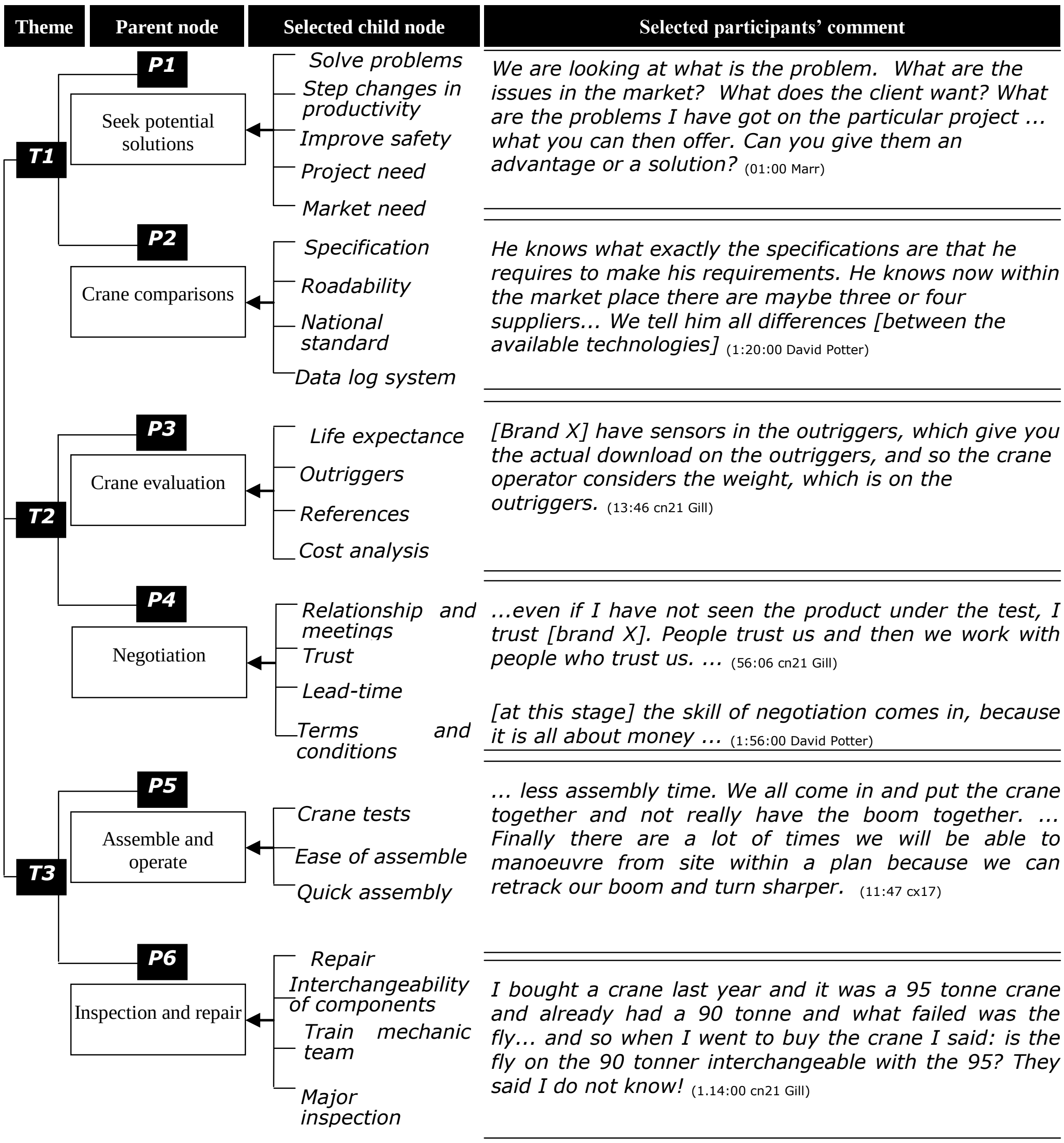

Figure 1. Diffusion process tree representing diffusion process of T1 (investigation), T2 (acquisition) and T3 (utilisation) behaviours.

Clustering customers

In order to identify whether there are groups of customers who follow the adoption process differently or have different concerns, a cluster analysis method was employed. In doing this, the clustering method inherent in Nvivo was utilised. For instance, this method categorises words with similar meaning together around different customer behaviours. The researchers were then able to view the individual groups and inductively derive names for each different type. Figure 2 shows the result of the analysis including the three main clusters of customers identified. Each shows that three clusters exist in the sample: 1) Leader corporations: keen to be the first in utilising advanced cranes earlier than other local companies; 2) Mid-sized leaders (hirers or subcontractors): keen to have an updated fleet with advanced cranes to rent them out to the contractors; and 3) Followers (small or medium sized family business companies): keen to utilize proven cranes based on the lessor's feedback.

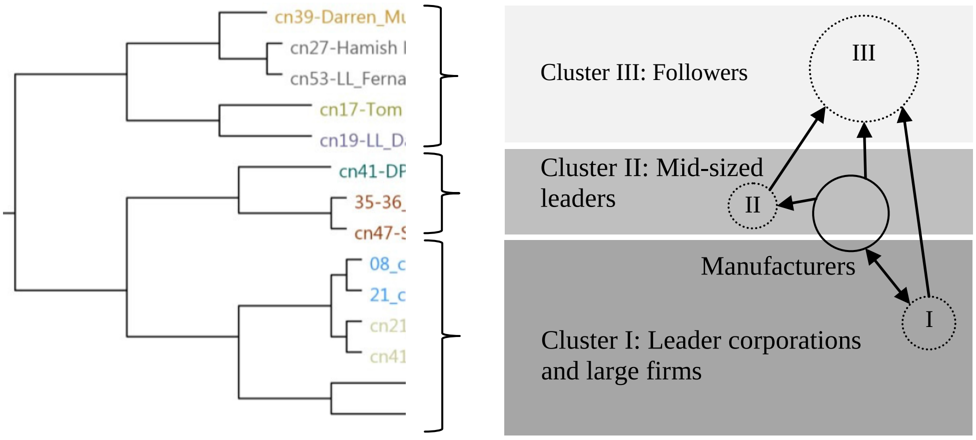

Figure 2. Customer classification based on their adoption behaviour

Comparing customers across themes

This section compares three clusters across three key themes discussed previously (i.e. T1, T2 and T3) with a view to characterising, profiling and distinguishing different types of HLE customers. Table 2 presents a matrix, where the three clusters are shown in columns and themes T1, T2, and T3 are shown in rows.

The previously presented findings are interesting in so far as they provide a more holistic view that goes beyond the HLE selection process (as an isolated purchase decision) and looks at the broader adoption approach (which links the purchase decision with ongoing actions required to holistically take up the technology). For instance, a participant stated that the decision to use a new crane is a "*big decision as [cranes] have a lot of components and different configurations*". This means the customer also takes the complexity of maintenance and availability of after sales services into account during HLE adoption analysis. This finding is separate from current customer behaviour perspectives in the crane literature which primarily focus on purely crane selection criteria. Rather, the study presents a model which refers to a process from seeking a potential solution to utilizing the technology including inspections and repair as requirements of technology adoption decisions.

Table 2. The matrix of cluster characteristics across each stage of the process

Theme	Cluster I (leader corporations)	Cluster II (mid size leaders)	Cluster III (followers)
Investigation (T1)	• Seek to solve problems and/or look for a step change in productivity • Collaborate with a manufacturer to modify their product	• Develop new market by increasing lift capacity • Actively seek new crane and updated	• Get the job done by using a proven crane; • Actively investigate what pioneers do to solve the same problem
Acquisition (T2)	• Decision being made in a longer process; • Owners not involved; • Many persons are involved in the decision • Premium price	• Informal and relatively quick process; • Decision being made in a shorter process; • Mainly the owner involved in the decision	• Informal and relatively longer process-financial problem (affordability); • Mainly the owner involved in the decision; • Price sensitive decision
Utilisation (T3)	Concerns about: • Complexity of assembly; • Availability of spare parts; • Resale value	Concerns about: • Complexity of maintenance; • Availability of support even remote services	Concerns about: • Any complexity; • Availability of spare parts; • Availability of technicians; • Maintenance cost

CONCLUSION

The aim of this study was to understand the process of handling and lifting equipment (HLE) adoption decisions in the construction industry. Understanding of the process requires a major shift from an 'HLE selection' modelling to 'HLE adoption' process perspective. This new perspective provides many more factors and variables to accurately predict customers' intentions towards adopting new equipment. This paper presents a proposed conceptual framework for HLE adoption which contributes to the body of knowledge by identifying three themes of activity representing the whole process of HLE adoption including investigation, acquisition, and utilisation. Common sub-features pertaining to each theme are provided (e.g. inspection and repair considerations are a subset of Utilisation). Further, customers can be seen in terms of how they respond to the above process by reflecting three differing degrees of customer driven leadership Here, the paper identifies new groups of HLE users in the industry called 'leader corporations and large firms', 'mid-sized leaders' and 'followers' which pass through the adoption process differently in terms of being innovative, intending to develop a market by new technologies, and being conservative respectively.

This paper identifies that the HLE adoption process is a complicated multi-stage process because customers (construction companies and HLE rentals) are professional and actively seeking new HLE technologies to increase their productivity (enabling the lifting of heavy objects faster and safer).

Understanding themes of activities and the customer's attitude toward new HLE are critical; because it enables researchers to modify the adoption decision is understood for relevant customer groups. These modifications give a better description and prediction of the HLE adoption process. By clearly delineating the current practice used in the industry, this finding enables new dealers to determine the best strategy for them to implement when disseminating their technology. Inexperienced contractors can use the process described as a benchmark for their own companies. The limited number of experienced professionals available for the interviews is a limitation of the current study, but future studies can use the findings as a base for a larger industry study. For instance, larger studies which would work towards improving the validity of the above findings.

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A FLIPPED CLASSROOM MODEL TO TEACH SKILL-BASED CONTENTS FOR A LARGE CONSTRUCTION TECHNOLOGY COURSE

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ABSTRACT

The 'flipped classroom' approach has received much attention in small-class teaching and to a lesser extent in research. However, the implementation of this approach has not systematically been reviewed, as applied to construction education, particularly not for larger class sizes. Focusing on this gap, the current learning and teaching methods in construction is evaluated, and a case study on 'Building Construction' which applies the flipped classroom for large class size is presented. A total of 115 courses of construction programs from six Australian universities have been chosen to evaluate whether they fit with the flipped classroom approach. Based on the practices in the construction discipline summarized from this data and the literature, a framework for implementing the industrial construction flipped classroom for large class is presented. The framework would assist lecturers to adjust their course design towards the flipped learning approach. The framework includes events and activities which are targeted at enhancing students' engagements and learning in different activities. The events are specifically designed for a specific course and can be adapted to the relevant literature and practices in other disciplines. The framework provides guidance to instructors regarding how to facilitate students' conduct during flipped events to lead towards higher engagement and learning. Future research is required to evaluate the implementation of the framework, using pre- and post-implementation data.

Keywords: Construction education; Flipped classroom; Large class; Student's engagement

INTRODUCTION

The architecture, engineering, and construction industry has become more complex in recent decades with the introduction of new technologies such as Building Information Modelling, laser scanners and advanced digital equipment. Consequently construction education is diversifying away from traditional construction engineering subject matter and principles by borrowing from different disciplines related to these new technologies.

Simultaneously, the methods by which the subject matter is taught has changed to ways that are more aligned with the 'wicked problems' experienced in construction and design (Buchanan, 1992). The change in education methods in engineering education has shifted significantly away from the traditional theory-based lecturing to team-based learning (Ma and Nickerson, 2006; Yeary et al., 2007; Sorensen et al., 2009), problem solving with open-ended solutions (Klotz and Grant, 2009; Lin and Tsai, 2009), hands-on projects (Yeary et al., 2007), and team-oriented communications (Leicht et al., 2009). More recently, the concept of active learning and student engagement has had a significant impact on engineering education design (Toto and Nguyen, 2009), arguing that students learn more and are more prepared for their careers by actively applying the course materials. Another recent trend is the adoption of the 'flipped classroom' (Bergmann and Sams, 2012). In engineering education, some publications provide flipped classroom models and methods. However, this new (and highly lauded) method has not yet received much attention in engineering construction. This paper investigates the potential of the current curriculum in construction in Australia to adopt flipped classroom methods. In doing so, this paper reveals differences in the current practice engineering education and the 'flipped classroom' approach.

REVIEW OF FLIPPED CLASSROOM PRINCIPALS

Flipped classroom recently become more popular and highly recommended by different universities in Australia. However, there is a lack of consensus on its method and effectiveness in different disciplines. Particularly, a practical method for flipped classroom has not been reported in construction. This section presents the flipped classroom approach as a generalized conceptual model which will then be adapted to construction engineering later in this paper. According to the pioneers of the flipped classroom approach:

> "*We think there is a fundamental question all teachers need to ask, and at the risk of sounding overly dramatic, we will refer to this question as the One Question. This One Question will be a common thread throughout this book:* ***What is the best use of face-to-face time with students?***" (Bergmann and Sams, 2014p. 3; emphasis original).

Bergmann and Sams' emphasize helping students get un-stuck and reducing failure by "enriching learning activities and relevant experiences" in the classroom (2014, p. 3). A key component to providing active learning experiences in the classroom is that students need to "understand their obligations regarding pre-learning, and are prepared for active engagement in the course" (Balan et al., 2015, p. 639). The flipped classroom is primarily a change in the sequence in which activities are done by which students interact with the course materials. Conventionally, a new lesson was introduced in a given class, followed by a homework assignment related to that class, which was then reviewed in the following class. In the flipped classroom, students preview the course materials before class, so they can 'do the homework' in class. The flipped classroom can be called inverted classroom. Lage et al. (2000) assert that events taken place inside the classroom can take place outside the classroom and vice-versa. As explained by (Bliemel, 2014, p. 119), "core lessons learned can be delivered before class in an online format, with preference for a short video. Students can then complete a short quiz about those lessons to make sure they are ready to do some lab exercise or other hands-on activity related to those lessons." This chronology is represented in Table 1.

Table 1 Flipped Classroom chronology (adapted from Bliemel, 2014)

Time	**Communication Way**	**Activity**	
		Lecturer	**Students**
Before class	On-line	Select and upload course materials (word, pdf, videos), Prepare quiz	'Pre-learn' course materials Complete quiz
In class	Face-to-face and On-line	Facilitate workshop incl. hands-on learning and professional development skills, Open discussion	Learn by doing. Get instant access to lecturer to help with workshop tasks, Participate in discussions
After class	On-line	Review assignments and quizzes	Submit assignments and reflective journal entries

Previous studies identified some main advantages of flipped classroom methods such as: 1) students are able to cover course material at a pace that conforms to their learning style (Roach, 2014) and move based on their capability; 2) teachers get feedback and modify the provided materials when students doing homework in class; 3) teachers can modify and customise curriculum anytime and communicate to students at any time; 4) classroom time can be used effectively and creatively (5) students can actively be involved in the learning process.

Importantly, this 'flip' has implications for the role and capabilities of the lecturer. In the traditional teaching approach, they were the 'sage on the stage'. In contrast, the flipped classroom means their role is to be the 'guide by your side.' This can create anxieties as "lecturers may need to learn to give up control of what happens in the classroom, and redirect their attention towards the development of soft-skills" (Bliemel, 2014, p. 125).

RESEARCH METHOD

In order to evaluate the current practice in construction education, six schools from six Australian universities were chosen. The course outlines are available online and open to public. Related courses were chosen to be examined. The selection criteria were: 1) the course is one of the core construction courses; 2) the course profile is developed in the recent four years. Based on these criteria, a total of 115 courses were chosen which they were delivered from 2011 to 2016. All 115 courses were divided into two main categories: skill-based courses and knowledge-based courses, as shown in Table 2. Skill-based course involves in practical knowledge improving students' skills and providing specific techniques and tools to resolve construction problems, such as construction operation course. Knowledge-based course refers to theoretical courses and help students to deeply understand different concepts in the construction context such as property law course.

The chosen course outlines were analysed to investigate the details of the course, and identify what assessable activities were weighted by the lecturer in the course. This weighting is important because higher percentage is an incentive to spend more time on the activity (second only to intellectual ability) (Keith, 1982; Keith & Cool, 1992).

Table 2 Sample profile

Faculty	Skill-based	Knowledge-based	Total
Engineering	30	14	44
Building and design	54	17	71
Total course profiles	84	31	115

Activities in each course profile were classified into two main groups: 1) activities typically done in-class, such as quizzes, mid-semester exam, final exam, class participations, discussions; 2) activities typically done out-of-class, such as individual and group assignments, projects, and reports. The weight for each group of activities was calculated for all 115 samples. T-test technique was employed to identify whether there are statistically any significant differences between different faculties (i.e. engineering and building), course types (i.e. skilled-based and knowledge-based). T-test was used to compare groups of courses based on their faculty and type. In addition, the percentage of different activities were analysed and were illustrated as bar charts to show the proportion of five groups of activities such as quizzes, mid-semester exam, final exam, class participations, individual and group assignments. Knowing the weightings and the nature of each assessable activity provides the basis from which to assess the feasibility and necessity of applying the flipped classroom approach.

ANALYSIS AND RESULTS

This section presents the results of t-tests for: each curriculum assessment criteria (e.g. quiz, final exam, and individual assignment), different groups of courses (i.e. skilled-based and knowledge-based), and different faculties (i.e. engineering and building). Table 3 shows the means for each curriculum assessment criteria (e.g. quiz, final exam, and individual assignment) for each course type and faculty. It shows that there are statistically significant differences between:

- Class participation in engineering (0.43) and building faculties (0.65); and for skill-based (0.7) and knowledge based courses (0.39);
- Quiz for skill-based (6.09) and knowledge based courses (4.01);
- Individual Assignment in engineering (45.54) and building faculties (47.02);
- Group Assignment in engineering (15.32) and building faculties (12.24);
- Group Assignment for skill-based (15.78) and knowledge based courses (10.58);

Table 3 T-test results for different curriculum assessment criteria Engineering and Building groups

	Engineering	Building	Sig.	Technique and Skill	Knowledge and Theory	Sig.
Class Participation	0.43	0.65	**0.617**	0.70	0.39	**0.468**
Quiz	11.31	1.1	0.001	6.09	4.01	**0.416**
Final Exam	27.40	38.70	0.021	38.51	28.7	0.039
Individual Assignment	45.54	47.30	**0.815**	38.44	56.47	0.001
Group Assignment	15.32	12.25	**0.385**	15.78	10.58	**0.136**

Note to table: all values are in % out of 100.

Table 3 shows that there is a big difference between Engineering and Building disciplines for group assignment. The current practice supports the idea of the need for group assignment for courses which are engineering in nature. This justifies that the weight of group assignment for "Industrial and Infrastructure Construction" course should be relatively high. This will be considered in the next section. The results of repeating the same T-test for comparing in-class against out-of-class assessable activities are given in Table 4.

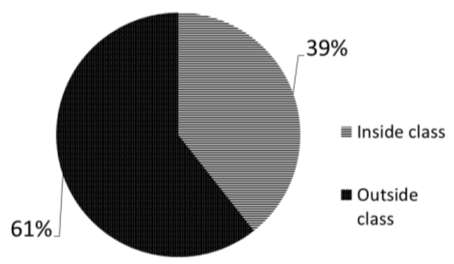
Table 4 T-test results for inside and outside class activities across different groups of sample courses

	Engineering	Building	Sig.	Technique and Skill	Knowledge and Theory	Sig.
In-side class	39.13	40.43	**.830**	45.31	33.14	.026
Out-side of- class	60.87	59.71	**.849**	54.69	67.06	.024

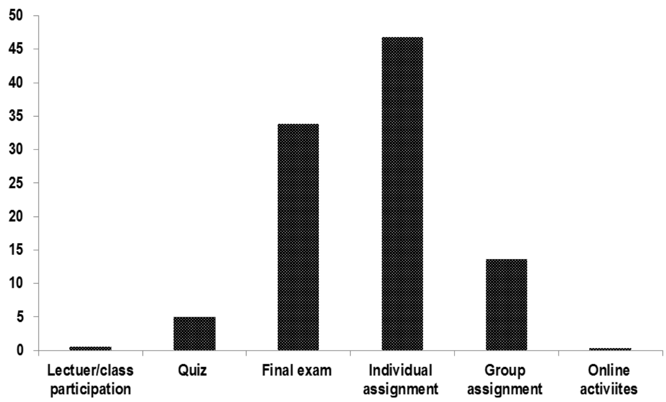
Based on the results in Table 4, there are statistical differences between in-class and out-of-class activities by faculty (greater than 0.05). However, the differences between skill-based and knowledge-based activities are not significantly different. In other words, the environment (faculty) in which a course is designed and delivered is important and affects teaching method. Interestingly, while there is a big difference between the mean value of mark weight for skill-based and knowledge-based courses, the differences are not statistically significant (less than 0.05).

Figure 1 (a) shows the average weighted marks for in-class and out-of-class assessable activities. In-class activities include lecture participation, quizzes and exams. These activities are directly related to the lecture materials (mostly written materials such as text book). Out-of-class activities include individual and group assignments, and online activities. These are often only indirectly related to the course materials, as they call for a re-interpretation of, reflection on, or application of the materials, and are not a direct recitation thereof.

Figure 1 (b) shows the overall average weighted marks for each activity. It shows that the lecture participation and online activities are the least among other activities. Arguably, lecture participation should be re-labelled lecture presence, since the assessment if often only a checklist roster of which students were present, and does not include consideration of each student's substantive contribution to the class. The same critique may apply to online activities if engagement in the activity is minimal. The figure also shows that the individual and group assignments still have the highest among all other activities excluding the final exam.



a) In-class and out-of-class assessable activities



b) The percentage of the mark for each activity of 115 courses

Figure 1 The average weighted marks for different activities

This analysis reveals that:

1) we are far from flipped classroom. Evidence: pedagogically, final exams are a poor use of classroom time, as are conventional lectures (not shown here because they are not an assessable activity). This justifies decreasing the weight of final exam in designing "Industrial and Infrastructure Construction" course, which will be discussed in next section. Major assignments (individual and group) could make much better use of the in-class peer learning opportunities that are provided by students working shoulder-to-shoulder on their assignments in-class. This is directly analogous to peer-learning in incubators and accelerators (e.g., Bliemel et al, 2016) that improves with the scale of the incubator/accelerator/class (e.g., Hong & Lu, 2016). So, we need a transition and model to get there. This supports the idea of increasing the weight of assignment in designing a new construction course, which also be discussed in the next section;

2) the content of courses allow us to apply flipped classroom models and potentially improve the education in construction as students will engage in the teaching and learning process, and are more likely to achieve program learning outcomes (Bliemel, 2015, 2016). Therefore, the "Industrial and Infrastructure Construction" course will be based on flipped classroom concepts.

"INDUSTRIAL AND INFRASTRUCTURE CONSTRUCTION" (IIC)

The "Industrial and Infrastructure Construction" (IIC) course is a first-year construction technology course in the Bachelor program of Construction Management and Property at UNSW, launched in 2016. Based on the investigation carried out on similar construction courses in the other universities (as presented above), and encouraged by UNSW's strategy on using innovative teaching methods, a "flipped classroom" model is proposed for this course. For a smooth transition between the traditional dominant face-to-face delivery model to the flipped classroom model, a partial flipped classroom model will be implemented in 2016.

Table 1 A flipped classroom teaching framework for the IIC course

Education attributes Time	**Teaching and Learning Activities**
Before class	Readings Materials provided on Moodle one week earlier than the class time; Pre-recorded teaching video and/or recommended online video clips. Online quiz one day before class;
In-class lectures	Focused lectures based on the students' online quiz outcome, and identified learning difficult areas. Questions and discussions. Industrial guest speakers and forums.
In-class tutorials	Smaller size tutorial group. Students complete individual and group tutorial questions in class. Tutors provide instant support and feedback.
After class activities	Participate in online forums, review comments on the video, and online Q & A sessions provided by lecturers/tutors. Review lecture or guest presentation recording; Reflective journals etc.

In the flipped-classroom model, visual materials (i.e. videos and pictures) and out-of-class activities were important (Sepasgozar and Bernold, 2012). These are generally accepted by students in their current use as short in-class videos or after-class lecture recordings that can be reviewed prior to exams. However, this is not the only way to use visual materials; they can be used to complement the pre-readings for any given class. Online engagement is also important in large enrolment classes. It is not exclusive to out-of-class, either, and can get students engaged in in-class learning and teaching by giving them the chance to contribute in non-verbal means during the class. The general flipped classroom framework (see Table 1) can be adapted for a large enrolment course, like IIC, enrolling over 250 students. In the partial flipped classroom model, the lecturer makes the academic content available online as pre-readings, and use recorded videos to replace the traditional face-to-face lectures. Online quizzes encourage students to study before the classes. Industry guest speakers give presentations of real-life projects and have direct communication with students' queries. The two-hour tutorial sessions are fertile grounds for flipped-classroom teaching, and students can actively apply the course materials through problem-solving activities, and get personal help and support from tutors. More specifically to the learning outcomes of the "Industrial and Infrastructure Construction" Course, the curriculum design is given in Figure 2.

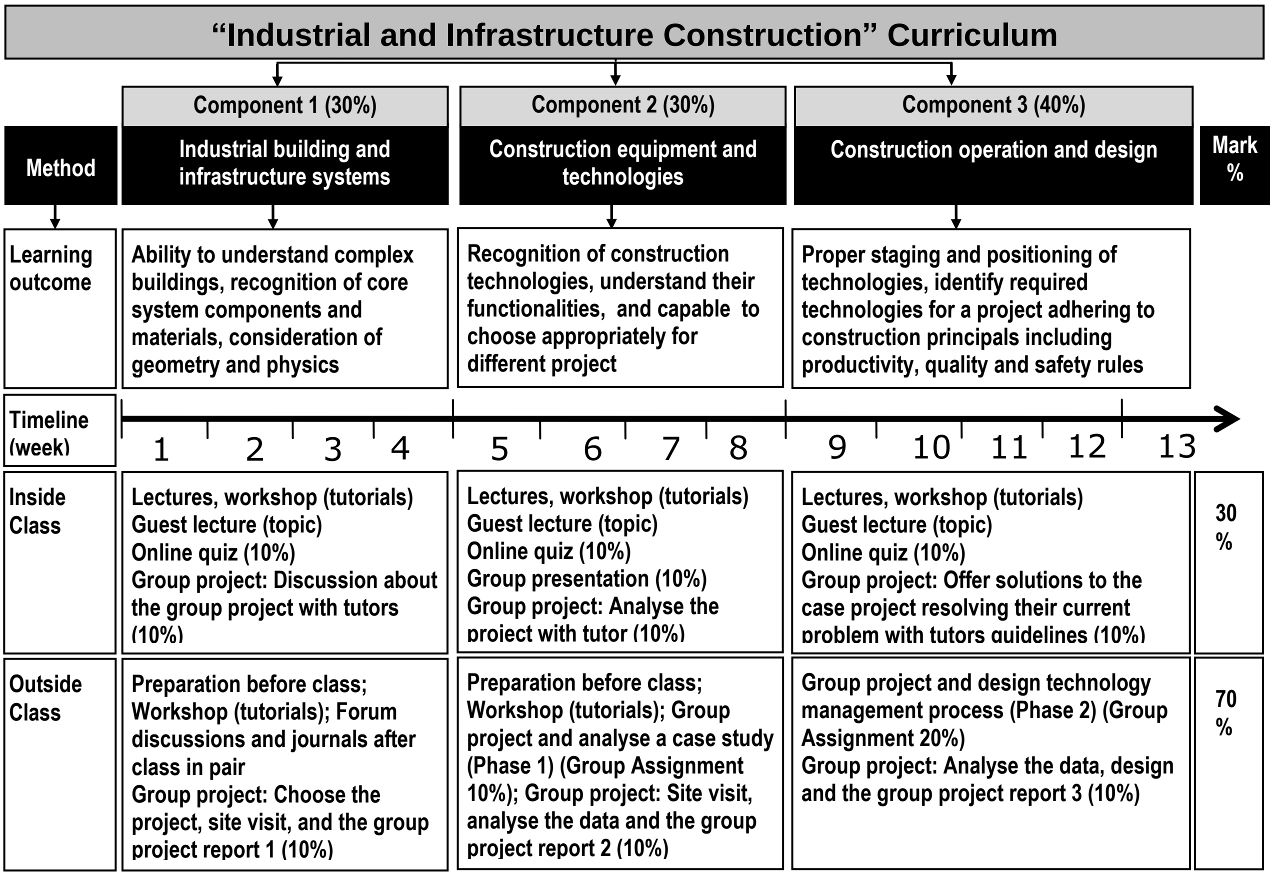


Figure 2 Industrial construction flipped classroom (ICFC) proposed model

CONCLUSION

This paper presented an overview of the current practice of construction education, framed by the flipped classroom's emphasis of making better use of 'in-class' and 'out-of-class' time. This revealed untapped potential and readiness of the construction disciplines to move toward applying the flipped classroom method in Australia. A framework was developed for a large, flipped ICC class (becoming the ICFC). The ICFC framework was detailed further to create an illustrative case study that shows more operational detail on how to structure the ICFC over the 13-week teaching term.

This study provides some insights into how construction education can apply flipped learning methods. Key questions guiding this research include asking "What is the current practice in construction education in terms of in-class and out-of-class assessable activities? How do these activities make the best use of in-class time and of eLearning technologies? The result of analysing 115 courses across six universities shows there is great potential to apply the flipped classroom in construction education. Flipping can be done one class or tutorial at a time, one course component at a time, or the entire course at once. This gradation gives lecturers the freedom to experiment how to shift from traditional teaching methods to the flipped classroom approach.

The findings show that there are statistically significant differences between engineering and building faculties in the means for each curriculum assessment criteria such as class participation, individual and group assignment. In addition, there are statistically significant differences between skill-based and knowledge based courses in the means for class participation, quiz and group assignments. The paper also provided the details of the ICFC course curriculum design which includes three main components of the course, and inside class and outside class activities.

The overview framework enables academics in construction engineering to compare their curriculum with the current practice in the discipline. In addition, the proposed ICFC framework also gives a reference guide on how flipped classroom concepts can be applied in this field. It is noted that the ICFC uses only one of several ways to flip. As currently there are little to no practical flipped classroom examples in construction education, the ICFC should serve as a point of reference, inspiration, or possibly a direct how-to guide.

Further research is required to explore the challenges and benefits of applying this framework in real teaching. This may include evaluating the framework based on feedback from tutors and students, and the students' learning outcomes. It is expected that the presented framework can also be applied and evaluated in courses beyond construction engineering.

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STRATEGIES TO IMPROVE SUSTAINABILITY AT THE PORT OF ABBOT POINT

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ABSTRACT

A key requirement for Australia's continued economic growth is the further increase of global export capacity. Port operations such as Abbot Point play a major role and must be able to meet increased shipping demands. Meeting future demands requires the expansion of port operations of which dredging is an unavoidable process. As such mining companies and port operators will need to consider methods in the future which offer improved sustainability. In light of the seemingly imminent growth facing Abbot Point such as Adani's T0 terminal this report investigated how North Queensland Bulk Ports could implement strategies and measures towards the promotion of improved port sustainability. A multitude of environmental options were presented to North Queensland Bulk Ports surrounding the beneficial reuse of dredge material along with recommending a more environmentally friendly dredging platform. If these environmental alternatives are investigated by North Queensland Bulk Ports in conjunction to the identified socio-economic considerations improved sustainability at Abbot Point will be achievable in the future.

Keywords: dredging, environmental, port, socio-economic, sustainability

INTRODUCTION

Infrastructure is depended upon by societies to deliver key services and facilities such as transportation, communication, power generation, water and waste management. The overall performance of infrastructure is measurable across many different areas such capacity, cost and safety (Martland 2012, p. 1). However, another way to measure performance is in terms of sustainability which involves consideration of the asset's ability to function well over the longer term. The Infrastructure Sustainability Council of Australia (ISCA 2014) define infrastructure sustainability as "infrastructure that is designed, constructed and operated to optimise environmental, social and economic outcomes of the long term."

The focus of this report is on Abbot Point and how sustainability of the likely upcoming port infrastructure expansion could possibly be improved. At core of this investigation will be evaluation of the potential environmental and socio-economic consequences which according to Bray (2008, p. 33) are numerous for major dredging projects. This report will offer North Queensland Bulk Ports (NQBP) a number of strategies towards improving the long-term sustainability of not only current port expansion plans but all future projects at Abbot Point.

TYPES OF DREDGING

Dredging is a very general term and as such is applied to a broad range of activities. Before proceeding it is important to briefly outline the various types of dredging which traditionally can be thought of across three main categories; capital, maintenance and remedial (Bray 2008, p. 34).

Capital Dredging

Capital dredging works concern the creation of new or improved facilities which are frequently instrumental in supporting large port infrastructure projects such as Abbot Point. Dredging activities can include navigation channels, berthing pockets, arrival aprons and harbour basins. According to Bray (2008, p. 34) these types of projects are typically characterised by;

- Relocation of large quantities of material
- Compact soil
- Undisturbed soil layers
- Low contaminant content (if any)
- Significant layer thickness
- Non-repetitive dredging activity

(Bray 2008, p. 34)

Maintenance Dredging

Maintenance dredging works primarily involve the removal of siltation from port areas such as navigation channels, berthing pockets and arrival aprons. The only focus of this style of dredging is elimination of built-up silt to maintain depth and does not involve the extraction of any new seabed. Noted by Bray (2008, p. 35) characteristics of maintenance dredging are as follows;

- Variable quantities of material
- Weak to well consolidated soil
- Thin to variable layers of material
- Occurring in navigation channels and harbours
- Repetitive activity
- Dredging in a dynamic environment
- Sedimentation/erosion on-going while dredging

(Bray 2008, p. 35)

Remedial Dredging

The scope of remedial dredging is on the extraction of contaminated material from the seabed. The process of remedial dredging is usually to rectify an existing harmful or undesirable situation where improving the environmental condition is the primary goal. Bray (2008, p. 36) identifies the following characteristics as being associated with remedial dredging;

- Small dredged quantities
- High contaminant content
- Weak to well consolidated soil
- A non-repetitive activity (if the problem is effectively controlled at source).

(Bray 2008, p. 35)

ENVIRONMENTAL SUSTAINABILITY ISSUES

From an environmental stand point this report has identified two areas for improved sustainability at Abbot Point. The first involves more productive approaches to the management and disposal of dredged material whilst the second considers a lower impact dredging technique.

Improved Management and Disposal of Dredged Material

Traditionally the disposal of dredged material has occurred at sea, often with very few restrictions. Increasing concern surrounding health of the marine environment has triggered the need for land-based disposal options to be more seriously considered (World Bank 1990, p. 53). Fortunately the scope for improving management and disposal of dredged material is increasing thanks to an expansion in scientific and engineering knowledge. Noted by Parson and Swafford (2012, p. 45) this expanded knowledge base has resulted in the reclassification of dredged material as a valuable resource. "It has been realized that dredged material can be used beneficially for a variety of applications that include habitat creation and restoration opportunities" (Parson and Swafford 2012, p. 45).

In 2013 Sinlcair Knight Merz Pty Ltd (SKM) and Asia-Pacific Applied Science Associates (APASA) were appointed by the Great Barrier Reef Marine Park Authority (GBRMPA) to conduct a study into better dredge material management for the Great Barrier Reef Region. The study investigated various alternatives for the beneficial reuse of dredge material at six major Queensland ports of which Abbot Point was included.

Table 1: Options for reuse of dredged material

REUSE OPTION	PORT OF HAY POINT	PORT OF ABBOT POINT	PORT OF TOWNSVILLE
Land reclamation	Y	Y	Y
Construction fill (supra-tidal)	Y	Y	N
Mine rehabilitation	N	N	N
Shore protection/ erosion control	N	N	N
Beach nourishment	N	Y	N
Construction material	N	Y	N
Parks and recreation	N	Y	N
Agriculture, Forestry, Aquaculture	N	N	N
Habitat restoration	N	Y	N
Landfill site recapping	N	N	Y
Total Suitable Alternatives	**2**	**6**	**2**

Source: SKM and APASA (2013, pp. 10-12)

Table 1 shows data from the study which identifies various options deemed suitable for the further use of dredged material at Abbot Point. Data on the port of Hay Point and port of Townsville have also been included for comparative purposes as both these ports are located less than 250 kilometres away from Abbot Point. At this point it is important to note that SKM/APASA (2013, p. 9) state whilst research results indicate the reuse alternatives listed are feasible a far more comprehensive investigation should be conducted via an Environmental Impact Assessment to ensure all project specific factors are considered prior to adoption.

The study identified a total of six reuse alternatives as viable for Abbot Point compared to only two for Hay Point and Townsville. Whilst not included in the above table Abbot Point also presented the greatest number of reuse options when compared against the other three ports in the study. SKM and APASA (2013, p. 13) stated the reason for dredged material from Abbot Point being suitable for so many reuse options was due to the presence of a very high sand content. Interestingly findings assembled by SKM/APASA are closely aligned to similar research throughout other parts of the world. A study completed by the United States Army Corps of Engineers in 1987 is widely regarded as one of the most comprehensive publications surrounding the beneficial reuse of dredged material in North America. The Army Corps concluded dredged material which contained a high sand content offered impressive latitude for reuse with a particular weighting placed on construction related applications (US Army Corps of Engineers 1987). The research completed by SKM/APASA offers NQBP a gamut of alternatives for dealing with dredged material at Abbot Point which presents a more sustainable trajectory in comparison to traditional disposal techniques.

Lower Impact Dredging Technique

There are many specially designed dredges that offer a reduced environmental impact in comparison to the conventional mainstream hydraulic and mechanical dredges frequently used. Noted by Bray (2008, p. 163) the Environmental Disc Bottom Cutter is one of the most effective and environmentally friendly dredging units available, and in the view of this report should be considered by NQBP for use in future Abbot Point projects.

The Environmental Disc Bottom Cutter (figure 1) is a stationary dredge which has a "cylindrical-shaped cutter with a flat, closed bottom and a vertical rotation axis" (Bray 2008, p. 163). A suction point is located inside the cutter to help in preventing spillage. Meanwhile a full height adjustable shield sits over the cutter and is responsible for stopping cut material contaminating surroundings and also limits the intake of excessive sea water (Bray 2008, p. 163). This type of design offers a multitude of environmental improvements over more traditional methods such as Cutter Suction Dredges (CSDs). These include as follows;

- *Accuracy* Placement of the cutting edge within centimetres of the desired depth is easily possible resulting in accuracy plus or minus 5cm of the target depth.

- *Turbidity* The closed shield around the disc base prevents spread of material reducing suspended sediment and turbidity.

- *Soil layers* The cutting device allows for a 'clear cut' at the target depth avoiding the mixing of soil layers.

- *Spill layers* The closed shield which surrounds the cutter helps to prevent material being sucked-up through the suction mouth. Furthermore the cutter plate gives a clear separation between the virgin layer and cut material resulting in a negligible residual spill layer.

- *Water usage* At periods of start-up, slow-down and anchor changes many hydraulic dredges use high volumes of wasted sea water. However, the Disc Bottom Cutter Dredge has an on-board system which slows consumption throughout these periods.

(Bray 2008, pp. 164-165)

Figure 1: Environmental Disc Bottom Cutter Dredge
Source: PIANC (2009, p. 23)

The output rate of a Environmental Disc Bottom Cutter Dredge is less than most other traditional dredging units. The main reason for a lower output is due to a concentrated effort on protecting the environment as opposed to maximising output levels. Whilst the technique is reasonably new Bray (2008, p. 164) notes it is well past experimental stages and offers a very viable environmentally friendly alternative.

SOCIO-ECONOMIC SUSTAINABILITY ISSUES

In addition to environmental issues various socio-economic issues must also be evaluated if port sustainability is to be improved at Abbot Point. From an economic standpoint any port expansion and future financial sustainability will be dependent upon adequate demand from overseas markets in conjunction to viable pricing models. However there are many more issues that need to be considered by NQBP besides purely financial. Port developments can have a huge effect on local community services and infrastructure throughout not only the construction phase but also after completion. As such total cost of any future Abbot Point project must be balanced against the potential benefits on offer to the surrounding community.
In order to improve sustainability at Abbot Point the NQBP board must give due consideration to the following socio-economic issues.

- Employment opportunities which are likely to be created due to construction and operational phases with specific consideration given to the target age group, sex and skill set.
- Advantages and disadvantages offered to the local community by a possible shift in employment structure and the likely effect on local salary levels.
- The value and subsequent effect on well established industries such as commercial fishing.
- Demands placed upon housing and general cost of living (eg. house values, rent pricing and food costs)
- Effect on public health such as excessive noise, dust and water quality.

(Bray 2008, pp. 51-52)

CONCLUSION

The World Organisation of Dredging Associations (WODA 2013, p. 1) note the key to sustainable dredging projects is the systematic consideration and integration of all environmental, social and economic objectives. This report has investigated at length alternatives for reduction of the environmental pressures at Abbot Point. A multitude of options have been presented for the reuse of dredge material in conjunction to recommendation that a Environmental Disc Bottom Cutter Dredge be employed for future offshore works. If these environmental alternatives are explored by NQBP in conjunction to the identified socio-economic considerations improved sustainability for Abbot Point will be achievable in the future.

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BARRIERS IN PROPER IMPLEMENTATION OF PUBLIC PRIVATE PARTNERSHIPS (PPP) IN SRI LANKA

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ABSTRACT

Public Private Partnership (PPP) projects have become a proven method of infrastructure procurement that allows off-balance sheet infrastructure development. Although Sri Lanka has tried to embark on various PPP projects during 1990's, the outcomes were far from desirable. A number of researchers have carried out investigations that have identified that inadequacy of an enabling environment has hindered implementation of PPPs. These studies have identified a range of different barriers to their adoption, though no attempt has vast far been made to systematically compare the characteristics of the Sri Lankan PPP and environment to those characteristic identified by previous research as being generically necessary for successful PPP projects. This research addresses this gap by firstly describing the evolution and characteristics of PPPs as they evolved in Sri Lanka, comparing this to the outcomes of a systematic literature review conducted in alignment with an appropriate conceptual framework (Zhang, 2005). The paper concludes that Sri Lanka as a developing country confronts many barriers in proper implementation of PPP. Mainly public opposition, distrust and lack of confidence in private sector are identifies as most crucial social barriers and other economical political and technological barriers are also visible in the industry.

Keywords: Barriers, Construction industry, Public private partnerships, SLEEPT approach

INTRODUCTION

PPPs are arrangements where the public and private sectors synthesize their expertise, skills to a project with varying levels of involvement and responsibility to bring about public services or infrastructure (Ismail, 2013). It has gained the attention for infrastructure projects both in development and financing due to the inherent benefits generated (Babatunde *et al*, 2015). Over last decade Public Private Partnerships (PPP) have created a rapid interest for the development, financing, & operation of infrastructure (RICS, 2012) conquering more than 40 countries all over the world (Gunnigan & Rajput, 2010). PPPs are important in accelerating economic growth of a country (Inderst, 2016), infrastructure development and delivery, and in achieving quality service delivery and good governance with collaborative effect of both public and private sector influences (Akintoye & Liyanage, 2011). According to the Central Bank Annual Report of Sri Lanka (2011), developing countries including Sri Lanka tried to establish PPP projects with targets of achieving innovative PPP strategies yet did not receive effective results (Yang, Hou & Wang, 2013). Kelegama (2014) illuminated the aforementioned condition by revealing that majority of the developing countries as Sri Lanka have a discouraging PPP experience after having embarked on ambitious PPP projects, without initially having a proper legal and regulatory framework in place. Regardless of the escalating adoption of PPP based procurement systems around the globe, only in a limited number of countries are properly implementing the scenario (Bäckstrand & Kylsäter, 2014), where as in a lot more specially in developing countries it is still not performing at the level best due to number of barriers. Thus, identification of barriers in implementing PPPs is crucial for the betterment of future construction developments in infrastructure sector (Cheung, Chan, & Kajewski, 2009). Hence the basis of this paper was formed in relation to the discussed, with a view in recognizing the constraints to PPPs implementation in developing countries taking Sri Lanka as an example.

LITERATURE REVIEW

Public Private Partnerships in Sri Lanka

Even though many developed nations have a long term relationship with the concept of PPP (Howes & Robinson, 2005; Yescombe, 2007; Inderst, 2016) many other countries have concerned PPP only in the recent past (Burger & Hawkesworth, 2011). The arrangement of PPP is structured in a way that it is intended to provide greater flexibility (Shen, Tam, Gan, Ye, Zhao, 2016) to achieve the provision on public infrastructure objectives by altering traditional public and private sector roles with a view to taking better advantage of the skills and resources that private sector firms can provide (Vadali, Tiwari, & Rajan, 2014).

Poor infrastructure coupled with inadequate budgetary capacity has mounted a considerable strain on Sri Lanka’s endeavor in achieving a higher rate of economic growth. Although Sri Lanka has tried to embark on various PPP projects during 1990’s, the outcomes were far from desirable. The investment in PPP projects over the last fifteen years in Sri Lanka amounts to 15 projects with total investments of US $1651.9 Million. When compared with others in the region Sri Lanka is placed behind India & Pakistan in terms of Investment & behind India, Pakistan & Bangladesh in terms of number of projects implemented (Wijewardena, 2014). In its Annual Report for 2012, the central bank had emphasised on the need for bringing in private sector to manage public projects efficiently. It stated that the initial capital outlay could be made by the government but the operation of the projects could be handed to private sector through PPPs (Central Bank, 2012). Even though many have identified the importance of proper implementation still there are number of challenges to overcome prior to achieving the core objectives of PPP in Sri Lanka.

BARRIERS FOR IMPLEMENTING PPP

SLEEPT Framework

Despite the huge identification of PPPs and its increasing usage in infrastructure development, the experience of both the public and private sector with PPP has not always been positive across the globe (Kwak *et al*. 2009). A number of PPP projects are either held up or terminated particularly in developing countries. This has triggered previous researchers to conduct studies on barriers to PPPs implementation. This research is a precursor to a full investigation of this in the Sri Lankan context, and as such is intended to develop a robust framework of barriers. This is most useful if it is constructed in accordance with a pre-existing structure such as Zhang's SLEEPT framework (Zhang, 2005). The following sections present state of the art in relation to each of the characteristics represented in the framework acronym.

Table 1 Barriers to PPP in SLEEPT approach

Category	**Sources**	**Barriers identified**
Social	Hamilton (2015)	Popular distrust of the advisors/consultants at the expense of the consumer
	Kosovo Ministry of Economy & Finance (2012)	PPP may lead to higher user charges once implicit or explicit subsidies are removed
		PPP do not achieve absolute risk transfer
	Zhang (2005)	Lack of understanding of PPPs
	El-Gohary et al (2006)	Public opposition
	Zhang & AbouRisk (2006)	
	Grimsey & Lewis (2004)	
	Corbett & Smith (2006)	Lack of flexibility
	Mustafa (1999)	
	Grimsey & Lewis (2004)	
	Gunnigan & Rajput (2010)	Cultural impediments
		Societal discontent against the private sector
		Public resentment due to tariff

		increases
		Lack of confidence mistrust in PPPs among others
	Li (2003)	High service charge to the end users
	Li et al (2005b)	
	Grimsey & Lewis (2004)	
	Mahalingam (2010)	Distrust between the public and private sector
	Abd Karim (2011) Chan et al. (2006) Environment, Transport and Works Bureau (2004) Zhang (2005) Li (2003) Xenidis & Angelides (2005) Mustafa (1999) Merna & Owen (1998) Gunnigan & Eaton (2006) Zhang & AbouRisk (2006) Satpathy & Das (2007) Ng & Wong (2006) Koppenjan (2005)	Misallocation of risks
Legal	Babatunde, Perera, Udeaja, & Zhou (2015)	Absence/ inadequate coverage of PPP legal regime/ institutional framework
	India Ministry of Finance (2012)	Weakness in enabling policy and regulatory frameworks
	Li et al. (2005)	Lack of well-established legal framework
	Mahalingam (2010)	A lack of project preparation capacity on the part of the public sector
	PPPIRC (2013)	Expropriation
Economical	UNESCAP (2013)	Lack of capacity in public (and private) sector (at the working level) concerning project development and implementation
		Lack of public sector project development funds
		Difficulties in obtaining long-term finance
	India Ministry of Finance (2012)	Lack of capacity to manage the PPP process over the lifecycle of the project

		Lack of capacity of the private sector to fully meet the challenge of investing in a very large number of projects
		Lack of a portfolio of credible and bankable infrastructure projects which could be offered for financing to the private sector
	KPMG Corporate Finance (2010)	Bidding for PPP projects is expensive
	Hamilton (2015)	Lack of transparency in deals, conflicts of interest, corruption etc
	Zhang (2005)	Unfavourable economic and commercial conditions
		Investment banks still prefer traditional procurement routes
	Zhang (2001)	Difficulties in seeking financial partners
	Grimsey & Lewis (2004)	
Environmental	Babatunde, Perera, Udeaja, & Zhou (2015)	Land acquisition difficult and time consuming
	Pirman (2012)	Limitation of Environmental liabilities
	PPPIRC (2013)	Restrictions on transfer of rights in public assets to private sector operator
		Vesting of Rights of Access to and use of Third Party Land
		Acquisition of Land for Project from Third Parties
		Environmental and social issues and environmental assessment
Political	Babatunde, Perera, Udeaja, & Zhou (2015)	Lack of ownership of, and support for PPP programmes
		Lack of awareness/ poor understanding about PPPs by politicians/ decision makers
		No provision by governments of incentives/ subsidies/ viability gap funding
		Lack of coordination between central and local governments
		Contagion effects of domestic/ regional economic and political environment

	Hamilton (2015)	Governments losing political will to promote PPPs
	Mahalingam (2010)	A lack of political willingness to develop PPPs
Technological	Babatunde, Perera, Udeaja, & Zhou (2015)	PPP process not clearly defined
		Non-availability of model concession agreements
	India Ministry of Finance (2012)	Inadequate advocacy to create greater acceptance of PPPs by stakeholders
		Inadequate instruments and capacity to meet the long-term equity and debt financing needs of infrastructure projects
	KPMG Corporate Finance (2010)	Inefficiencies in the procurement process
		Uncertainty and lack of a clear project pipeline, delayed communication of decisions and protracted procurement processes
	Hamilton (2015)	Weak institutions
	Kosovo Ministry of Economy & Finance (2012)	PPP are complex and relatively inflexible structures
	Chan et al. (2006)	Lack of suitable skills and experience
		Lengthy bidding and negotiation process
	Corbett & Smith (2006)	lack of innovations in design
	Mahalingam (2010)	The absence of an enabling institutional environment for PPPs
		Poorly designed and structured PPP projects

Social barriers

The study revealed a considerable number of social barriers indicating public opposition as the most critical to take into matter supported by a number of researchers (El-Gohary et al, 2006; Zhang & AbouRisk, 2006; Grimsey & Lewis, 2004). Although not stating in the same template Gunnigan & Rajput (2010) also have exposed that cultural impediments and societal discontent against the private sector governing towards lack of confidence in them distracting private sector from investing in PPP projects. The distrust in private sector is not the only reason for refusing PPP but also due to high user charges of the public services and facilities once private investments are used to supply services. Even though the living status is improved through these projects society still pulls back the proper implementation because of the nature of the procurement which is not the traditional and the doubt that the future generation will be in dept even before their birth if the PPPs are to continue as the private sector is going to recover the investments for a long period of time. Moreover misallocation of risks of PPP projects (Abd Karim, 2011) is also emphasized as another drawback by the society where the private sector owns the whole income though the risk is shared with public sector.

Legal barriers

The literature demonstrated inadequate coverage of PPP legal regime, poor regulatory frameworks and weakness in enforcement of policy, lack of institutional capacity and PPPs strategy, absence of PPP disputes resolving legal institute among others as legal constraints for proper implementation of PPPs in most developing economies. This indicates that some developing countries governments with less matured economies execute PPPs even when overall PPP policies are absent, which drives towards improperly established goals and objectives ultimately creating greater possibility of issues with projects implementation. PPP generates exceptional pressure on the legal regime affecting economic maturity, renaissance, and mechanism for developing infrastructure. Although in PPP projects a large number of agreements and conditions are involved in documentary lack of a proper package has become a barrier to proper implementation of PPP. PPP involves a great deal of disputes among parties involved due to different interests of stakeholders, for protection of public interests and legitimate rights of private sector. According to Grimsey and Lewis (2004) and Satpathy and Das (2007) lack of well-established legal framework, has given rise to number of disputes which are inevitable in PPP.

Economical barriers

PPP project preparations are considered complex in nature due to variety of interests and objectives of involved parties which has higher possibility of conflicts compared to a traditional procurement contract. This nature creates the necessity of extensive expertise input and comparatively high costs in PPP projects and requires lengthy time in negotiation stage. Hence the financial requirement to be achieved has become a barrier in proper implementation of PPP in less mature economies (Chan, Lam, Chan, Cheung, & Ke, 2010). Difficulties in obtaining long-term finance, lack of capacity of the private sector to fully meet the challenge of investing in a very large number of projects, and unfavourable economic and commercial conditions have been identified as common constraints in achieving financial goals of PPP. Moreover with the bidding procedure for PPP being expensive private sector confronts issues in seeking financial partners also due to lack of confidence of investment banks and financial institutions in new procurement methods. Corbett and Smith (2006) and Carrillo et al.(2008) mentioned that the potential high transaction costs create a negative impact on proper implementation of PPP. Additionally, lack of transparency in deals and corruption in both public and private sector has become a major threat for PPP projects security. Even though many have identified high transaction cost as the most affecting barrier Babatunde, Perera, Udeaja, and Zhou (2015) had discovered that perceptions of developing countries as high risk economies by foreign investors and inadequate domestic capital markets among others were identified as economic barriers to PPPs implementation in developing countries.

Environmental barriers

The prior studies have revealed that land acquisition problems, lack of coordination between national and regional governments, lack of transparency and accountability, and acquisition of land for project from third parties as environmental barriers to PPP projects. PPP projects require the transfer of rights of public assets to the private sector in order to fulfill their operations effectively and efficiently. But according to the legal systems transferring of property has many restrictions regarding the level of environmental liabilities and occupiers liabilities to be transferred with the property. Hence it has become a major constraint in PPP implementation in many countries as land acquisition has not been easy due to public distrust in private sector and many other social issues. Moreover obtaining planning permission with an error free EIA (Environmental Impact Assessment) report also require a considerable time and costs of getting approvals from the relevant authorities is high. Thus these have prevented private sector interests in investing in PPP projects.

Political barriers

Lack of awareness about PPPs by politicians and decision makers, lack of political willingness and commitment to develop PPPs have been stated by the researchers as the constraints for PPP in developing countries. Moreover, political reneging, politicization of the concessions and lengthy delays due to political debate also have affected as barriers in implementing PPP in a more stabilized platform. According to Kwak et al. (2009) insufficient contribution and lack of maturity of governments to administer PPP projects has lead to project failure in developing nations. But Gibson and Davies, (2008) mentioned a contrast fact stating where in mature economies local political opposition has become a barrier to PPPs. Hence it is significant that political influence is a more crucial factor for proper implementation of PPP in both matured and less mature economies. Moreover absence of provision by governments of incentives, subsidies or viability gap funding to overcome the financial issues in the private sector in investing in PPP also creates an obstacle. In PPP only a fewer employment opportunities are available compared to traditional method which would create an excessive floating workforce in construction industry being a threat to any government in a developing economy. Therefore lack of political willingness to develop PPPs on such grounds has become a critical issue.

Technological barriers

The literature review has identified non-availability of model concession agreements, Lack of suitable skills and experience, inconsistent risk assessment and management, and shortage of expertise as technological barriers to PPPs. Li et al., (2005) and Mahalingam (2010) stated absence of an enabling institutional environment for PPPs. Thus it is significant that less mature economies are seeking knowledge and resources from developed nations in structuring a proper PPP procedure where PPP process not clearly being defined has become a barrier to proper implementation. Absence of a well established institution has also being identified as a barrier to PPP by Hamilton (2015). Uncertainty and lack of a clear project pipeline, delayed communication of decisions and protracted procurement processes together with complexity and relatively inflexible structures are also issues in implementing a proper PPP in the real world scenario. Poorly designed and structured projects would also pull back private sector investors from engaging in PPP projects in the future.

DISCUSSION AND IMPLICATIONS FOR FUTURE RESEARCH

Discussion

The paper has revealed constraints for proper implementation of PPP around the globe according to the SLEEPT approach proposed by Zhang (2005). According to the literature during past decade, Sri Lanka has successfully implemented a number of PPP projects in improving services in highways, ports, power and telecom sectors. However, the number of PPPs which have successfully implemented and completed have decreased due to many constraints. Among them most concerning has been the social barriers which covers the public opposition, lack of confidence and distrust in the private sector and the higher charges to the end user. Moreover the situation is more complex where the general public is still lacking proper understanding of PPP using the term to define what is traditionally been called privatization. Absence of proper PPP legal regime/ institutional framework and weakness in enabling policy and regulatory frameworks has become also become a critical issue in the Sri Lankan industry. Lack of public sector project development funds, difficulties in obtaining long-term finance, conflicts of interest, corruption, unfavourable economic and commercial conditions and constraints of local finance markets have been identified as the economical barriers restricting the proper implementation of PPP in Sri Lanka. Among the identified environmental barriers in the global context, difficulty in land acquisition, limitation of environmental liabilities and lengthy time period in obtaining approvals from the authorities have been mentioned from the Sri Lankan context. Weakening of political commitment, lack of awareness, poor understanding about PPPs by politicians or decision makers, no provision by governments of incentives and governments losing political willingness to develop and promote PPP have been identified as the most critical political barriers. Lack of expertise in structuring transactions, management inefficiencies, labour resistance, lack of awareness of entrepreneurs' have mentioned as the technological barriers to implement PPP in Sri Lanka. Moreover inefficiencies in procurement strategies and lack of experienced workforce are also constraints to PPP in the local context.

Further Research

The literature review of the global context revealed that many countries have successfully harnessed PPPs for creation of new goods and enhancing the quality of services in infrastructure sector. However studies have also exposed that the number of PPPs reaching the stage of implementation and completion have declined due to several constraints in the industry. According to the identification of barriers for PPP under SLEEPT approach it has rationalized that the effects of the constraints differ in mature economies and less mature economies. Hence it is crucial to identify the inherent barriers to implement PPP in a proper manner. As the study focuses on Sri Lanka, which is a developing nation, identification of barriers to PPP is essential for proper implementation of PPP for the benefit of both development of the country and the people. Therefore it is proven that the Sri Lankan construction industry lacks PPP projects implemented due to the mentioned barriers under the 6 categories of SLEEPT approach. Currently the government is facing a daunting challenge. There is an enormous requirement to supplement of the existing infrastructure, and extending public services to the area which are currently not receiving them, and also to improve the quality of the infrastructure so that all the public receives the services. Hence it is essential to conduct a further study to identify the barriers in depth and to develop a framework to overcome those issues urgently in Sri Lanka.

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ONSITE – NEW METHODS FOR THE TEACHING AND LEARNING OF INTRODUCTORY CONSTRUCTION

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ABSTRACT

This paper will present and discuss the outcome of research undertaken on the use of immersive digital technology in the teaching of introductory construction, including the development of appropriate learning environment plans. The particular focus is the immersive site-visit project created by the authors for the teaching of an introductory domestic construction course. The paper will describe the pedagogical basis for the project, give a description of the methodology for creating the assets for the modules and functionality of the project and the outcomes of its implementation into tertiary construction education.

Keywords: construction, digital, education, game, simulation

CONTEXT

The *OnSite* project was a component of a larger research undertaking that sought to consolidate a number of introductory domestic construction courses within, initially, 4 major tertiary institutions in Australia: UNSW, UWS, Adelaide and UniSA. Recognising that there was considerable consistency in the curriculum content for the introductory course across not only architecture and building programs intra-institution, but also across institutions, it was recognised that the potential existed to consolidate recommendations within building standards education. The Situational eLearning research project was framed within this context, and the *OnSite* immersive environment was a demonstration of how this could take place in an innovative learning and teaching framework. Primarily, though, the motivation for the research project generally, and *OnSite* specifically was the importance of site visits within introductory construction courses, and the difficulties associated with incorporating and managing them within course curriculum.

The reality of site visits in our contemporary circumstances is that there are a number of factors that negatively impact the construction educator's ability to ensure that the maximum benefit is gained from a site visit. These are: group numbers, site availability, consistency between site construction and teaching periods, insurance and OHSW issues, student attendance, equity of access, and consistency of experience. For example for the situational eLearning research team it was recognised that the high volume of student enrolments typical of introductory courses made the logistics of organising these visits was becoming increasingly difficult. Travel to sites that could demonstrate these conditions could often involve considerable commuting time across the Sydney metropolitan area, and in Adelaide there was inconsistency in the availability of suitably accessible sites. In addition, across the team, there was no guarantee that all students would attend site visits unless compelled to do so, that there was no associated costs for travel and insurance, that there would be sufficient diversity of construction progress available to view, and that the volume of student enrolments (typically in excess of 100 persons) could be given access to the same examples at the appropriate time.

In this context, there was a clear and logical motivation to create a learning experience that captured the reality and immersivity of a site visit while ensuring that it contained all of the elements necessary to be relevant to construction curricula. The authors were responsible for the creation of this environment, *OnSite*, and its deployment within a number of tertiary trial settings.

OnSite

OnSite is an immersive learning environment that employs a commercial game engine (Unreal Engine 4 or UE4) to create a realistic digital environment that allows students to move around a domestic construction site using the same type of interactive commands consistent with a commercial video game. Where a commercial game encourages the player to interact with the environment to achieve tasks relevant to the gameplay, *OnSite* created a sequence of site conditions that were typical of site-inspection stages: set out and trenching; slab; ground floor framing; upper floor framing, and; roof framing and sheeting.

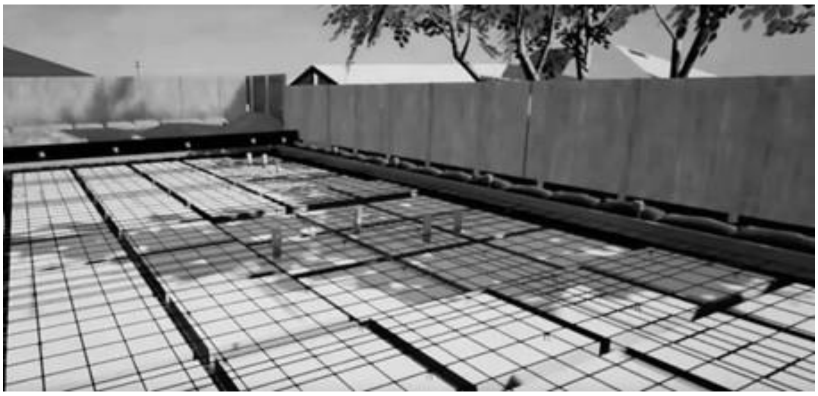

Figure 1 *OnSite* Slab Environment (Screen Shot)

In addition, the negotiable environments were embedded within a Moodle learning plan that encouraged the exploration of the material though a variety of learning processes. Both the immersive environment and the Moodle site worked together to deliver a focussed learning experience.

PEDAGOGICAL METHODOLOGY

The rationale for the creation of the *OnSite* environment rested on the idea that enhanced immersive environments positively contributed to the learning experience for architecture and construction students. Site visits themselves have traditionally been employed within these learning environments to show students the material reality of how a domestic construction site progresses through the life of a construction project. Where students are initially introduced to the orthographic system of documentation that is employed in producing contract documents of overall building configurations and subsequent details, there is a point at which the student has to become familiar with the manner in which these two dimensional graphic abstractions represent a complex three dimensional reality. The site visit, when conducted in the context of an introductory construction course, is of course intended to demonstrate to students the relationship between documentation, best-practice construction and constructional sequence.

In addition, when employing digital environments such as OnSite, there is considerable literature on the effectiveness of immersive software and its relationship to an experience of authentic learning. In these conditions Jan Herrington and Jenni Parker (Herrington and Parker, 2013) identify that authentic learning using emergent technologies requires a number of conditions to be met:

(i) Authentic context
(ii) Authentic tasks and activities
(iii) Access to Expert performances
(iv) Multiple perspectives
(v) Collaboration
(vi) Reflection
(vii) Articulation
(viii) Scaffolding
(ix) Authentic assessment

OnSite addressed this issue by creating a site that was, by definition, consistent for all students, accessible, appropriate in terms of learning objectives for construction content and sequencing. In addition, a dedicated Moodle Learning Plan was created that required students to view the material in a particular sequence consistent with a self-directed learning programme. Within the Moodle plan, students were initially directed to an external website repository, SeLAR (Situational eLearning Repository) that contained the necessary files for the *OnSite* environment as well as a variety of relevant documents (plans, sections, etc) and images that described the project context. Once these files were downloaded, the students were able to run the game file on their PC, or via Apple Boot Camp, to enable them to be within the environment.

After this material was accessed, students were required to view a 6-10 minute YouTube video in which the site in question was navigated by an instructor, pointing out relevant details consistent with a site inspection that would be conducted within a real-world scenario. Following the *OnSite* experience and the YouTube video, students were asked 10 multiple choice questions on material relevant to the site visit and the knowledge base that it demonstrated. At the end of each question, students were given an indication whether their answer was correct and prompted to proceed to the next question. At the end of the 10-question quiz, students were offered the opportunity to repeat the quiz in order to improve their grade. If they chose to do so, the questions remained the same, but the location of the correct multiple-choice answer changed. Students were given a window of 30 minutes to complete the quiz, assuming they would switch between the *OnSite* environment, the supporting documentation and the relevant YouTube video to find the correct answer. This pedagogical framework was consistent for the 5 separate *OnSite* environments.

Figure 2 *OnSite* Roof Framing Environment (Screen Shot)

CHALLENGES

A number of logistical and competence challenges occurred during the creation of the project. The solving of these issues contributed to the functionality of the *OnSite* project overall and to its development as a vehicle for further learning and teaching research projects. The first logistical challenge was the creation of the *OnSite* environments themselves. The editing software that accompanies the game engine is uniquely different to that of contemporary documentation software such as AutoCad, Revit, ArchiCAD and three dimensional modelling software such as 3DS Max. Learning to use the UE4 editing suite requires advanced competence in three dimensional modelling in the first instance, and an understanding of the differences between parametric environments in which most building models are produced and the 'what you see is what you get' functionality of game engines. The development of this competence by the research team contributed to the successful delivery of the *OnSite* environments, and is a contributor to the degree of radical innovation this project demonstrates, but it will possibly be a potential bar to a more general uptake of this method.

Figure 3 *OnSite* Double Storey Framing Environment (Screen Shot)

Once the environments themselves were developed and packaged as a stand-alone file, there was then the issue of how this would be delivered to the students. Since the file sizes were in the range of 800-900 MB, there were limitations regarding storing them on Moodle servers since this scale of file is outside of Moodle's functionality. The SeLAR site, accessed by students via a registration and login process, proved a successful alternative since it exists independently of each institution's individual Digital Learning Environment and could accommodate files of that magnitude. In addition, at UniSA, efforts were made to allow students to download and run the software on designated pool computers that temporarily permitted '.exe' files that might otherwise have been blocked by anti-virus software. A further, minor, issue was the prevalence of Mac based desktops, which was generally solved by their use of parallel desktop software such as Boot Camp.

Once the access to the *OnSite* material was as seamless as possible, there were further challenges within the Moodle platform regarding student engagement. The authors presented the material in two separate courses, one of which incorporated the material as a component (25%) of summative assessment for the course, one that presented the material as a formative component of the course. Unsurprisingly, there was considerably more engagement with *OnSite* for the course in which completion of the Lesson Plans was a required, summative submission.

OUTCOMES

There are a number of outcomes from the project that can be reflected upon and contribute to the proposal that the *OnSite* project constitutes a radical and innovatory development in tertiary construction studies. In the first instance, the proposal confirms current pedagogical practice that values the site visit as a form of engaged learning. In particular the level of detail available and the immersivity of the environments is a particular feature of the project that allows students to understand the relationship between abstract representation of building components in drawings, specifications and Australian Standards and their visual appearance when observed *in situ*. For many students unfamiliar with how drawings document a selected, usually typical or idiosyncratic, aspect of a construction project the opportunity to see this presented in a three dimensional context is invaluable. Further, the establishment and maintenance of the SeLAR website and repository ensures that this material is available as part of a Creative Commons obligation required by the Office of Learning and Teaching

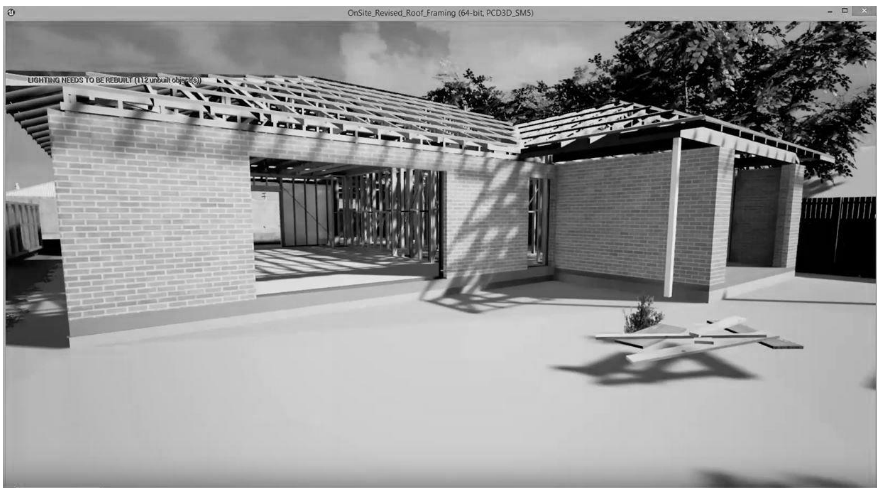

Figure 4 *OnSite* Single Storey Environment (Screen Shot)

Analysis of the data collected by Moodle for engagement with the *OnSite* material showed a high degree of recursive learning. Students overwhelmingly (97% of participants) repeated the quiz in order to improve their score and, by so doing, reinforced the pedagogical content of the exercise. This degree of engagement was consistent across all five of the Moodle Learning plan exercises. As part of UniSA's current Digital Learning Strategy (2015-2020), the *OnSite* project clearly demonstrated the opportunities for enhanced forms of learning that flow from increased digital capacity. This capacity has been recognised within the institution with the awarding of further funding to produce a multi-player form of the environment that will permit multiple learners/players to interact simultaneously within the same environment.

SUMMARY

Chris Dede summarized the potential for future research into immersive teaching environments by making four points that reflect a number of the outcomes of work completed by himself and associated researchers, and which are relevant to the *OnSite* project (Dede, 2009). These are:

1. To what extent does good instructional design for immersive environments vary depending on the subject matter taught or on the characteristics of the learner? For what types of curricular material is full sensory immersion important?

2. To what extent can the successes of one's virtual identity in immersive environments induce greater self-efficacy and educational progress in the real world?

3. To attain transfer, what is the optimal blend of situated learning in real, augmented, and virtual settings?

4. What insights about bicentric frames of reference can generalize from immersive environments to pedagogical strategies in face-to-face settings?

Whilst Dede's questions refer generally to the total enterprise of immersive educational environments, it is clear that the structure and outcome of the *OnSite* project addresses and matches the core ambition of the questions: to enhance learning outcomes through immersivity in synthetic and augmented environments. The *OnSite* model, as a component of the *Situational eLearning* research project, demonstrates that the investment in simulated environments for introductory material has a great deal of potential in terms of pedagogical development in the architecture and construction industry. By paying attention to the needs for authentic learning experiences that emulate the complex conditions of construction, and the development of a shared repository that is relevant and accessible to construction educators, there is a clear proof of concept that radical innovation in this domain of learning is possible and achievable.

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THE APPLICATION OF BUILDING INFORMATION MODELLING IN A CONSTRUCTION PROJECT IN CHINA

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ABSTRACT

Previous studies have proved the application of Building Information Modelling (BIM) can lead to greater efficiencies. Slowly adopting new technologies and limited technological innovation are criticised for the construction industry. In this paper, we present research that examines the practices of BIM technologies for the clash detection and coordination among building structure, equipment and pipelines, quantity statistics and construction simulation in a construction project in China. The BIM application significantly promotes the abilities to achieve construction schedule, quality, budget, and scope objectives in the project. The technological capabilities of BIM, the illegal issues of BIM outputs and developing cooperative project management culture are needed in order to promote BIM application in the construction industry.

Keywords: Building Information Modelling, China, Construction Project, Clash detection

INTRODUCTION

Construction projects and project management systems become more complex in the modern construction industry. Although information and communication technologies have apparent potentials for development in the construction industry, slowly adopting new technologies and limited technological innovation are characterised and documented, because of structural and work nature of the construction industry such as disintegration, undefined workload, project changes, construction variation, outdated skills, and fieldwork environment (Davies and Harty, 2013). Building information modelling (BIM) is "an intelligent 3D model-based process that equips architecture, engineering, and construction professionals with the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure”(Autodesk, 2016). In the BIM system, modelling a construction project in digital form can support project participates in optimising their decisions and actions by simply and naturally displaying a building using a digital model. More importantly, BIM provides a pathway and tool to clear the extremely interdependent feature of structures, architectural layout, and the mechanical, electrical, plumbing, fire life safety systems, and technologically connects project participants (Dossick and Neff, 2009). Therefore, the BIM application can add values for the construction industry through technology innovation.

This research aims to summarise the experience from a successful BIM application in a large-sized construction project in China, which can promote the BIM application in a construction project and demonstrate the application value in the project design and construction stages. Furthermore, some comments for improving the BIM technology and application are provided, which are desired to promote technological innovation and productivity enhancement in the construction industry.

BIM APPLICATION IN THE CONSTRUCTION INDUSTRY

Research on BIM benefits is desirable due to that BIM is considered as a key in solving problems in the construction industry by governments and construction professionals (Demian and Walters, 2014). A BIM-based system possesses the benefits to information management, as the system can exchange considerable information more accurately, on-time and appropriately through diverting information flow and away from the extranet system (Demian and Walters, 2014). Mäki and Kerosuo (2015) investigated BIM as a new technology and a tool in site management and pointed out that few site managers have the abilities in performing BIM software although actively using BIM is beneficial for their daily work of site managers, and insufficient contents of the BIM models are also identified for construction work. Furthermore, the use of BIM in facilities management is increased in coordination, consistency and computation of building information and knowledge management during a building’s life cycle of design, construction, maintenance and operation (Becerik-Gerber et al., 2011).

In the Chinese construction industry, some pioneering participants (especially design institutes) began to explore the BIM application and benefits in construction projects since 2003. Some BIM research institutes have been founded and attempted to apply BIM technologies in project inanition, planning, design, tender, construction and maintenance. Cao et al. (2016) investigated the drives of designers and general contractors to apply BIM in construction projects and studied how different inspirations are affected by organisational BIM capability and other contextual aspects through surveying data in the Chinese construction sector. Ding et al. (2015) surveyed key factors for the BIM adoption by architects in China and believed that the motivation, technical issues and capability of BIM are the statistically significant influences affecting architects' BIM utilise. However, little research about BIM applications can be identified in the Chinese construction projects.

BIM APPLICATION IN A CONSTRUCTION PROJECT

The Jinan West Railway Station is a high-speed railway station in Jinan city of Shandong province in the People's Republic of China. The Station Square Integrated Project delivers the station square, commercial buildings, public transit facilities and underground engineering sub-projects. The integrated project is with a construction area of 320,000 square metres including the underground construction area of 240, 000 square metres. The typical nature of this project is large-scale underground engineering works and complex pipeline installation. Improving design accuracy and reducing design changes are vital management factors in guaranteeing to reach the construction schedule established. Therefore, in order to realise the construction schedule and budget targets through improving pipeline installation efficiency, the project client introduced the BIM system in this project. The main contents of the BIM application consist of the clash detection and coordination among building structure, equipment and pipelines, quantity statistics and construction simulation.

The major precondition is to model the virtual building using the Revit software based on design drawings. The modelling procedures are generally from building structures to building services, from top to bottom, and from big module to small model. The virtual models of building structure and equipment and pipelines are displayed in Figure 1a and Figure 2b, respectively.

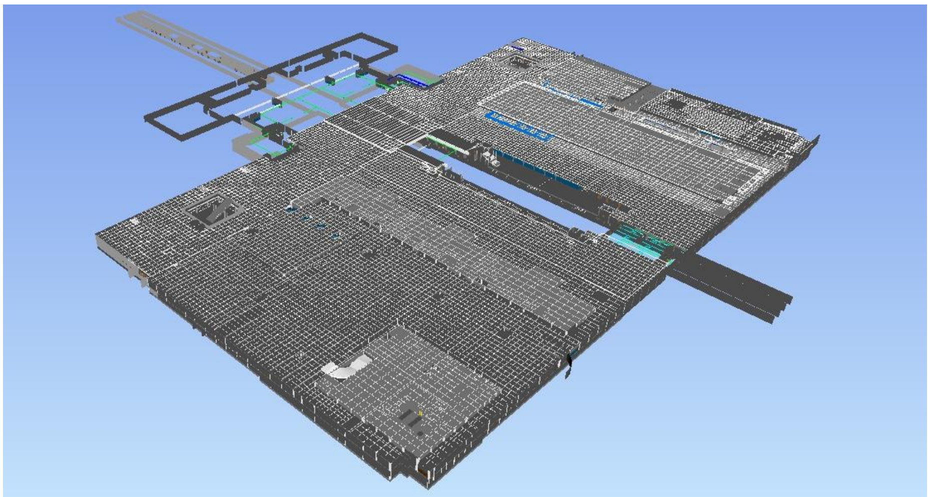

Figure 1a. The virtual model - Building structure

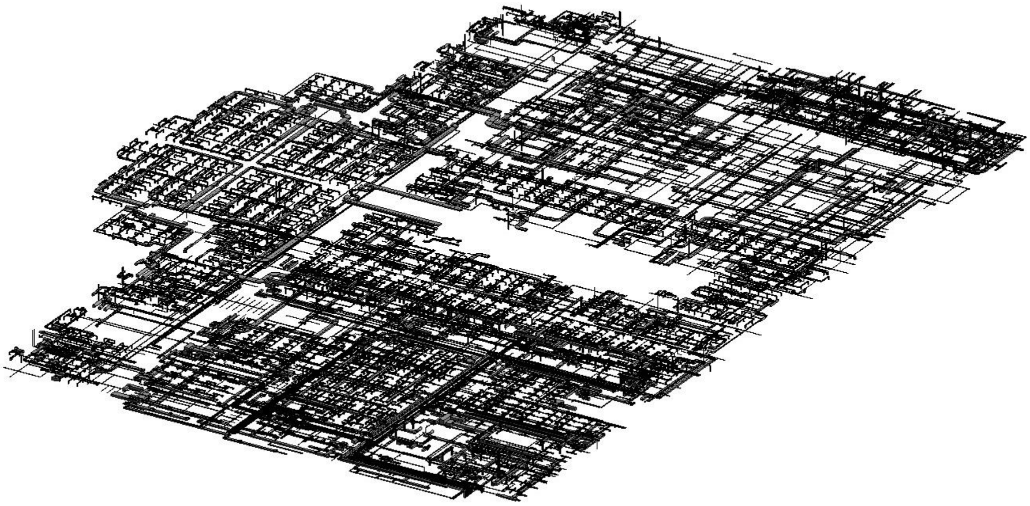

Figure 1b. The virtual model - Equipment and pipelines

The clash detection and coordination among building structure, equipment and pipelines

Firstly, using the produced virtual models, the clashes among building structure, equipment, and pipelines are detected. The process mainly includes three aspects. The first aspect is to check the clashes inside the building structure model, especially for the unreasonable layout of architectures and engineering. For example, a beam elevation is very low and closes to the door, so that there is not enough clear height for the outflow passage. The second aspect is to check the clashes between the virtual models of building structure and the equipment and pipelines. This kind of clash should be adjusted and usually from adjusting the pipelines. For instance, Figure 2 demonstrates a clash between a beam and chilled water pipe, hot water return pipe, cooling water supply pipe. The third aspect is to detect the clashes among the equipment and pipelines of electrical, plumbing, fire life safety and HVAC systems using the automatic detection function of the Revit MEP software. For example, Figure 3 displays a clash between a ventilation pipe and a fire pipe.

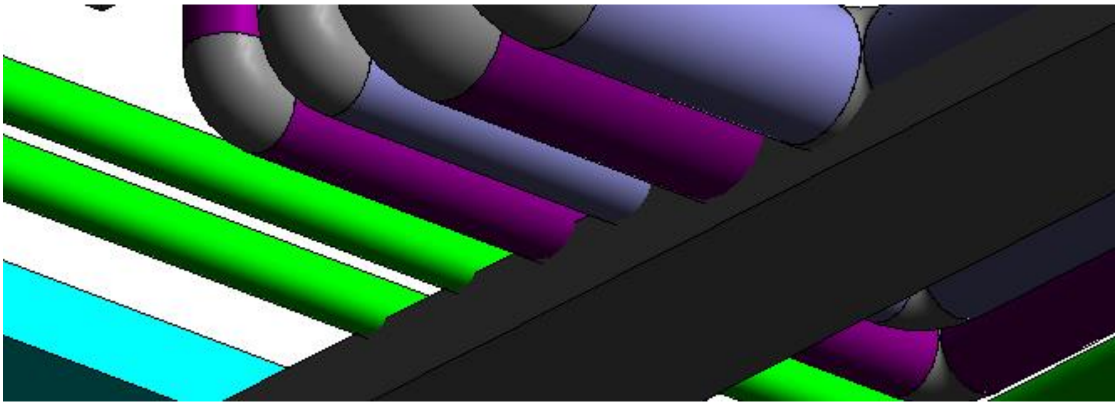
Figure 2. A clash between a beam and a chilled water pipe, a hot water return pipe, a cooling water supply pipe

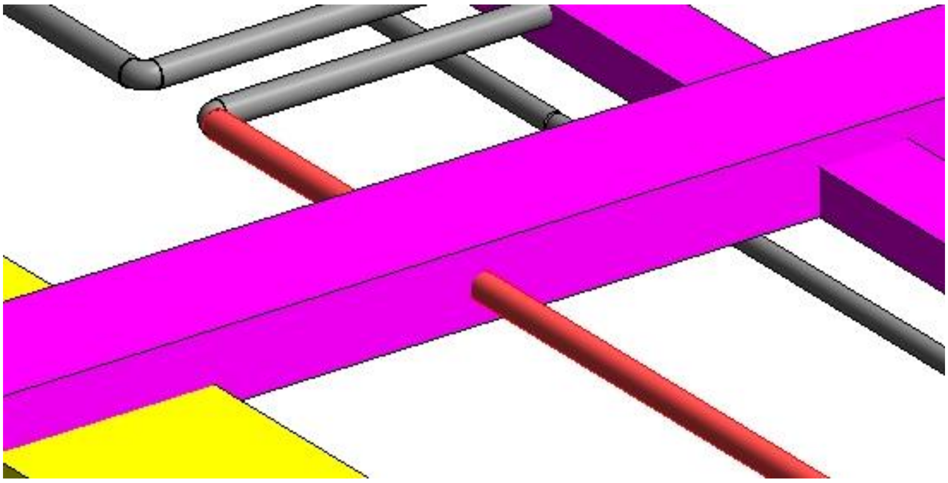

Figure 3. A clash between a ventilation pipe and a fire pipe.

Secondly, the coordination and design optimisation for building structure, equipment and pipelines are operated according to these detection results. More than 1,000 positions in design drawings are needed to adjust in this project. Experienced architects and engineers are needed in the process of coordination, adjustment and optimisation. The BIM models provide precise information of line elevation and location features for the architects and engineers. An illustration of the coordination and adjustment of pipes are shown in Figure 4.

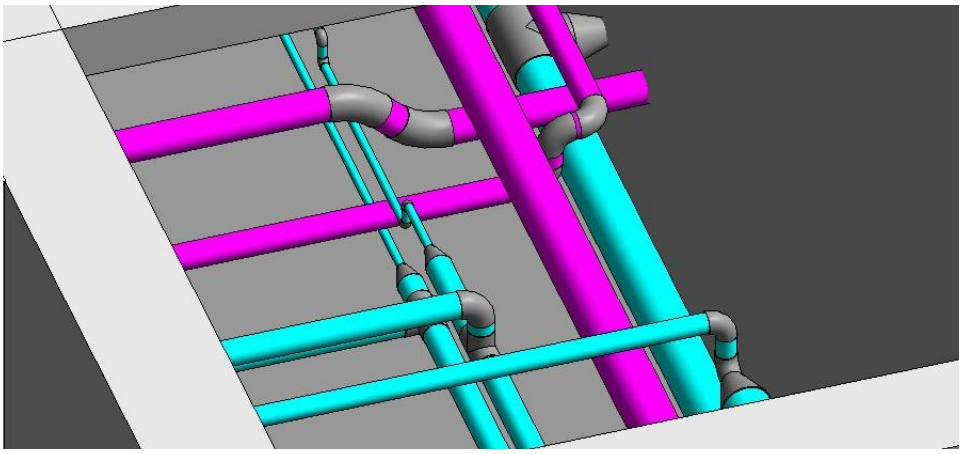

Figure 4. A sample of the adjusted pipes

Finally, a report and three-dimensional design outputs are provided for the client. The report generally provides the information of the clash detection, coordination and adjustment among building structure, equipment and pipelines. The three-dimensional design outputs primarily consist of comprehensive pipeline drawing, partial cross-sectional views, partial three-dimensional isometric drawings and BIM models in the DXF file format. Figure 5 is a sample of a partial three-dimensional isometric drawing.

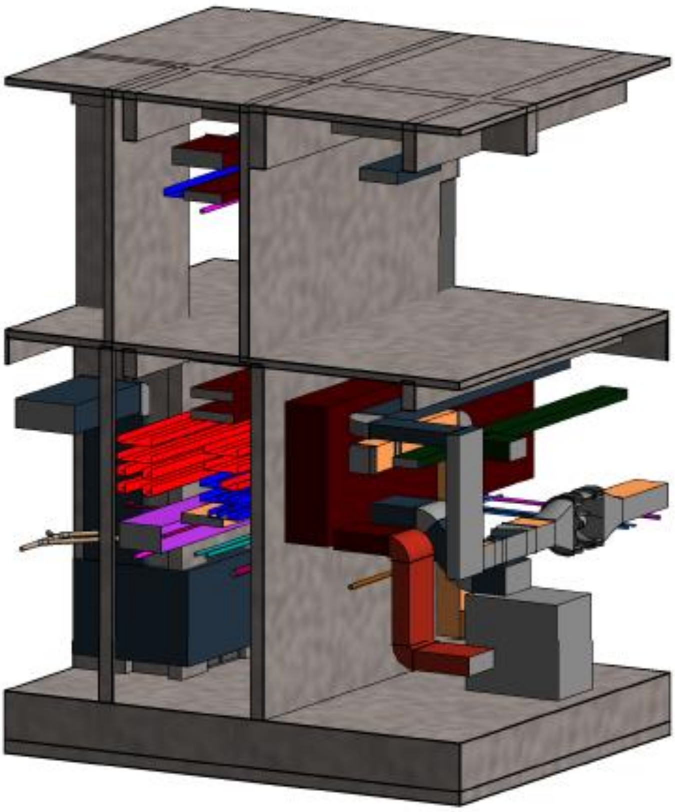

Figure 5. A sample of a partial three-dimensional isometric drawing

Quantity statistics

Quantity statistics is to compute the quantities of construction and materials based on the adjusted BIM models. There are three ways to calculate the quantities from the BIM models: building the connections between the BIM models and other project cost software through the Application Programming Interface (API), directly accessing BIM databases by the Open Database Connectivity (ODBC), and using the automatic statistical function to import the model results into Excel sheets. As a result, it can be concluded that the correct detailed BIM models can provide the accurate quantity statistics and then supports project budget management.

Construction simulation

Construction simulation is to perform construction process in the dynamic four-dimensional formation by combining BIM models with time factors using Navisworks. Construction simulation can support visualization and simulation for a construction process, and can achieve dynamic management and optimisation for a construction schedule. In this project, construction simulation is mainly used in the complex pipeline installation, which includes three key work procedures such as work breakdown, construction schedule and simulation video. Using construction simulation, the construction schedule is optimised; the issues of cross construction is avoided; the requirement information of construction materials and labours is obtained; and which all support to achieve of the established construction schedule.

DISCUSSION FOR PROMOTING BIM APPLICATION

Some comments and improvements are also identified in the process of BIM implication in this project. Firstly, BIM engineers should understand the construction process and management in accurately and clearly modelling the building. Secondly, the material list produced by the BIM system has differences with the traditional material list which is produced by the construction budget software in China. Thirdly, some BIM technique capabilities need to be developed, such as modelling the inclination of the drain pipe and displaying the detailed information of daily construction in construction simulation. Fourthly, the BIM outputs are a lack of the legal validity compared to the design drawings, therefore, in which some engineers and builders did not accept the BIM outputs. Actually, the legal issues related to BIM have repeatedly been recognised from the previous BIM studies (Kuiper and Holzer, 2013).

Although the BIM technology has potentials in developing construction management, lack of collaboration among project participates is a significant application challenge. For example, some project changes in fieldwork could have not been reflected in the BIM models due to lack of communications between the general contractor and BIM professional. Whether BIM is utilised or not in a project, organisational and cultural divisions among all project participates probably hinder collaborative work and problem-solving in a complex construction nature of the various expertise and professionals needed for construction projects (Dossick and Neff, 2009). Establishing a collaboration project management culture for all participants could be a vital pathway to promote the BIM effective application in construction projects (Fanrong et al., 2013).

CONCLUSIONS

The BIM software has been successfully applied in the Jinan West Railway Station Square Integrated Project. The BIM application significantly promotes the achievements of the construction schedule, quality, budget and scope objectives through the process of clash detection and coordination among building structure, equipment and pipelines. Before the process, virtual buildings should be modelled using the Revit software based on design drawings. After the process, three-dimensional design outputs and a report including the results of the clash detection, coordination and adjustment are provided for the project client. Moreover, the function of quantity statistics in BIM provides the building information related to construction quantities and project cost. Construction simulation supports to solve construction difficulties in complicated construction systems and to value the benefits for the project schedule target.

The BIM application would definitely add values to manage construction projects and drive project success. The participants in construction project management have also been recognising the BIM advantages and preparing to adopt BIM. However, the knowledge framework of BIM engineers, the technological capabilities of BIM, the illegal issues of BIM outputs and establishing cooperative project management culture are needed to be locally and internationally developed. Consequently, these requirements and strategies of BIM applications should be deeply investigated so as to promote the BIM application in the construction industry. Future studies are also expected to utilise and enhance BIM technologies in more situations during the project initiation, planning, design, construction, maintenance and operation phases.

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HISTORY OF THE CONSTRUCTION INDUSTRY STUDENT PERCEPTIONS

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ABSTRACT

The students' pre-course perceptions of a subject provide insight relative to their understanding and appreciation of a subject and challenges that the lecturer may encounter. Furthermore, post-course perceptions can be compared with pre-course perceptions to determine the impact of the presentation of the subject, if any. The purpose of the study reported on is to determine the pre- and post-course History of the Construction Industry perceptions of second-year construction management students, based upon a self-administered questionnaire survey conducted in a South African university. The purpose of the subject is to provide construction management students with historical perspectives with respect to the role of construction and the related professions and industrial processes in the progress and development of civilisations. Findings include: the subject History of the Construction Industry is perceived important relative to the other subjects in the BSc (Construction Studies) programme, History of the Construction Industry knowledge areas are perceived important, and History of the Construction Industry knowledge will assist respondents to a major as opposed to a minor extent relative to approximately 50% of the construction management activities / functions. Based upon the findings it can be concluded that the students have an understanding and appreciation of the importance of the subject History of the Construction Industry, and that it can be deemed important and relevant. It is recommended that such research be conducted on an annual basis, and a preparatory lecture module 'The role and importance of History of the Construction Industry' should be evolved for first time students.

Keywords: Construction, Education, History, Perceptions, Students

INTRODUCTION

During the 1960's and 1970's, the role of construction professionals was straightforward and clear. Dams were required to stop flooding and to promote hydroelectric power or the construction of advanced roads, highways, railways and bridges was required for efficient transportation. However, the need for construction underwent a total paradigm shift. The reason being that in society the value of construction changed due to the diverse increase in the implications of construction for the built environment. Due to the complexity of projects, construction professionals are required not only to ensure durability and health and safety (H&S) on projects, but to also be involved with aspects of history and culture (Isohata, 2006).

The literature indicates that students commence courses with pre-conceived notions with respect to the courses, which are possibly influenced by normative views of members of the larger campus community (Heise, 1979, 2002 in Francis, 2011). Furthermore, results of prior research have shown student attitudes toward a course before the start of the semester affect student course evaluations (Barke, Tollefson & Tracy, 1983 in Francis, 2011). Research conducted by Barth (2008) in Francis (2011) relative to student evaluations, using factor analysis, determined that prior 'interest in the subject matter' was shown to have a significant impact on the overall course ratings.

Given the aforementioned, and the Department of Construction Management's focus on 'lecturing and learning' research in addition to general assessment of courses, programmes, and related interventions, a survey was conducted among construction management registered for the subject History of the Construction Industry to determine the perceived:

- importance of the subject;
- importance of History of the Construction Industry knowledge areas, and
- extent to which the subject History of the Construction Industry History of the Construction Industry knowledge will assist with the following construction management activities / functions.

REVIEW OF THE LITERATURE

The development of Construction History

History, in a broad sense, can be perceived as the starting point whereby the history of art and architecture followed one after each other. Today engineering history will also form a prominent role, but due to the fact that boundaries merge with other professionals in the built environment, the description 'construction history' forms a correct terminology. Saint (2005) argues that construction history allows the inclusion of many professionals involved in many great building components such as architects, engineers, builders, and craftspeople. The page and a half manifesto in the opening pages of the first volume of the Construction History, Summerson (1985) proposes that the history of the construction industry can be divided into two components, namely the history of construction technology, and the history of building practice. In simple terms, the history of technology, also known as structural design, can be said to be the study of technological revolution and material improvement (Source & Linked, 1987). It can furthermore be described as a component of problem-solving where the aim is to understand what was done previously to assist in progressing within the subject matter and not reinvent. On the other hand, the building practice can be described as being in touch with human behaviour, which includes social, cultural, and economic aspects with reference to building practice.

History of Construction Technology

Due to the industrial revolution, the nineteenth and twentieth century underwent a technical evolution due to the demand for industrialisation. Morley (1987) defines technology as the knowledge of materials, tools, machines, techniques and the innovation of these processes. However, when comparing the Middle Ages and Western Classical Antiquity to the nineteenth and twentieth century it is clear that the manufacturing process received more attention as the construction process. Picon (2005) argues that during the nineteenth-century, construction history, with attention to technology, emerged as a field of study and research. The concerns raised were in the form of questions as to how to build and of style, which dominated the scene towards the end of the nineteenth century. Therefore, a direct link to the use of technology to solve design problems can be seen. Hence, Picon (2005) states that the history of construction technology has a direct link to intellectual and cognitive aspects.

Construction History Building Practice (Cultural)

Picon (2005) describes culture as a system of shared values, representations and practices which allow for collective life to be possible. Morley (1987) summarises building culture simply as the individuals, groups, organisations, and industries who work, practice, and produce relating to the construction of the man-made environment. That leads to the question 'can construction history teach us something about the culture of a society'? Vinegar (1998) and Campa (2009) state that Viollet-le-Duc, who was a pioneer of the domain in the nineteenth century, believed that the relationship between culture and construction history was self-evident. For example, he believed that medieval urban is revealed within the Gothic style and that Cathedrals serve as a civic gathering space within the city. Picon (2005) furthermore adds that in Dictionnaire raisonné, the author place emphasis on the thin high rib vault as a direct consequence on the high cost of material and labour which was a characteristic of urban life. Therefore, Gothic buildings were more than just structure, it represented reasoning.

The linkage between ornamentation and the expression of culture can furthermore be seen in the work of Le Baron, Jenny's Fair Store Building, which is a question between the steel structure and the ornamentation. At a first glance, the link between cultural and construction is vague in modern and contemporary western style of construction. Picon (2005) on the other hand argues that for modern and contemporary construction to be linked to a particular culture, it is important to understand their impact on architecture and engineering. For example, during the 1950's and 1960's, the use of air-filled structures represented the quest for freedom from the past militaristic influences. Therefore, the history of the construction industry is a well-balanced fusion of both the technical and cultural aspects. It is the analysis of structure and material, but also the understanding of cultural, social, and economic factors.

What is the role or purpose of teaching history?

To implement history successfully, it is very important that the educator has a strong sense of why history must be taught, which leads to informed decisions to teaching content and approaches. History education aims at the development of a student's historical thinking and reasoning skills by providing the student with historical knowledge, procedures and skills (Ashby, Gordon, and Lee, 2005; Yilmaz, 2009). Isohata (2006) in turn adds that the main aim of construction history is not to provide students with an introduction linked to other specialist subjects, but to train students in observation / recording of heritage, and the understanding of technology and society. It should be noted that during the 59th annual conference of JSCE by the Committee on Civil Engineering History, the content of the construction history modules was presented by several universities. The content included both technological and cultural aspects (Isohata, 2006).

Student perceptions of learning history

When mentioning the word history to students, the general reaction is that of a negative perception. Upon asking 'Why the negative perception?' the answer quickly returned is that the subject is boring or irrelevant in contemporary life. However, the fact is that history plays a rather prominent role in society, which includes not only to know your roots, but offers a platform for individuals to make informed decisions regarding present issues and future developments. History also contributes to developing critical thinking and problem-solving skills (Joseph, 2011). When history is taught correctly, it establishes a context particular to time, art, architecture, literature philosophy, law, and language (Voss, 1998). VanSledright (2009) furthermore adds that history strengthens a student's ability to draw comparisons, reason, and also promotes exploration.

The negative perspective that students have regarding history education can be manifold. Various authors suggest that the main influence is that many students do not understand why they need to study history. Another explanation to why students lack interest can be ascribed to the manner in which they are taught. In many instances, facts and dates relative to multiple events are fed to the students, which they are required to memorise, and then to recall during a test or examination. A further reason is that there is no relevance to present day existence (Joseph, 2011, 2012).

Programme evaluation

According to Springer (2010), programme evaluation is the process of evaluating the merit and effectiveness of educational programmes. Although evaluations are research-based, the goal is not simply to understand programmes, but also to arrive at judgments about their impact and worth. Two studies conducted by Gigliotti (1987) and Koermer & Petelle (1991) cited in Francis (2011) addressed the effect of student pre-course expectations on subsequent course evaluations. These significant associations with student evaluations included expected relevance and expected stimulation and communications as types of interaction in a course. Research also shows student ratings of courses vary significantly by field of study (Cashin, 1990 in Francis, 2011), suggesting the presence of normative attitudes toward various disciplines on a campus.

RESEARCH

Research method and sample stratum

The sample stratum consisted of construction management students registered for the subject History of the Construction Industry. The students were surveyed during the first lecture and again during the last lecture of the second semester using a self-administered questionnaire consisting of four five-point Likert scale type questions. Although 22 out of a potential 28 responses were received, it was discovered that only 13 of the 22 responses were common and therefore to ensure integrity of the data, only the 'matched' pre and post responses were included in the analysis of the data i.e. 13 in total.

Research findings

Table 1 presents the importance of the subject History of the Construction Industry relative to the other subjects in the BSc (Construction Studies) programme in terms of a scale of 1 (not) and 5 (very), and a mean score

(MS) between 1.00 and 5.00. Although the post MS is lower than the pre MS, they are both > 3.00, which indicates that it is perceived as more than important, than less than important. The pre MS is > 4.20 ≤ 5.00, which indicates the perceived importance is between more than important to very important / very important. The post MS indicates the perceived importance is between important to more than important / more than important.

Table 1. Importance of the subject History of the Construction Industry relative to the other subjects in the BSc (Construction Studies) programme.

Stage	Unsure	Not ………………………………… Very					MS
		1	2	3	4	5	
Pre	28.6	0.0	0.0	0.0	42.9	28.6	4.40
Post	0.0	0.0	10.0	40.0	40.0	10.0	3.50

Table 2 indicates the pre and post perceived importance of nineteen History of the Construction Industry knowledge areas in terms of MSs between 1.00 and 5.00, and a variance. It is notable that all the pre MSs > 4.20 ≤ 5.00, which indicates the perceived importance is between more than important to very important / very important. However, only 5 / 19 (26.3%) post knowledge areas have MSs > 4.20 ≤ 5.00. The MSs of the remaining 14 / 19 (73.7%) knowledge areas are > 3.40 ≤ 4.20, which indicates the perceived importance is between important to more than important / more than important. The top ten and for that matter, notable post-course rankings include development of materials and methods (1^{st}), development of plant and equipment (2^{nd}), development of structural forms (3^{rd}), schedule (time) experiences (4^{th}), sustainability experiences (5^{th}), managing construction projects (6^{th}), development of industry structure (7^{th}), organisation of construction (8^{th}), architectural forms (9^{th}), and organisation of labour (10^{th}). The aforementioned are notable as they relate to the intention of the History of the Construction Industry module

The aforementioned led to the computation of a variance. The only positive variance is relative to 'Development of materials and methods' (0.15), and there is only one knowledge area where there is a 0.00 variance, namely 'Development of plant and equipment'.

Table 2. Importance of History of the Construction Industry knowledge areas.

Knowledge area	Pre		Post		Variance	
	MS	Rank	MS	Rank	+ / -	Rank
Development of materials and methods	4.46	11	4.62	1	0.15	1
Development of plant and equipment	4.38	12	4.38	2	0.00	2
Sustainability experiences	4.33	14	4.23	5	-0.10	3
Architectural forms	4.23	19	4.08	9	-0.15	4
Schedule (Time) experiences	4.58	7	4.23	4	-0.35	5
Development of structural forms	4.62	4	4.23	3	-0.38	6
Development of Industry structure	4.58	6	4.15	7	-0.43	7
Environmental experiences	4.31	15	3.85	12	-0.46	8
Development of management	4.25	17	3.77	14	-0.48	9
Organisation of labour	4.50	9	4.00	10	-0.50	10
Development of building standards	4.38	12	3.85	13	-0.54	11
Quality management experiences	4.23	18	3.69	17	-0.54	12
Managing construction projects	4.75	2	4.17	6	-0.58	13
Organisation of construction	4.67	3	4.08	8	-0.59	1
Development of forms of procurement	4.30	16	3.62	19	-0.68	4
Development of skills	4.75	1	4.00	11	-0.75	15
Development of built environment disciplines	4.62	4	3.75	15	-0.87	16
Health and safety experiences	4.50	10	3.62	18	-0.88	17
Cost experiences	4.58	7	3.69	16	-0.89	18

Table 3 indicates the pre and post perceived extent to which History of the Construction Industry knowledge will assist respondents relative to 34 construction management activities / functions in terms of MSs between 1.00 and 5.00, and a variance. It is notable that only two (5.9%) pre MSs > 4.20 ≤ 5.00, which indicates the perceived extent is between near major to major / major. These are 'Resolving design problems' and 'Resolving construction problems'. Thereafter, 11 (32.4%) MSs > 3.40 ≤ 4.20, which indicates the perceived extent is between some extent and a near major / near major extent. In terms of the variance between post and pre MSs, 16 (47.1%) of the post MSs are greater than the pre MSs. Two (5.8%) the activities' / functions' MSs are equal. A further 16 (47.1%) of the pre MSs are greater than the post MSs. In summary 20 post MSs > 3.00, which indicates the perceived extent is major as opposed to minor.

Table 3. Extent to which History of the Construction Industry knowledge will assist respondents with the following construction management activities / functions.

Activity / Function	Pre		Post		Variance	
	MS	Rank	MS	Rank	+ / -	Rank
Environmental management	2.92	21	3.82	7	0.90	1
Outlining the scope of work	2.50	29	3.27	13	0.77	2
Information management	2.36	31	2.89	25	0.53	3
Coordinating	2.67	28	3.18	15	0.52	4
Sustainability	3.69	6	4.17	2	0.47	5
Controlling	2.30	33	2.73	29	0.43	6
Technology development	3.58	9	4.00	5	0.42	7
Information technology	2.38	30	2.75	28	0.38	8
Organising	2.73	27	3.08	20	0.35	9
Integrating design and construction	4.00	3	4.31	1	0.31	10
Labour management	2.90	24	3.17	17	0.27	11
Administration	2.00	34	2.25	33	0.25	12
Estimating	2.36	32	2.60	30	0.24	13
Procurement	2.78	26	3.00	23	0.22	14
Measuring materials	3.00	20	3.15	18	0.15	15
Productivity management	3.17	18	3.27	12	0.11	16
Innovation	3.92	4	3.92	6	0.00	17=
Human resource management	2.91	23	2.91	24	0.00	17=
Materials management	3.58	9	3.54	8	-0.04	19
Health and safety management	3.50	12	3.44	10	-0.06	20
General management	3.08	19	3.00	22	-0.08	21
Quality management	3.60	8	3.45	9	-0.15	22
Supervision	3.27	14	3.08	19	-0.20	23
Resolving design problems	4.23	2	4.00	4	-0.23	24
Plant and equipment management	3.25	15	3.00	21	-0.25	25
Resolving construction problems	4.38	1	4.08	3	-0.30	26
Production (Site) management	3.50	11	3.18	16	-0.32	27
Subcontractor management	3.17	17	2.82	26	-0.35	28
Resolving disputes	2.90	24	2.55	31	-0.35	29
Preparing site layouts (Planning)	3.75	5	3.36	11	-0.39	30
Public relations	2.92	21	2.50	32	-0.42	31=
Temporary works design e.g. support work	3.67	7	3.25	14	-0.42	31=
Programming and scheduling (Planning)	3.42	13	2.80	27	-0.62	33
Industrial Relations	3.17	16	2.22	34	-0.94	34

CONCLUSIONS

The subject History of the Construction Industry is perceived important relative to the other subjects in the BSc (Construction Studies) programme, albeit the perceived importance post-delivery of the subject is less than pre-delivery thereof. Furthermore, a similar scenario applies in terms of the importance of History of the Construction Industry knowledge areas. Then History of the Construction Industry knowledge will assist respondents to a major as opposed to a minor extent relative to approximately 50% of the construction management activities / functions. Therefore, it can be concluded that the students have an understanding and appreciation of the importance of the subject History of the Construction Industry, and that it can be deemed important and relevant.

It is recommended that pre and post course perception based research be conducted on an annual basis, particularly given that many of the post MSs are lower than the pre i.e. to determine if this is a trend. The importance of related knowledge areas and the linkages with construction management activities / functions should also be highlighted to raise the level of awareness relative to and the complementary role of the subject History of the Construction Industry in the programme, and to promote the 'integration' of knowledge derived from the range of subjects even though an 'integrative' project is included in the programme.

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IT MOBILE APPLICATIONS IN EDUCATION AND SECURITY ISSUES IN UNITED ARAB EMIRATES AND MIDDLE EAST

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ABSTRACT

In the contemporary age of communication and information system, people are familiar for adopting computer oriented application. Mobile application is rapidly growing and adopted by the most of the users. The main purpose of this research is to review information mobile applications in education and security issues in United Arab Emirates and Middle East. Paradigm selected for this particular study is interpretivism. Qualitative approach is adopted as the research approach for this specific research. This research utilizes primary and second handled source of data. Text analysis is adopted for analyzing the data in this research. Motives for use of a mobile application in marketing education reviewed in this study are up-to-dateness, interactivity and high speed. It was found that up-to-date information or updates, interaction and high speed of the internet provided in the mobile applications had created have an impact among students to adopt mobile applications. Security issues were taken into consideration for this research is authentication, integrity and authorization. It was noticed from the literature that authentication, integrity and authorization are important for mobile applications and thus it is important to the service provider to focus on overcoming these security issues in order to attract customers. Future work can be extended into an empirical study of information technology mobile applications in education and security issues in United Arab Emirates and Middle East. Moreover this work can be focused on collecting primary data from the customers to study about the information technology mobile applications in education and security issues in United Arab Emirates and Middle East.

Keywords: information technology, mobile applications, up-to-dateness, interactivity, high speed, authentication, integrity and authorization

1. INTRODUCTION

Contemporary mobile application is by any principles a radical shift of technology or radical innovation which incorporates a wide spectrum of developments in technology in a large-scale and complex technological system. Mobile application is a software application developed to execute on perspicacious tablet computers, phones and other mobile devices. Mobile applications are available through distributed platforms on concrete stores for application. Such applications were provided for purposes of productivity and information which entails calendar, email, weather information, calculator and contacts. With fast growth in the technology and prospects of the user the developer deploys established into other categories like global positioning system, ticket purchases, banking, mobile games, social media, factory automation, fitness apps, ticket purchases, location based services and more as mentioned by Uskov, 2013.

In the present scenario, teachers experience which influence technological changes in practice and education of marketing. Teaching methods and academic programs are being redesigned for reflecting these changes in marketing practice and use of mobile application particularly for marketing education (Santandreu and Shurden, 2012, Laffey and Lowe, 2011 and Clarke and Flaherty, 2002).

Further it was agreed by Dye (2013) that mobile applications have allowed customers to carry out task in a more efficient and convenient manner versus adopting slowly loading websites in the mobile, industry is recognizing that most of these applications are hurried through development to sacrifice security along the approach. Moreover there are current activities to better regulate development of mobile application as it regarding security with the help of certification and also assists for protecting users of mobile application to move forward. Most of the applications are previously in customer markets which involve vulnerabilities in the security; consumers have to know how to safeguard themselves against security issues as pointed out by Feldman and Feldman, 2013.

Aim of the research is to review the information mobile applications in education and security issues with specific reference to United Arab Emirates and Middle East

2. Literature Review

2.1 Motives for the Use of a Mobile Application in Marketing Education

There are eight elements associated with the motives for the mobile application usage in marketing education (Ozata and Kezkin, 2014).

These are up-to-dateness, high speed, interactivity, non-monotonic, entertaining, reward, and obligation and arouse curiosity. Some of them are detailed below.

2.1.1 Up-to-dateness

Up-to-dateness has considered as the most highlighted element. Many consumers have made use of several updates especially from facebook, twitter etc (Ozata and Kezkin, 2014). Hotseat, Mixable, Double take and jet pack are some of the mobile learning applications which has used to the students effectively. These are also kept up-to-date wirelessly and it can be also delivered to the smartphone of the students. Updates have created an impact for the usage of mobile application in marketing education (Bowen and Pistilli, 2012). Mobile applications have embodied several technology convergences which lend themselves to the use of education including social networking tools, tools of annotation and applications of composition etc. Social media platforms have stimulated the students with new updates of information in the marketing education (Cochrane, 2013).

2.1.2 Interactivity

Mobile learning environment system (MLES) has created an impact among the undergraduate students (Hanafi and Samsudin, 2012). Internet interactivity plays an important role among the students and many researchers have identified that many students are receptive to the accessibility, interactivity and system convenience more when compared to other motives. But these have quite frustrated with the interruptions of occasion due to the problem of internet connectivity. Mobile applications also have developed through the development technology of android which is more efficient than other technologies (Alecu, Pocatilu and Capisizu, 2009; Williams and Pence, 2011). Interactivity and quality motivations have accepted technologies among the higher education students. Use and interactivity of the mobile phone applications have created both the positive and negative impact among the students of higher education (Olmo and Jimenez, 2014). The revolution of technology and communication has arisen from the use of mobile devices socially. It also has led an increase in research towards the interactive communication based on the mobile devices (Boase and Ling, 2013).

2.1.3 High Speed

High speed internet of mobile application has created a motivation among the higher education students. Smart phone learning has created an impact on the distance learning and mobile phone usage for the purpose of internet has considered as one of the habit with all the students of higher education (Kumar, 2011). Students have easily retrieved many data related to their education with the utilization of high speed mobile applications. Mobile learning approach has used to access the opportunities of an education to different society segments. Smart phones from 2012 have the capability of high-speed mobile broadband 4G LTE web browsing of internet, mechanisms of mobile payments and motion sensors. These have played an important role in marketing education. High speed has considered as the important characteristics features of smart phones. Short-range wireless communications, internet access, applications of business, email are some of the effective application of mobile phones which have created an impact among the students of higher education (Nath and Mukherjee, 2015).

2.2 Security Issues

There are many security issues associated with the mobile phone technologies some of them are detailed below.

2.2.1 Authentication

Authentication is considered as the important security issues related to the technologies of the network. It is also defined as the process of verifying the user identity. The security of network has become more and more important in which the people has spent more time to connect via mobile phones (Wadhaval, Mehta and Gawade, 2013). Mobile distance education has also affected by the authentication process. The threat of security has ranged from passively eavesdropping into many other messages to actively steal the data of the user. Many of the security in wireless network have measured through integrity, authentication, confidentiality and authorization. Unauthorized access to the mobile information and avoiding the internal access to the stored authentication of information process for the application of mobile phone are some of the threats of the wireless technologies. Privilege escalation, malicious applications and risky-in-app ad libraries are some of the attacks and threats associated with the mobile phone applications (Mahmood et al, 2016).

2.2.2 Integrity Authorization

Mobile phone platform technology has created the effective learning experience to the students of higher education. Mobile phone applications have closely linked with the integrity in which it also has created the negative influence on the higher education (Piotrowski, 2013). Kim, Mims and Holmes (2006) studied about the current trends and benefits of mobile wireless technology use in higher education. Among many other issues, the issues of security has also considered as the more crucial when compared to the other issues of mobile wireless technologies used in the higher education. Generally, integrity issue has arrived from the data in which the data arrival has same as that of the data sent and it has influence the performance of the students in higher education (Shim and Shim, 2001). Identification integrity and the message integrity are the two components of problems associated with the security issues of the wireless technologies.

2.2.3 Authorization

Poor authorization has relayed on the identifiers of users such as international mobile equipment identity (IMEI), international mobile subscriber identity (IMSI) etc. The mobile phone applications have created many challenges to the society especially in education sector. Malware, spyware, privacy threats and vulnerable applications are some of the application based threats associated with the mobile applications. There are various threats associated with the mobile applications such as application based threats, web-based threats, network-based threats and physical threats (Sujithra and Padmavathi, 2012). Integrity has considered as the fundamental requirements for the security of mobile database. It also has additional risk and challenges due to user mobility and many wireless links. Confidentiality and integrity are provided through encryption. Security and privacy are considered as the important critical issues to the mobile applications which have required mobile database effectively (Selvarani and Ravi, 2014). Mobile applications have explored the new set of security challenges. Integrity and non-repudiation are created both the positive and negative impact on the mobile applications (Temkar, Gadekar and Shah, 2015).

3. Research Methodology

Paradigm selected for this particular study is interpretivism. Qualitative approach is adopted as the research approach for this specific research. Data is significant for executing for any kind of investigation. This study adopts only second handled type of research. Secondary type of research is collected from existing resources, studies, journals, interviews, magazines, newsletter, governments' publications, internets, articles, books and so on. Text analysis is adopted for analyzing the data in this research. This research follows strict regulations and rules for executing the investigation.

4. Discussion

Table 1 depicts motives for use of mobile applications in marketing education. From the above table, it was clear that motives for adopting the mobile applications in the marketing education are up-to-dateness, interactivity and high speed. Up-to-date information or updates, interaction and high speed of the internet provided in the mobile applications had created have an impact among students to adopt mobile applications.

Table 1 Motives for use of mobile applications in marketing education

Author	Year	Motive factors	Findings
Bowne and Pistilli	2012	Up –to-dateness	Many consumers adopted to upgraded technologies like facebook, twitter
Cochrane	2013	Up-to-dateness	Social media platforms provide new updates of information for students in the marketing education
Ozata and Kezkin	2014	Up-to-dateness	Updates have created an impact for the usage of mobile application
Alecu et al; Williams and Pence	2009, 2011	Interactivity	Many students are receptive to the accessibility, interactivity and system convenience more when compared to other motives.
Boase and Ling	2013	Interactivity	Revolution of technology and communication has arisen from the use of mobile devices socially
Olmo and Jimenez	2014	Interactivity	Interactivity have created positive and negative impact among the students
Kumar	2011	High speed	High speed internet among mobile application has created a motivation among the higher education students
Nath and Mukherjee	2015	High speed	High speed has considered as the important characteristics features of smart phones.

Table 2 depicts security issues associated with mobile applications in marketing education. From the findings of the research, it was clear that major security issues found in adopting mobile applications are authentication, integrity and authorization. Integrity issue, unauthorized access and authorization problems are major issues faced by adopters in mobile applications. Thus authentication, integrity and authorization are important for mobile applications. Therefore, it is important to the service provider to focus on overcoming these security issues to attract customers.

Table 2 Security issues associated with mobile applications in marketing education

Author	Year	Security issues	Findings
Wadhaval et al	2013	Authentication	Authentication is process of verifying the user identity
Mahmood et al	2016	Authentication	Unauthorized access to the mobile information and avoiding the internal access to the stored authentication of information process
Shim and Shim	2001	Integrity	Integrity issue has arrived from the data in which the data arrival has same as that of the data sent and it has influence the performance of the students
Piotrowski	2013	Integrity	Mobile phone applications have closely linked with the integrity in which it also has created the negative influence on the higher education
Sujithra and Padmavathi	2013	Authorization	Poor authorization has relayed on the identifiers of users
Selvarani and Ravi	2014	Authorization	Authorization has considered as the fundamental requirements of the security of the database
Temkar et al	2015	Authorization	Authorization and non-repudiation are created both the positive and negative impact on the mobile applications

5. Conclusion and Future Work

The main intention of this paper is to review information technology mobile applications in education and security issues in United Arab Emirates and Middle East. This research utilizes only secondary or second handled data alone. Motives for use of a mobile application in marketing education reviewed in this study are up-to-dateness, interactivity and high speed. Up-to-date information or updates, interaction and high speed of the internet provided in the mobile applications had created have an impact among students to adopt mobile applications. Security issues were taken into consideration for this research is authentication, integrity and authorization. Authentication, integrity and authorization are important for mobile applications and thus it is important to the service provider to focus on overcoming these security issues in order to attract customers. Future work can be extended into an empirical study of information technology mobile applications in education and security issues in United Arab Emirates and Middle East. Moreover this work can be focused on collecting primary data from the customers to study about the information technology mobile applications in education and security issues in United Arab Emirates and Middle East.

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CASE STUDY ON A RADIANT FLOOR SYSTEM

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ABSTRACT

The paper introduced an application of radiant floor system integrated with ground source direct cooling and displacement ventilation. The paper did simulation and field testing. The simulation gave the dynamic load of the application. The field data includes indoor temperature, power consumption, temperature and flow of water through which it gained the cooling capacity of underground heat exchanger. The results show that the capacity of radiant system can match that of underground exchanger and load of building. Direct cooling technology is one of the most important technologies of the application which utilized the passive performance and high temperature cold source. Thermal storage of building itself and tank brought both thermal and power peak shift and energy efficiency. The cost of heating and cooling was less than 10 Chinese Yuan/ m^2·a.

Keywords: direct cooling, radiant floor, energy efficiency

INTRODUCTION

Energy consumption and occupants' satisfaction have drawn concern of researches (Amasyali et al., 2016). Radiant floor cooling system, which has been applied in commercial buildings, has many great characters such as energy savings, load-shift, good indoor thermal comfort, reduced draft. (Feustel and Stetiu, 1995; Stetiu, 1999). There have been many researches focus on radiant floor systems (Dong and Lam, 2013; Flores Larsen et al., 2010; Li et al., 2014). Recently, review researches has been conducted on the radiant heating and cooling system for improving thermal comfort and energy savings potential (Hu and Niu, 2012; Rhee and Kim, 2015). Based on the above results, energy efficiency and new technology combination and its analysis are concerns in these fields.

However, there are limited researches focusing on generalizing radiant floor cooling/heating system to directly utilize low-grade energy (such as shallow geothermal energy) to radiant floor systems (Li et al., 2014).

The paper is aimed at introducing an application of radiant floor system integrated with water storage tank system and displacement in a commercial building in China and explaining why it can get good performance and low operation costs.

DESCRIPTION OF THE APPLICATION

Antaeus building as office building is located in the high-tech development zone of Jinan City, Shandong Province, China with 5453 m2, 5 floors on the ground and one basement. The exterior view of the building is shown in Figure 1.

Under the concept of integral method of design and operation, Antaeus building is designed as a building with low energy consumption due to utility of low-grade renewable energy with low auxiliary primary energy and passive energy-saving. Its operation, considered carefully in the design, is under dynamic operating strategies which cover the thermal storage of building, power rating structure and weather condition and so on.

Figure 1 The exterior view of Antaeus building

The air-conditioning of the building is radiant floor with displacement ventilation where indoor sensible heat and latent heat treatment are handled by two systems, respectively. So it can handle temperature and humidity separately, called temperature and humidity independent control (THIC).

In summer, high temperature cooling water in embedded floor tubes is directly from underground tube about 18 ℃ which is direct cooling strategy. Meanwhile 7 ℃ chilled water is stored in thermal storage tank for displacement ventilation which is produced by heat pump. 7 ℃ chilled water is prepared during night when the power rate is low under electricity rating structure in Jinan city. The schematic of direct cooling is shown in figure 2.

The operation process in summer is: radiant floor with high temperature cold water handle most of the indoor sensible heat load. Fresh air heat pump system uses 7 ℃ chilled water remove the latent heat load by displacement ventilation which also addresses part of the sensible heat load. Because of the low power of distribution pump (2.2 kW), the operation power consumption is very low.

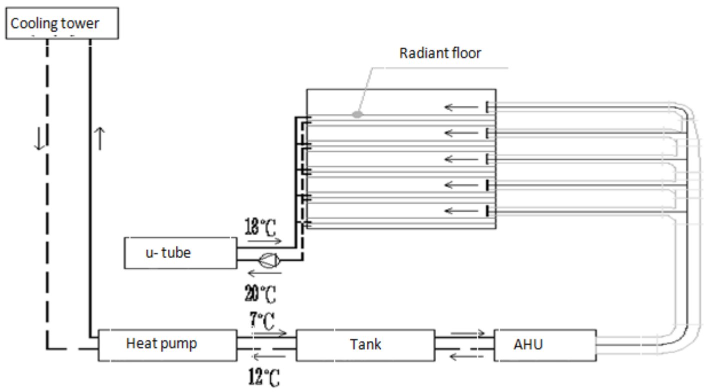

Figure 2 The schematic of direct cooling

In heating season, the air-conditioning system shares the floor cooling system. Water in floor tube is 40 ℃ low temperature hot water which is produced by heat pump unit from 18 ℃ water in underground u-tube.

SIMULATION AND FIELD TESTING

Simulation

DeST is used to simulate the dynamic load of the building. And TRNSYS is used to simulate the changes of floor surface temperature and indoor air temperature.

Antaeus building is well insulated with low area ratio window to wall, shading within shutter, well insulated windows. Heat transfer coefficient of exterior wall and top is 0.49 $W/m^2 \cdot K$, 0.49 $W/m^2 \cdot K$ respectively. And total heat transfer coefficient of side windows is 2.4 $W/m^2 \cdot K$. Shading rate of blind is 50%. Area ratio of windows to wall is 35% (south), 33% (north), 16% (east), 3% (west). According to fresh air standard of $30m^3/(h \cdot person)$, ventilation times to 0.5 times/h.

Table 1 Density of Occupants, Lighting and Equipment

Floor	occupants	DoLE (W/m^2)
1	15	3.96
2	15	3.82
3	60	17.69
4	40	5.13
5	10	5.28

According to architectural drawings of the project, the building load simulation model, it is necessary to establish each room one by one. Building model is shown below.

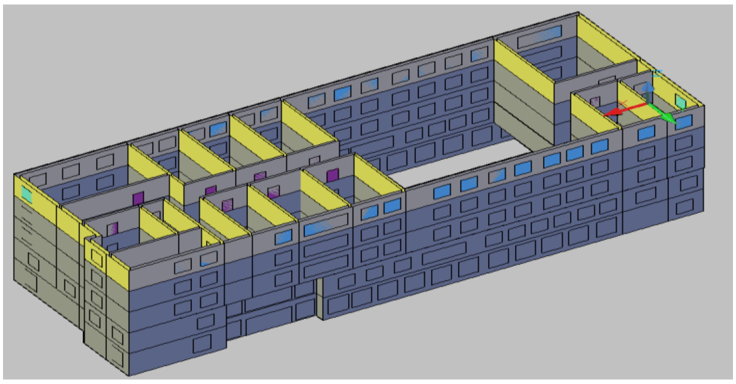

Figure 3 Model of Building in DeST

Field testing

We get operating data from the monitor system of Antaeus Building in 2014. It is very beneficial to compare the results from simulation and operation. Figure 4 shows the monitor system.

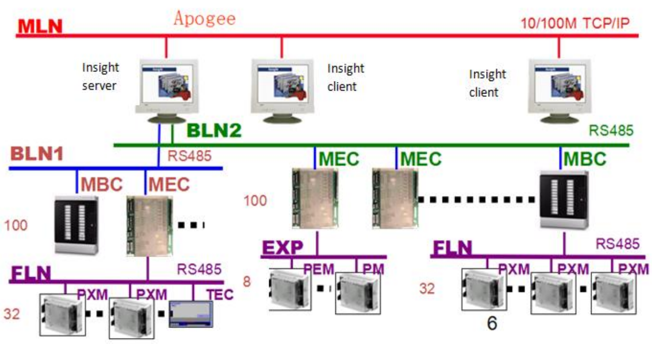

Figure 4 Monitor System of Antaeus Building

RESULTS

Simulation analysis

The output of DeST is shown in figure 5 (hourly air conditioning load in a year) and figure 6(hourly air conditioning load per square meter in a year). As shown in these figures, the maximum of hourly cold load is 259.28kW, and the maximum of cold load per square meter, 47W/m^2.

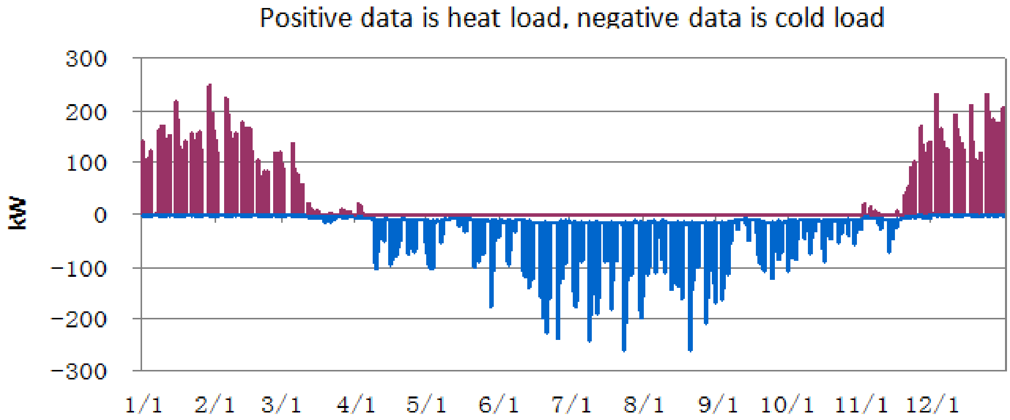

Figure 5 Hourly air-conditioning load in a year

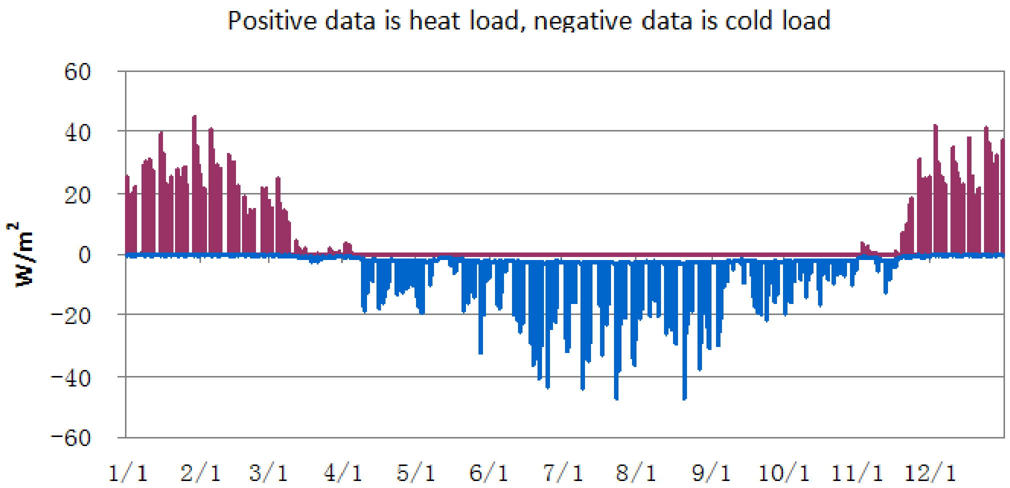

Figure 6 Hourly air-conditioning load of unit area in a year

Field data

Figure 7& Figure 8 show the cooling energy provided by underground heat exchanger and radiant floor in the cooling season of 2014. The indoor temperature is shown in figure 9. The total cold energy provided by cooling radiant floor is up to 76.4MWh, equivalent to unit area of 20kWh/m^2.

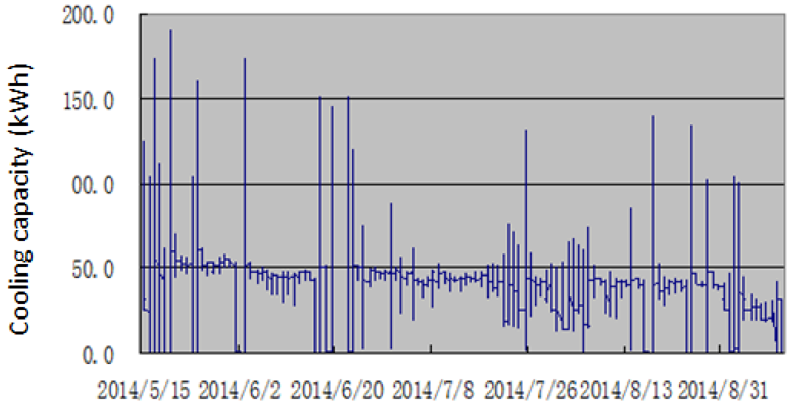

Figure 7 Cooling Capacity of Underground U-tube

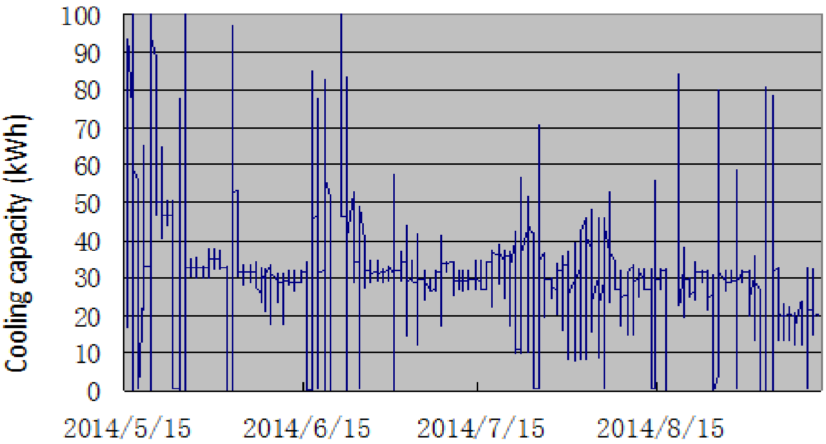

Figure 8 Cooling Capacity of Radiant Floor

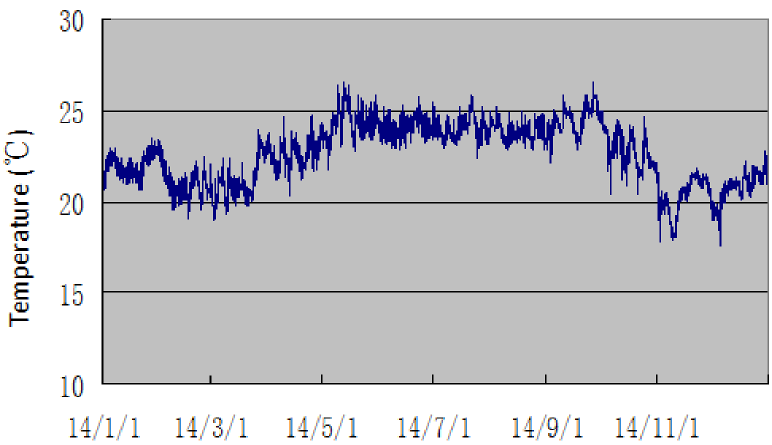

Figure 9 Indoor temperature

The result of electricity consumption based on the data during 1st November, 2013 till 1st November, 2014 shows that the total consumption of the whole building is up to 150,000 kWh annually, electricity intensity per unit area of 32.7kWh / (m2 a) in which air conditioning system contributes to 33%. Cooling consumption is only 13% of the total electricity consumption.

The total operating cost in cooling season was 11300 Chinese Yuan, 2.97 Chinese Yuan /m^2. Total heating cost was 20700 Chinese Yuan, 5.42 Chinese Yuan /m^2. The total operating cost, 8.39 Yuan /m^2, is very low compared to other similar office buildings.

Table 2 electricity power information during different period in cooling and heating season

period	Rate (Chinese Yuan /kWh)	Cooling energy （kWh）	Heating energy （kWh）
23:00~7:00	0.3270	12848.13	42331.59
7:00~8:30 11:30~18:00	0.8174	4022.93	5944.37
8:30~10:30 18:00~19:00 21:00~23:00	1.3078	1085.42	443.73
10:30~11:30 19:00~21:00	1.3896	1746.56	999.04

DISCUSSION AND CONCLUSION

Because of well insulated envelope of building, match between cooling capacity of underground heat exchanger and radiant floor doesn’t require low temperature cooling water. The temperature of cold source requires only 15℃-18℃. That is why direct cooling is possible. According to the field data, the temperature of floor surface is 22℃-23℃. Meanwhile, high temperature cooling conquers the problem of dewing of radiant system. Radiant asymmetry and thermal comfort are not problems any more.

Radiant floor system can lead to low operating cost by good design and operation strategies. In the climate zone like Jinan city, Shandong Province, China, air conditioning system with heating and cooling is necessary that is beneficial for the thermal balance of ground source pump between the cooling season and heating season. Once the building is of well insulated envelop, it is very suitable for ground source pump system. And when radiant floor system is equipped, direct cooling will bring huge energy savings of primary energy by utilizing the low grade shallow geothermal energy. Due to the characteristic of the radiant floor, low distribution power is enough that why the auxiliary energy is very low. Radiant heat exchange contributes most to thermal comfort of human body. So the indoor air temperature can be higher by 2℃-3 ℃ than conventional air conditioning system. Based on above, building can gain energy efficiency and thermal comfort of occupants. Thermal storage is very good technology of passive energy efficiency. On one hand, storage tank is the normal means. One other hand, building itself including furniture and other stuffs inside can be viewed as a thermal storage object. In such prospective, passive performance of building itself is possible to be used to make peak shift and energy savings. What is more, electricity rating structure is very common in many countries which make it possible to save operating costs in the case of the same power consumption. Because of all the above, we can get good thermal comfort and low air conditioning cost less than 10 Chinese Yuan/m^2·a. This paper just gave some parts of the profile of the application. It covers the cooling capacity and energy consumption on which deeper details of analysis should be provided. What is more, it should be noted that huge thermal inertia also brings difficulties to control. Further researches are also necessary to analyze the specific progress of start-up phrase and peak shift, impact on surface temperature of inner walls and furniture, different strategies in different conditions, how to evaluate and control the operative temperature. Summarizing parameters of design and operation for radiant floor systems will be an important target for the future researches.

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INTERNATIONAL CONSTRUCTION MEASUREMENT STANDARDS – A GLOBAL FIRST

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ABSTRACT

This paper examines the lack of global measurement standards in the construction industry and highlights the problems that this creates in the global sphere. Measurement is a fundamental activity for contractors, project cost management consultants (quantity surveyors/cost engineers/construction economists), project managers and a wide range of other professionals in the industry. Whilst a wide variety of national and regional methods of measurement have been developed around the world there is currently no over-arching international method of measurement. The paper commences with an analysis of global standards generally and the various methods of measurement that have been developed around the world. It then explores the issues and problems associated with the lack of a global measurement standard. The research method underpinning this study comprises a literature review, interviews and discussions with Quantity Surveying/Cost Engineering professional associations and a case example of a global measurement standard in the property/real estate field. The paper then introduces an initiative to address the identified problems through the development of a global measurement standard for the construction industry. The approach used to develop this standard is described and the potential benefits of the standard are articulated. The main findings of the paper are that whilst the development of an international measurement standard faces many barriers, early indications are that the standard currently being developed will be successful and will have the spin-off benefit of helping to provide a global identity for the profession. The paper contributes a new innovative strategy for the development of a standard for one of the most fundamental of all construction activities – measurement.

Keywords: Quantity Surveying, Cost Engineering, Professional Standards

INTRODUCTION

The professional field of Project Cost Management (be it quantity surveying, cost engineering, project controls or other like descriptor) lacks global professional standards that are typically found in other professional fields such as accountancy. A concomitant benefit of global professional standards is that they unite a profession – something that the fragmented nature of the project cost management field could certainly benefit from. This paper examines this issue with a focus on measurement standards for the profession.

LITERATURE REVIEW

Global Standards

The International Organization for Standardization (ISO) is the leading authority on global standards. They describe a standard as *'a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose'*. More pointedly they note that *'for business, (standards) are strategic tools that reduce costs by minimizing waste and errors, and increasing productivity. They help companies to access new markets, level the playing field for developing countries and facilitate free and fair global trade'* (ISO 2015, p.1). The ISO have a membership of over 164 national standard bodies throughout the world and publish over 19,500 standards.

The Organization for Economic Cooperation and Development and the US Department of Commerce has estimated that standards and related conformity assessment (checking that products and services measure up to standards) have an impact on 80% of the world's trade in commodities (ISO 2015). Major global entities such as the World Trade Organisation (WTO) require their members to use international standards where available. This helps to avoid the technical barriers to trade that can be caused by differing national or regional standards.

It is notable that there is no ISO Standard or any other global standards that relate directly to the core processes/services of the project cost management profession. Whilst ISO standards exist in allied fields such as Risk Management, Quality Management, Environmental Management and Project Management there are none that relate specifically to project cost management.

The accounting profession provides a good example of global professional standards that have been developed and now form the basis for financial reporting in most countries around the world. The development of these standards importantly had the support of major global organisations such as the G20, World Bank, International Monetary Fund, the IOSCO, and IFAC (IFRS 2014).

The objective of the financial standards is to provide a common global language for business affairs so that company accounts are understandable and comparable across international boundaries. Most countries are now adopting these international standards in lieu of their own national standard. They enable accountants to prepare accounts using a common international framework that can be understood across international boundaries (IFRS 2014). These standards have the added benefit of uniting the accounting profession through common goals and frameworks.

Measurement Standards for the Construction/Property Sectors

The most common standards developed for the project cost management profession are Standard Methods of Measurement for building work. Standard methods or measurement are also commonly prepared in many countries for civil engineering works. Cost management professionals generally adopt a Standard Method of Measurement that has been developed for their particular country, region or market sector or develop their own informal 'in-house' methods that meet their clients' needs. These standards are commonly adapted to suit particular measurement approaches and or client/market requirements. An example is the adaptation of a standard method of measurement to a more concise/abbreviated form.

The first Standard Method of Measurement (SMM) of building works dates back to 1922. This was prepared by the Royal Institution of Chartered Surveyors (RICS) in the United Kingdom. The RICS have subsequently developed numerous versions of this standard. The RICS standards have been widely adopted by the quantity profession in Commonwealth countries. Mills et al. (2006) found that the RICS SMMs are the most widely used around the world for the building sector. Nanil et al. (2008) reported on research that has shown that the use of SMMs is widespread. A global survey by the Building Cost Information Service (BCIS) identified 32 different SMMs in various countries (RICS, 2003) while Mills et al. (2006) identified 44 SMMs used in 32 countries. This research also found that many SMMs are amended versions of the RICS SMMs.

There has also been measurement standards developed on a regional basis. This includes a European Code of Measure developed by the European Council of Construction Economists and the Africa Standard Method of Measuring Building Work developed by the Africa Association of Quantity Surveyors. The Association for the Advancement of Cost Engineering International (AACE) have developed a Total Cost Management Framework (TCM) that is being increasingly used in many countries. The AACE are based in the United States but have sections in many countries around the world. Whilst not strictly a measurement standard it provides a standard for the whole cost management process.

However, research undertaken by the BCIS (2009) found substantial variations in the costs derived from various methods of measurement. Their research, undertaken in collaboration with the European Committee for Construction Economics (CEEC), found that costs varied by as much as

160% and costs per m2 varied by 140% with no clear correlation between the two. They commented that *'even though there had been a long held suspicion that comparing costs between countries was dangerous, the results came as a bit of a shock, particularly as cost per m2 tended to be the lingua franca in any discussions about costs in different countries. It was clear that, in arriving at cost per m2, different countries were including different costs and dividing them by different floor areas'* (BCIS 2009, p.5)

Building on these research findings, the BCIS (2009) undertook an extensive international survey of measurement standards used around the world and found a range of important issues. The survey covered 40 countries. Key findings were that:

- 19 out of the 40 countries did not claim any published standard method of measurement or standard elemental classification of building parts.
- in the absence of locally agreed standards, professionals frequently adopt 'foreign' standards or ad hoc in-house developed standards
- there was no common way of expressing cost per m2, both in terms of the cost definition and the floor area
- there were many countries where the quality of cost information and data classification falls short of what local professionals might wish.

BCIS (2009, p. 4) concluded that *'although there are countries with quite complete cost related standards and information sources, there appear to be many more where the quality of published guidance and cost information falls short of what local professionals might wish'.*

The Problem – The Need For Global Measurement Standards

Business activity is increasingly global in nature with a concomitant increase in demand for consistent global standards and rules. The International Financial Reporting Standards are a prime example of this. The property and construction industries are certainly global with multi-national investment in property development and international partnering in large scale building and infrastructure projects. Muse (2015) contends that as 70% of global wealth is held in land and property the need for global standards in the construction/property industries is paramount.

PWC (2014) predict that global investable real estate will increase by more than 55% compared to 2012 and then expand by a similar proportion in the following decade. This will be dominated by emerging/developing markets. Muse (2015) argues that this rapid change in global investment with more focus on emerging/developing economies adds even more strength to the argument for global standards – emerging/developing real estate/construction markets generally have standards lagging well behind more developed countries.

Muse (2015, p.6) articulates the problem as follows. *'One factor which is hampering the efficiency of the market revolves around a lack of consistency about how costs and measurements are defined throughout different parts of the world. Imagine, for example, we were to say that a commercial building in Sydney costs $A3,000 per square metre to design and construct whereas one in New York costs $US2,500. As things stand at the moment, such a comparison would be affected not only by exchange rates but also by whether or not the 'cost' in each case includes or excludes finance costs or amounts paid for professional fees and whether or not the floor area in both cases includes or excludes space associated with balconies, car-parks or elevator shafts. In short, we have no straightforward way of comparing costs across international jurisdictions on a like-for-like basis'*.

Uncertainty and risks are a major inhibitor to investment in construction and infrastructure, often caused by a lack of comparable, consistent and collaborative standards. This lack of measurement standards means that construction projects, their inherent works elements and the resultant assets are incomparable from one geographical market to another. In addition, robust global benchmarks for cost, time, quality, risk and technology are not available.

Extensive research by Meikle and Gruneberg (2014, p. 126) found that *'consistent approaches are required as to what is included in, or excluded from, construction activity, and how variables should be measured and presented. This needs to take account of the data requirements of statisticians, policy makers, international bodies, industry, researchers and others. It is an international issue and needs to be addressed at that level; construction is too important a sector of the economy to be measured so poorly'.*

The lack of international measurement standards means that comparison of construction works between countries is typically inefficient, inconsistent and misleading for the unwary investor. This scenario creates a barrier to well-informed investment decisions, from commercial real estate portfolios, through to the individual dwellings and land rights of the poorest sections of society.

The Global Alliance for Buildings & Construction further the argument for the need for global measurement standards. *"Real estate markets are increasingly global. Whether constructing, buying, leasing or occupying property assets, global investment decisions crucially depend on transparency and comparability, regardless of where the investment originates from. Without it, markets are inherently risky and unsustainable. Transparency and comparability rely on consistent data. Yet the way buildings are currently measured varies dramatically, this significant variability introduces high uncertainty in valuation and project-cost estimation"* (GABC 2015, p.8)

CASE EXAMPLE - INTERNATIONAL PROPERTY MEASUREMENT STANDARDS

These measurement problems have long been identified in the property sector. The IPMS (2016) comment that the way property assets are currently measured varies dramatically. For example, in some parts of the world it is established practice to include common space (lift shafts; communal hallways etc) in floor area measurements; in others off-site parking might be included or even swimming pools. With so many different methods of measurement in use, it makes it difficult for property users, investors, occupiers and developers to accurately compare space. IPMS (2016) cite research by global property firm JLL that showed that a property's floor area can deviate by as much as 24% depending on the measurement method used.

This led to a major global initiative to address this problem. Professional associations representing the property sector began joining forces in 2013 in collaboration with and the support of major global organisations such as the World Bank and the International Monetary Fund. They formed an International Property Measurement Standards Coalition (IPMSC) with a clear focus on global collaboration amongst professional associations.

It was very apparent that this initiative would not have been successful if it was developed by a small number of organisations – this would limit the global 'take-up' of the standards and would open up the standards to criticism/cynicism due to perceptions that they were influenced by the vested interests of these organisations. Focusing on global collaboration and ensuring that the coalition drove the standards development, rather than individual organisations, has seen the IPMS flourish in a very short space of time. A fundamental feature of the coalition was equal voting rights for each of the coalition members to help ensure that the standards are truly global rather than just cater to the needs of major organisations.

The IPMSC selected real estate experts from around the world to form its Standards Setting Committee (SSC) – the core group who would develop global standards for property measurement. Momentum built quickly and the International Property Measurement Standards Coalition (IPMSC) now comprises 70 professional and not-for-profit organisations from around the world (from a base of 34 foundation members) working together to develop and implement international standards for measuring property.

The first property measurement standard for offices was published in 2014. Importantly, this standard has been quickly endorsed and adopted by governments and clients in many countries. Further standards are currently being developed for the residential, industrial and retail sectors (IPMS 2016).

THE INTERNATIONAL CONSTRUCTION MEASUREMENT STANDARD

The success of the International Property Measurement Standards (IPMS) initiative spawned proposals to implement a similar strategy to develop International Construction Measurement Standards with input and support from project cost management organisations around the world.

The development of an international construction measurement standard was initiated by the Royal Institution of Chartered Surveyors (RICS) and the European Council of Construction Economists (CEEC) in 2014. They were soon joined by the International Cost Engineering Council (ICEC) in support of the venture. Using their extensive international networks, these associations set about informing the project cost management profession about the initiative and inviting participation. The author was integrally involved and continues to be involved in this global industry consultation and development of the standard. The following outlines the development of this standard based on the author's involvement and the internal meetings and internal documentation/reports that have been prepared by the working groups (ICMS 2016).

The first formal meeting for the development of the standard was held in June 2015 at the International Monetary Fund (IMF) head office in Washington DC in the United States. The IMF and the World Bank were two early supporters of the initiative and continue to be so. The meeting resulted in the formation of the International Construction Measurement Standard Coalition (ICMSC) with 17 project cost management associations signing up as foundation members.

The IPMS development model has been adopted for the ICMS. The purpose is to develop international standards that are recognized by world bodies and national governments. This would be ideally similar in character to the International Financial Reporting Standards (IFRS) outlined earlier that is universally adopted by the accounting profession and recognized by all major corporations and governments around the world. The objective is for professional associations to lead the development of common, internationally agreed standards. Working as a coalition of equals, it is planned that these professional bodies will have the authority and ability to drive forward common rules of engagement which practitioners will be responsible for delivering around the world (ICMS, 2015).

Each professional association in the ICMS coalition appointed a trustee to represent them and the trustees then elected a trustee board. In line with the IPMS model, each trustee (i.e. each association) has one vote per body to help ensure real global participation and approval (and help offset perceptions that the initiative would be driven by the larger organisations). The trustees then set about appointing a Standard Setting

Committee (SSC) comprising expert measurement professionals from around the world nominated by coalition members. They are tasked with developing the standards with a key criteria that they are not writing a standard representing their country, body or jurisdiction - conversely they are writing an international standard for the benefit of all stakeholders.

The ICMS coalition and support for the measurement standards has grown quickly. The coalition has now grown from a foundation membership base of 17 professional associations in mid-2015 to a membership of 41 associations by mid-2016. It was widely acknowledged that the development of a construction measurement standard would be more complex and difficult than the property measurement standard (which focused largely on floor areas) but these difficulties are being worked through and indications are that the Standards Setting Committee (SCC) will be successful in their goal.

One of the first things that the SCC recognised was that there was a need to cover both infrastructure and building works. Given the inherent differences between the two sectors the SCC decided to develop separate standards for these two sectors. Whilst the standards are still in the development stage, some key principles emerged during preliminary discussions. Key characteristics of the standards will be that they will:

- be high-level, over-arching and principles-based
- cover both capital cost and whole life cost
- define construction cost (adopt universal definitions of construction costs and the associated variables)
- be consistent with the International Property Measurement Standards (IPMS) in terms of expressing cost per m2, but acknowledging the construction process
- provide consistent cost comparisons on a per m2 basis through consistency with the International Property Measurement Standard
- create a single classification system for building and civil engineering projects for use with digital tools such as BIM
- recommend a consistent data framework for the collation of national statistics
- be as simple as possible, commensurate with allowing robust comparisons to be made
- articulate with local measurement standards wherever possible
- recommend a standard reporting format
- allow global cost comparisons and benchmarking for global investors, corporate bodies and contractors
- provide a checklist for international best practice
- provide consistent language and terminologies for the worldwide and increasingly mobile profession
- accommodate the need for continuous refinement, updating and change.

Drafts of the standards will shortly be ready for internal review by Coalition members and it is expected that drafts will be circulated for external review and comment before the end of 2016. The overall objective is to develop an international framework that will contain overarching international standards which will harmonise cost, classification and measurement definitions. This will require agreement on what is included and excluded from construction costs at both a project level and a national reporting level and creating a framework for a standard system of costing for building and civil engineering projects.

This will enable governments and international bodies to compare the costs of construction of building and civil engineering projects (works) so that national costs can be benchmarked, the causes of differences in costs can be identified, properly informed decisions on the location of construction projects can be made, and the relative performance of the construction industry in different countries can be more readily determined.

CONCLUSION

At the core of the development of the International Construction Measurement Standards (ICMS) is collaboration between the project cost management profession and their representative professional associations on a global scale. There are well over one hundred national associations as well as regional/international associations representing the profession around the world. The project cost management profession has traditionally been fragmented with a lack of global recognition – this is largely due to the different cost management approaches and various cost management professional title descriptors used in various countries. This initiative is bringing the profession (be they quantity surveyors, cost engineers or other project cost management professionals) together to work on a global standard that has great potential to be recognised and endorsed by major global entities such as the World Bank, the International Monetary Fund and the United Nations as well as major multi-national corporations. These organisations are increasingly requiring global standards - gaining recognition and working with these types of organisations (and gaining their support) can provide the global platform for further standards to be developed, recognized and adopted around the world.

The lack of global standards inhibits the development and identity of a profession. The International Construction Measurement Standard (ICMS) initiative has much potential to provide the first step in the development of a range of much needed global standards. Recommendations for further study would therefore include research into other project cost management fields that would benefit from global standards such as BIM and environmental measurement standards.

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PERFORMANCE BASED LEGISLATION – MANAGING RADICAL INNOVATION

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Abstract

This paper proposes that performance-based legislation should be defined as a form of radical innovation. Performance-based legislation seeks to provide flexibility and promote efficiencies alongside the traditional prescriptive compliance approach. However the structure and application of performance-based legislation differs in critical respects to the historical prescriptive approach to code management, requiring organisations to develop a new conceptual framework to more effectively manage this innovation. If such frameworks are not developed, the risk exists that the use of performance-based solutions may fail to meet the broader code objectives and that these failures become sedimentised institutional benchmarks.

Keywords: prescriptive legislation, performance legislation, logical incrementalism, emergent strategy, radical innovation

Introduction

In an era characterised by globalisation and innovation, organisations are required to develop effective and sustainable change management strategies to effectively manage existing and anticipated change. One such innovation is the move from traditional prescriptive to innovative performance based legislation. However, many organisations have not recognised that the traditional change management strategies that have been adequate in managing prescriptive legislation are fundamentally different to those necessary to manage performance based legislation.

In seeking to develop a more effective change management strategy for performance based legislation, this paper firstly identifies the historic change management models by which traditional prescriptive legislation was developed. This paper will then briefly describe the principal elements of performance based legislation and how this model differs from traditional prescriptive legislation. The concept that performance based legislation is more accurately described as a form of radical innovation will then be discussed. Finally, this paper will describe how radical innovation management theory can be used to create an adaptable framework for the management of performance-based solutions.

The conceptual basis for tradition building codes - logical incrementalism and emergent strategy

There are two identified change management models with direct relevant to the creation and management of traditional prescriptive codes; logical incrementalism and emergent strategy (O'Brien, 2016). Logical incrementalism is defined the process of codification of existing practice that is pro-active, continuous (although gradual) and based on existing patterns and structures. In a broad organisational sense, as described by Idenburg (1993, p.135) 'The process develops in phases but each following phase builds on the previous stage and has its own internal logic.' Related to building codes, McDowell and Lemer (1991, p.1) describe this process as 'The influence of these criteria and practices on safety is presumed on the basis of past experience, scientific analysis, and reasoned discussion by those concerned with protecting the public-at-large and the interests of property owners'. This *status quo* approach was summarised by Zimmerman and Martin (2001, p.172) as occurring where 'there is little incentive to do anything different than standard practice. What has been provided in the past is assumed to have worked and therefore provided again.' Where change is proposed, this is most commonly in response to incremental improvements in process over a long time frame or periodic technical review of existing codes, such as seem with the Building Code of Australia annual amendments (Australian Building Codes Board, 2014).

The second strategic management theory that can be adapted to the code development process is described as emergent strategy (Idenburg, 1993). Emergent strategy can be described as an intermittent process of reactive and discontinuous change based upon specific events where 'it is not possible to develop a perspective of the future and formulate explicit objectives in an unpredictable environment: instead, it is necessary to react in a flexible, opportunistic and accidental manner to new, unpredictable developments, and 'muddle through'' (Idenburg, 1993, p.136). As related to building codes McDowell and Lemer (1991, p.9) characterise this approach as occurring where 'From time the time, new hazards are identified and become the subject of debate, public policy and regulation.'

Both logical incrementalism and emergent strategy content are grounded in technical considerations. However, what differentiates the emergent strategy model is that the originating hazard is deemed unacceptable by the public, requiring an immediate legislative response. It should be noted that after the original emergent strategy response, code amendments revert to a logical incrementalist process.

The reliance on the historic logical incrementalism, and to a lesser extent emergent strategy, change management models has created a stable structure that has seen little need for the organisational culture to adapt to change. As Dewar and Dutton 1986 (p.1424) observed 'complexity and knowledge depth should be less important for incremental innovations because adaptation of these types requires less knowledge resources in the organisation for development or support.' However, with the introduction of performance based legislation, organisations were presented with a second compliance option. It is this change from stable logical incrementalism to radical performance legislation that has presented the need for organisations to recognise and adapt to this change.

Performance legislation described

The evolution of performance-based legislation reflects a view that traditional prescriptive controls are process rather than outcome based, a framework that potentially limits technical innovation, restricts trade and increases compliance costs. Alternatively, performance-based legislation is seen as being outcome focussed, permitting a range of compliance options that encourage innovation and reduce costs (Sexton & Barrett, 2005) and thus is seen as a more adaptable compliance option for an environment characterised by rapid and at time unplanned change. As identified by Becker (1999, p.525), performance-based legislation 'provides a rational framework for building design and construction that is flexible and amenable for accommodating innovation and change.' In this respect, performance-based legislation differs significantly from the traditional prescriptive approach, where code users had a limited range of compliance options that had evolved over a historic time scale.

Theoretically performance legislation offers organisations operating in an environment characterised by rapid change operational advantages. However, the ability to introduce innovative materials or designs without new organisational structures explicitly designed to monitor the effectiveness of the solution could lead to hitherto unforeseen outcomes. The use of performance-based solutions therefore requires practitioners to 'remain cognizant of their relatively untested quality, and consciously monitor the accumulation of evidence (from their own organizations as well as others) on the effectiveness' of these solutions' (Tolbert & Zucker, 1996, p.183). This is particularly important because by their very nature each time an alternative solution is used it may set a precedent that enables a minor or major reinterpretation of the goals of the performance based code. Whilst use of the traditional prescriptive compliance options retards innovation it does to a large extent ensure that the goals of the code are met.

To date, research into performance-based legislation (e.g. Buchanan, 1999; Becker, 1999; Bergeron et al., 2001; Bergeron, 2003; Meacham, 2010) has largely focussed on the identification of specific process issues associated with the use of performance-based legislation. This line of research generally assumes that the foundations of performance-based legislation are sound, and consequently seeks to identify areas where improvements in operational systems can be made. However, this research focus has not considered performance-based legislation as a form of radical change to the existing governance framework. This paper proposes that performance-based legislation represents a seminal change from traditional prescriptive governance structures and process and is a subject worthy of research in its own right. In order to support this view, we must first identify the change management models that underpin radical innovation, to which this paper will now turn.

Radical innovations defined

The field of organisational management, as an area of research in its own right, has a history spanning from the 1940's (Tolbert & Zucker, 1996). The innovation management framework associated with this line of research is sufficiently adaptable to be applied to analyse whether the performance-based legislation meets the definition of radical innovations.

Adapted from manufacturing literature, radical innovation is described by Un (2010, p.3) as 'creating knowledge in order to make fundamental changes that represent revolutionary alterations in a product's technology.' This process is contrasted with incremental change, where participants 'deal with creating knowledge for minor improvements or simple adjustments in a product's current technology' (Un, 2010, p.3). Comparing these definitions, it can be seen that radical innovation more accurately describes the process of performance legislation. Recognising the fundamental difference between managing radical and incremental innovation will allow the optimal organisational approach to be applied to the selected compliance path.

One key component of the radical innovation change management paradigm is the understanding of new processes and language. The core characteristics of radical innovation were clearly described by Dewar and Dutton (1986, p.1422) as 'fundamental changes that represent revolutionary changes in technology. They represent clear departures from existing practice'. As O'Connor and McDermott (2004, p.429) note, the effective management of a radical innovation thus requires 'the creation of truly new abilities and knowledge within the firm.'

This observation points to the need for those involved with performance-based alternative solutions to recognise the critical need to develop new organisational structures, skills and knowledge to manage this form of radical innovation. Figure 1 provides an illustration of the relationship between organisational knowledge and risk as related to prescriptive and performance solutions. As Figure 1 demonstrates, where organisational knowledge of traditional prescriptive processes exists, risk is lower. However, where organisations lack the institutional knowledge and capacity required to manage change associated with performance based solutions, the inherent risk rises.

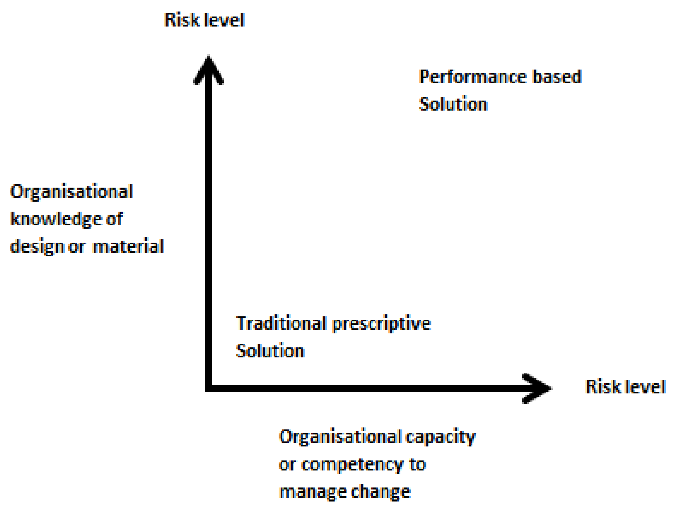

Figure 1 The relationship between organisation capacity, governance frameworks and risk

The need to develop new processes and knowledge to manage performance based solutions is necessary in an environment characterised by constant change and innovation. This is because the organisational roles within institutions managing only incremental change associated with traditional prescriptive solutions are necessarily different from those within institutions that embrace radical innovation, including performance legislation. The fundamental difference in the two change management processes points to the need for those organisations exposed to radical innovation to develop new frameworks. A generic framework for the management of radical innovation, as related to performance legislation, will be the focus of the next part of this paper.

Radical innovation management theory – a framework to describe change

A method for describing and managing radical innovation can be adapted from Tolbert and Zucker's (1996) conceptual framework for describing the process for identifying and embedding institutional knowledge within organisations. Figure 2 describes the generic three stage process for managing radical innovation from conception to application.

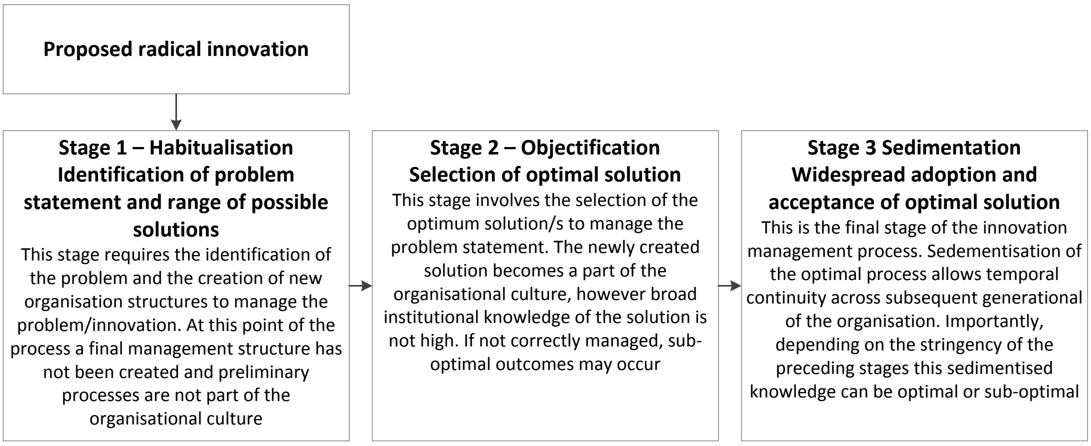

Figure 2 Generic framework of the radical innovation process

(Tolbert & Zucker, 1996)

The first stage of the process is identified as habitualisation. This stage 'involves the generation of new structural arrangements in response to a specific organization problem or set of problems' (Tolbert & Zucker, 1996 p.181). Developed in response to emerging or previously unrecognised matters (such as an alternative solution) the new management structures are preliminary and subject to change as the problem scope becomes better defined. Reflecting the preliminary nature of this stage, all potential solutions developed during this stage are described as being 'pre-institutionalized' (Tolbert & Zucker 1996). To develop an effective response to the identified matters, this stage requires examination of multiple methodologies which, lacking precedent may be without a strong empirical base. It is the identification of the problem statement and a range of potential solutions that is a defining characteristic of this stage. The range of research methodologies applied to identify the optimal solution may include (McDowell & Lemer, 1991, p.13) 'extensive testing and measurements in laboratories and field situations, and by the experience of professionals working in the field.'

The next and perhaps most important stage in moving to a formalised and permanent institutional framework for managing radical innovation are described as objectification. This stage 'involves the development of some degree of social consensus among organisation decision-makers concerning the value of the structure, and the increasing adoption by organizations on the basis of the consensus' (Tolbert & Zucker, 1996, p.182).

Management of this stage of the change process begins with further clarifying the problem statement. This process is described by Tolbert and Zucker (1996, p.183) as the 'creation of a definition of a generic organisation problem, a definition that includes specification of the set or category of organizational actors categorised by the problem.' The second stage of this process involves the creation of a solution, where a ‘justification of a particular formal structural arrangement as a solution to the problem on logical or empirical grounds’. This process ‘involves developing theories that provide a diagnosis of the sources of dissatisfaction or failings, theories that are compatible with a particular structure as a solution or treatment’ (Tolbert & Zucker, 1996, p.183). It is at this stage that the preliminary range of possible solutions identified at the habitualisation stage are critically examined to identify the most appropriate solution. Building upon the preliminary data gathered during the habitualisation stage, the objectification stage identifies and implements the most appropriate solution to manage the radical innovation (performance solution).

The process for managing radical innovation then progresses to the final stage, described as sedimentation. This is a process resulting in ‘the historical continuity of structure, and especially on its survival across generations of organizational members’ (Tolbert & Zucker, 1996, p.184). It is at this final stage the innovation has the potential to become established custom and practice and creates the precedent from which new interpretations of the code evolve. The nature of the sedementisation stage was described by O’Connor and McDermott (2004, p.424) as ‘radical innovations, in turn, provide the foundation upon which future generations of products are manufactured.’ Importantly, the knowledge that underpinned the radical innovation becomes culturally normalised across successive generations of the organisation. Although initially a unique solution to a previously unidentified problem, sedimentation allows the radical innovation to become normalised organisational practice. Subsequent solutions based on the sedimentised radical innovation then revert to periodic, incremental changes.

To summarise, the Tolbert and Zucker (1996) model comprises three individual stages; habitualisation, objectification and sedimentation. Habitualisation is the first stage and involves identification of a problem statement or operational goal. Identification of the problem/goal allows a range of preliminary research methodologies/solutions to be identified. The objectification stage further explores possible research methodologies/solutions to select the most appropriate. The optimal solution is then introduced to the organisation. The final stage of the process is sedimentation, where the optimal solution becomes normalised practice within the organisation.

From the preceding discussion it can be seen that the three stage process is sufficiently flexible to be applied as a framework for the management of radical innovations in a range of circumstances to ensure optimal outcomes. Correctly implemented, this process can ensure that sub-optimal outcomes do not become entrenched as normalised practice across successive organisational generations.

Conclusion

The brief paper has described how logical incrementalism and emergent strategy are the conceptual basis for traditional prescriptive legislation. Traditional change management models remained effective in an environment characterised by incremental change. However, the introduction of performance-based legislation, described as an example of a radical innovation, has seen the need for new change management models capable of responding to an environment characterised by constant change and innovation. Based on the work of Tolbert and Zucker (1996), this paper has described how it is possible to create an effective framework for the management of radical innovations, including performance based solutions. Knowledge of these processes is of significance as the innovative nature of the performance legislation represents a potential hazard if appropriate measures are not made to systematically manage this process.

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