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CIB World Building Congress 2016

Proceedings of the CIB World Building Congress 2016

Volume II

Environmental Opportunities and challenges

Constructing commitment and acknowledging human experiences

Edited by
Matthijs Prins, Hans Wamelink, Bob Giddings, Kihong Ku and Manon Feenstra

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Constructing Commitment and Acknowledging Human Experiences

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Preface

The main theme of WBC16 is the cogent message that the built environment is an important enabler for the well-being of its citizens, the success of its companies and the competitiveness and coherence of the whole society. Special attention is given to the development of the built environment in different countries and continents, and the interplay of various stakeholders and experts at all scales of activities.

This is the second volume of five for the proceedings of the *2016 CIB World Building Congress "Intelligent Built Environment for Life*" (WBC16) held May 30 – June 3 2016 in Tampere Finland. This volume contains contributions, which were submitted to the themes 'Environmental Opportunities and Challenges; Regarding Nature and Outdoor Conditions' and 'Constructing commitment and acknowledging human experiences', and thus it is divided into two main parts. The first part (sections one and two) contains 16 papers, which were allocated to the theme 'Regarding nature and outdoor conditions'. The second part (sections three to six) contains 46 papers, which were allocated to the theme 'Constructing commitment and acknowledging human experiences'. In total, there are 156 authors from throughout the world.

Environmental Opportunities and Challenges; Regarding Nature and Outdoor Conditions

This theme considers issues such as the interaction of the built and natural environment, sustainability indicators, environmental aspects, resilience, roles and responsibilities, and international cooperation. The assessment of sustainability issues, from life cycle impacts, to service life predictions and carbon emission measurements, appear as a distinctive collection of papers and are therefore grouped in section *1* under the heading **'***Sustainability Assessment'*. Papers about the effects of the natural environment and climate change on buildings, workers conditions, resilience and facades, are grouped in *section 2* under the heading *'Nature and Outdoor Conditions'.*

Constructing commitment and acknowledging human experiences

The second part of this volume presents papers related to leadership, end users, decision making, human resource management, communication and behavioural studies. A significant proportion of the papers submitted to this theme investigate health and safety issues; with specific topics like national regulations, post-accident disputes, permits, SME safety policies and even workaholics on site. These are grouped in *section 3* under the title **'***Health and Safety'*. Knowledge management, organisational characteristics, skills development, and communication are also vital issues, and these papers are grouped in *section 4*, titled **'***Organisations, Knowledge and Communication***'**. Papers exploring subjects such as contract management, project management, procurement and tendering, project organisation, project performance and productivity constitute *section 5 'Projects, Procurement and Performance'*. A genre of papers about human experiences attracted contributions focused on learning behaviour, clients and stakeholders' experiences, as well as user satisfaction. Papers addressing these issues are grouped in *section 6* with the title *'Users, Clients and Stakeholder Engagement'*.

Acknowledgements

The editors of the second volume of the WBC16 proceedings would like to express their sincere thanks to all authors who contributed to this volume with their valuable work. We are grateful to all the reviewers from the scientific committee who assisted authors to improve their papers to the level of publishable quality. Last but not least we would like to compliment the members of the Congress Programme Committee and the Local Organising Committee for their efforts over the

past years, which have resulted in the inspiring CIB World Building Congress 2016, of which this volume is one of the deliverables for future reference.

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Part I: Environmental Opportunities and Challenges

1. Sustainability Assessment
2. Nature and Outdoor Conditions

Co-production of energy use and carbon emission reductions in building environmental assessment

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Abstract

Building Environmental Assessment (BEA) has been increasingly utilized in low carbon building design as a structured approach to evaluating alternative design solutions. Energy use and relevant carbon emission are two most important aspects of BEA schemes. However, almost all BEA schemes only allow credits to energy use and carbon emission reductions to certain levels, which are far below the net zero standards promoted in many countries as a government climate change policy. Any interaction between energy use and carbon reductions is largely unknown. The aim of this paper is thus to explore the co-production between energy use and carbon emission reductions in order to support the delivery of buildings towards net zero energy and net zero carbon in tandem. This paper first examines the weights of the energy use and carbon emission related criteria in selected typical BEA schemes. The paper then drawing on the case of Hong Kong traces the evolution of such weights in BEA during the period 1996-2015 since BEA was first introduced in Hong Kong. The scenario of zero carbon was used to forecast the trend of the weights' evolution using the industry life cycle theory combined with linear, polynomial and ladder functions. The results show that the use of ladder function can best describe the possible trend of the weights of energy use and carbon emission reductions criteria in BEA, while linear and polynomial functions are more applicable if emerging low-carbon technologies are popularly adopted. The findings suggest that the co-production existing between energy use and carbon emission reductions can accelerate the transition of buildings towards net zero energy and zero carbon.

Keywords: Decision criteria weight, carbon emission, energy use, building environmental assessment, zero carbon.

1. Introduction

Buildings together account for over a third of greenhouse gas (GHG) emissions and energy consumption in the world, and therefore are a key sector where to achieve energy consumption and carbon emission reductions (Zhang, Pan and Kumaraswamy, 2014). There have been concerns about how to improve building practices to eliminate or minimise their detrimental effects on the environment (Cole, 1999; Holmes and Hudson, 2000; Ding, 2008). Since the 1990s, the concepts of sustainable design and high performance building, as well as their increasing industrial applications, have been furthering with the cognisance of the impact of buildings on the environment (Todd, Crawley, Geissler and Lindsey, 2001; Haapio and Viitaniemi, 2008). Significant changes were witnessed to mitigate the side impact of the building sector, such as the application of renewable energy and the usage of recycled materials. More recently, low-carbon building (LCB) and zero-carbon building (ZCB) have emerged as innovative and important approaches to reducing carbon emissions and energy consumption of buildings, and have attracted essential policy attention in many countries and regions (Pan and Ning, 2015). For example, in the United Kingdom (UK), the government has set ambitious targets to achieve “zero carbon” for new homes from 2016 and for non-domestic new buildings from 2019 (DCLG, 2007; HM Treasury, 2008). Similarly, in the United States (USA) and the European Union (EU) member countries, carbon reduction agenda of new buildings has been prompted as part of their building energy policies with clear goals (EU, 2010; Crawley, Pless and Torcellini, 2009; Panagiotidou and Fuller, 2013).

With the rising interest and demand from policy decision makers for achieving buildings’ energy savings and carbon emission reductions, there is also an increasing need for comprehensive and structured building environmental assessment (BEA) (Forsberg and Malmborg, 2004). The first attempt to establish comprehensive means of simultaneously assessing a broad range of environmental considerations in buildings was the Building Research Establishment Environmental Assessment Method (BREEAM) established in the UK in 1990 (Crawley and Aho, 1999; Grace, 2000; Haapio and Viitaniemi, 2008). Since then many different BEA schemes have been launched and adapted around the world, *e.g.* PromisE in Finland, Leadership in Energy and Environmental Design (LEED) in the US, Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in Japan and Building Environmental Assessment Method (BEAM) in Hong Kong. These BEA schemes cover different phases of a building’s life cycle and take different environmental issues into account, assessing different building components and whole buildings in global, national and even local contexts (Haapio and Viitaniemi, 2008).

There have been previous studies of reviewing various BEA schemes (Crawley and Aho, 1999; Reijnders L and van Roekel A, 1999; Forsberg and Malmborg, 2004; Aotake et.al, 2005; Finnveden and Moberg, 2005; Haapio and Viitaniemi, 2008; Ding, 2008), comparing the assessed criteria in different BEA schemes (Jonsson, 2000; Todd, Crawley, Geissler and Lindsey, 2001) and exploring the application of BEA in the building sector (Lowe, Kortman and Howard, 2000; Gibberd, 2005). However, little research has focused on the weighting systems or credits of the detailed criteria and indicators. Furthermore, almost all BEA schemes only allow credits to the reductions of energy use and carbon emission to certain levels that are far below the net zero standards promoted in many countries as a government climate change policy. Any interaction between energy use and carbon reductions is largely unknown. The aim of this paper is thus to explore the co-production between energy use and carbon reductions in BEA in order to support the delivery of buildings towards net zero energy and net zero carbon in tandem. The results of this exploration should inform decision making in building energy and carbon policy and practices and help accelerate the take-up of the LCB and ZCB approaches.

2. Methodology

The research was carried out through the combination of a comparative analysis of the weights or credits of identified energy use and carbon emission criteria in selected BEA schemes, and a detailed examination of the co-production of energy use and carbon emission reductions in Hong Kong during the period 1995-2015 since the first BEA was introduced in Hong Kong. The overall research design is illustrated in Figure 1.

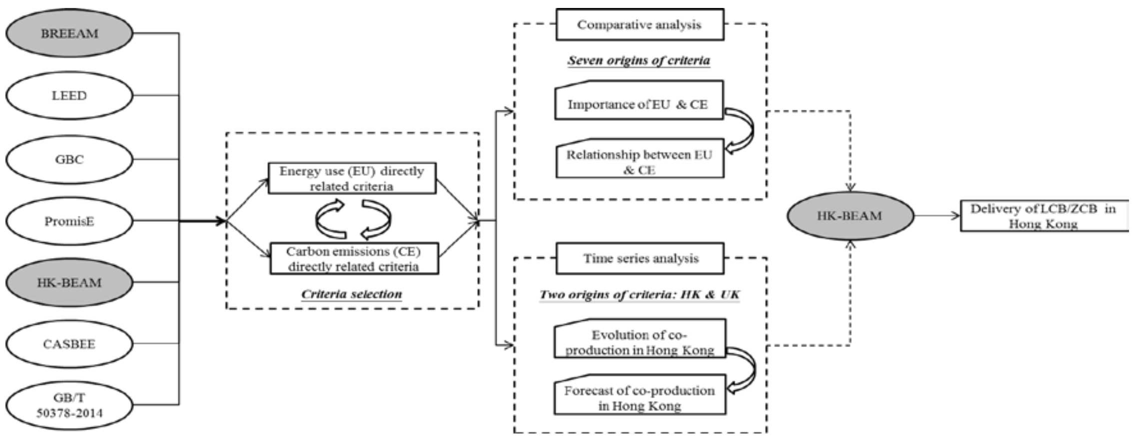

Figure 1: Detailed research methodology

There exist many different BEA schemes that share many similarities and also contain differences (Haapio and Viitaniemi, 2008). In order to achieve focused and effective comparison, only typical BEA schemes were selected to be included in the analysis reported in this paper. The in-depth examination of the co-production of energy use and carbon emission reductions was carried out with the case in Hong Kong for the period from 1996 (when the first BEA was introduced in Hong Kong) to 2015 when the results are being reported. The practices of building towards zero carbon in the UK are regarded as leading in the world, and thus are used as a benchmark for the analysis of the case in Hong Kong. The industry life cycle theory (Klepper, 1997) and mathematical methods were adopted to analyse the trend of the weights of energy use and carbon emission reductions in BEA in Hong Kong. The scenario of zero carbon was engaged for forecasting the trend.

2.1 Selection of BEA schemes

Seven typical BEA schemes were selected for analysis (*Table 1).* The selection took into account the factors of evaluation objects, climate, culture of building and living, the development of building industry and the moderate uniform of new buildings (Haapio and Viitaniemi, 2008), and was particularly based on the following considerations. First, all the schemes included in the analysis have been published and widely adopted (*e.g.* Grace, 2000; Hansen, 2005). Second, only those for new constructions were considered due to the focus of the study on design decision making for sustainable buildings. Third, considered in favour were those BEA schemes developed in Europe and North America, where the BEA schemes are comparatively more established and widely used, and in Hong Kong, Japan and Mainland China which share similar climatic and/or building conditions.

As a result, the seven selected BEA schemes include BREEAM, LEED, Green Building Challenge (GBC) and PromisE which were developed and adopted popularly in North America and Europe, and HKBEAM/BEAM Plus, CASBEE and Assessment Standard for Green Building which were developed in Hong Kong, Mainland China and Japan, respectively.

Table 1: Building environmental assessment schemes selected

Name	***Issue year (Latest version)***	***Country/ Region***	***Primary level assessment criteria***
BREEAM[1]	*2014*	*UK*	*Management; Health and wellbeing; Energy; Transport; Water; Materials; Waste; Land use and ecology; Pollution; Innovation.*
LEED[2]	*2014*	*USA*	*Location and transportation; Sustainable sites; Water efficiency; Energy and atmosphere; Material and resource; Indoor environmental quality.*
GBC	*2012 (known as SBTool 2012)*	*Canada*	*Site regeneration and development, urban design and infrastructure; Energy and resource consumption; Environmental loadings; Indoor environmental quality; Service quality; Social, cultural and perceptual aspects; Cost and economic aspects.*
PromisE[3]	*2006*	*Finland*	*Health of users; Consumption of natural resources; Environmental loadings; Environmental risks.*
HK-BEAM/BEAM Plus	*2012*	*Hong Kong*	*Site aspects; Materials aspects; Energy use; Waste use; Indoor environmental quality; Innovations and additions.*
CASBEE	*2014*	*Japan*	*Indoor Environment; Quality of service; Outdoor environment (On-site); Energy; Resources and materials; Off-site environment.*
Assessment standard for	*2014*	*Mainland China*	*Land saving and outdoor environment; Energy saving and energy utilization; Water saving and water*

green building (GB/T 50378-2014)			*resources utilization; Material saving and material resource utilization; Indoor environment quality; Construction management; Operation management; Promotion and innovation.*

Note 1: BREEAM UK New Construction for non-domestic buildings.

Note 2:LEED v4 for Building Design and Construction: New Construction.

Note 3: PromisE for new office buildings.

2.2 Identification of energy and carbon criteria

Each typical BEA scheme contains various assessment criteria, at different levels of the criteria hierarchy, to achieve the comprehensive and detailed evaluation of buildings and constructions. Relevant energy use and carbon emission criteria as specified in the selected BEAM schemes were selected. Those criteria are primarily at the first level of the criteria hierarchy. Nevertheless, relevant criteria at the secondary level are also considered for the special cases where there exists overlap between energy use directly related criteria and carbon emission directly related ones. The identified criteria are summarized in *Table 2*.

Table 2: Building environmental assessment targeted criteria

Name	***Targeted criteria***
BREEAM	*For energy use:* ➢ *Energy;* *For carbon emission:* ➢ *Energy-Reduction of energy use and carbon emissions;* ➢ *Energy-Low carbon design.*
LEED	*For energy use:* ➢ *Energy and atmosphere (EA);* *For carbon emission:* ➢ *Energy and atmosphere (EA)-Green power and carbon offsets.*
GBC[4]	*For energy use:* ➢ *Energy and resource consumption;* *For carbon emission:* *Environmental loadings-* ➢ *C1.1 GHG emissions from energy embodied in original construction materials;* ➢ *C1.2 GHG emissions from energy embodied in construction materials used for maintenance or replacement(s);* ➢ *C1.3 GHG emissions from primary energy used for all purposes in facility operations;* ➢ *C1.4 GHG emissions from primary energy used for project-related transport.*

PromisE	*For energy use:* ➢ *Consumption of natural resources-Energy consumption;* *For carbon emission:* ➢ *Environmental loadings-Emissions into air.*
HK-BEAM/BEAM Plus	*For energy use:* ➢ *Energy use (EU);* *For carbon emission:* ➢ *EU-EU 1Reduction of CO_2 emissions.*
CASBEE	*For energy use:* ➢ *Energy;* *For carbon emission:* ➢ *Off-site environment-consideration of global warming.*
GB/T 50378-2014	*For energy use:* ➢ *Energy saving and energy utilization;* *For carbon emission:* ➢ *Promotion and innovation-bonus item (no weights).*

Note 4: Cause the active criteria and their weights are adjustable in SBTool, this paper uses the example focusing on Energy and Emission issues in design phase of SBTool 2012 User Guide-Part B.

3. Comparative analysis using typical BEA schemes

3.1 Overview of weights of energy use and carbon emissions

(1) USA-LEED: LEED does not specify weights of each criterion, but allocates available credits to each indicator. The weights of energy use (EU) and carbon emission (CE) related criteria can be calculated:

$$\begin{aligned} EU\quad weights &= (Available\quad credits\quad of\quad EU/Total\quad available\quad credits)\times 100\% \\ CE\quad weights &= (Available\quad credits\quad of\quad CE/Total\quad available\quad credits)\times 100\% \end{aligned} \tag{1}$$

(2) Canada-GBC (SBTool): In the latest version of GBC framework, SBTool 2012, the criteria and weights are both adjustable by users. In order to simplify this study, all the criteria and their weights used in this study are all derived from the example of SBTool applications focused on energy and emission issues in SBTool 2012 User Guide-Part B (2012).

(3) UK-BREEAM: In the latest version of BREEAM (UK) New Construction for non-domestic buildings (2014), the weights of primary level criteria, section weighting, have been given, but the weights of secondary level criteria have not been given. Having the available credits of each criterion and considering the overlaps existed between EU and CE criteria, we can get:

$$CE \quad weights = \frac{Available \quad credits \quad of \quad CE}{Total \quad available \quad credits \quad of \quad EU} \times EU \quad weights \tag{2}$$

(4) Finland-PromisE: PromisE (2006) provides the weighted value, available weights, of indicators. Therefore, equation (1) can also be used to calculate the weights in this scheme.

(5) Hong Kong-BEAM (BEAM Plus): Hong Kong BEAM and BEAM Plus are similar to BREEAM in the UK. The weights of EU criteria are given without weights of CE criteria, and can also be calculated using equation (2).

(6) Japan-CASBEE: CASBEE divides the criteria into two equal parts: environmental quality of building (Q) and environmental load reduction of building (LR). The weights of EU criteria are given, and CE related criteria can be calculated using:

$$CE \quad weights = (1/3 \times \Pr imary \quad Level \quad weights) / 2 \tag{3}$$

(7) Mainland China- GB/T 50378-2014: The weights of the EU related criteria have been provided in this scheme, but not of the CE related criteria.

3.2 Comparative analysis

According to the identified criteria in *Table 2* and their corresponding weights embedded in the typical BEA schemes, the statistic results are summarized in *Table 3* and *Figure 2*.

Table 3: Weights of energy use and carbon emissions directly related criteria

Countries/Regions / ***Criteria***	***North America***		***Europe***		***Asia***		
	USA[5]	*Canada*	*UK[5]*	*Finland*	*Hong Kong[5]*	*Japan*	*Mainland China*
Energy use	*26.40%*	*27.61%*	*15.00%*	*13.5%*	*35.00%*	*20.00%*	*28.00%*
Carbon emission	*1.60%*	*45.82%*	*7.26%*	*17.5%*	*12.50%*	*10.00%*	*0*

Note 5: Overlaps existed in EU and CE related criteria.

(1) Importance of energy use & carbon emission

The comparative analysis reveals that all of the countries affiliated with the BEA schemes studied are concerned with the EU criteria, whose weights are all above 10%. The weight of the EU criteria in BEA is the highest in Hong Kong (35%), followed by in Mainland China (28%), Canada (27.61%), USA (26.4%) and Japan (20%), albeit being much lower in the UK (15%) and Finland (13.5%). These results indicate that energy saving has become an international consensus, with increasing recognition of the importance of the EU criteria in BEA schemes.

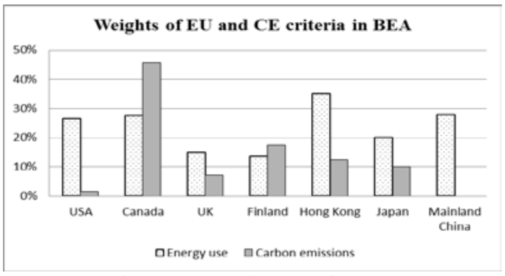

Figure 2: Comparison of weights of identified EU and CE related criteria

The weights of the CE criteria in the BEA schemes vary from each other to a greater extent than that of the EU criteria. Canada takes the lead in specifying the weight of the CE criteria being 45.82%, far higher than other countries and regions, including Finland (17.5%), Hong Kong (12.5%), Japan (10%) and UK (7.26%). It is worth noting that such weights in the USA and Mainland China are extremely low or none, being 1.60% and 0%, respectively. Considering the criteria in LEED and GB/T 50378-2014, this result suggests that the USA and Mainland China are still focusing on energy use rather than carbon emission reductions. However, similar with the UK, the USA and China incorporate the importance of carbon emissions reductions into that of EU criteria, leading to the relatively low weights of CE criteria. These results reveal very imbalanced recognition of the weighting level of carbon emission reductions among the BEA schemes in different countries and regions, which is mainly attributed to the scope of CE and EU criteria in different BEA schemes.

(2) Relationship between energy use and carbon emission

The interrelationship is obviously existed between EU and CE criteria in BEA schemes from the UK, the USA, Mainland China and Hong Kong. In these four countries and regions, CE criteria always act as sub-divisions of EU criteria which usually have higher weights than CE criteria, revealing that the reductions of energy use can be achieved through the reductions of carbon emissions. However, unlike the BEA schemes where the weights of EU criteria are higher than CE criteria, GBC and PromisE have the relatively lower importance of EU criteria, which is mainly attributed to the relatively independence of EU and CE criteria in these BEA schemes.

4. Evolution of co-production of energy use and carbon emission reductions in BEA in Hong Kong

In Hong Kong, EU criteria and CE criteria in BEA schemes are interrelated as mentioned before. As a pioneer in the delivery of low-carbon/zero-carbon buildings in subtropical climate, it has developed its own BEA schemes, HK-BEAM/HK-BEAM Plus. The first version of HK-BEAM (for new offices) was launched in Hong Kong in 1996, and the latest version of HK-BEAM (Plus) in 2012. During the past two decades, HK-BEAM and HK-BEAM Plus have been prompting the development of sustainable buildings, low-carbon buildings and zero-carbon buildings in Hong Kong. The importance of energy saving and carbon reduction has been revealed to the public and the government (*Table 4 and Figure 3*). Meanwhile, the Hong Kong government has set ambitious carbon reduction targets (Environment Bureau, 2010) and issued comprehensive building energy codes and regulations (BEC) in Hong Kong (EMSD, 2012). BEC in Hong Kong have evolved during the past nearly two decades since their introduction, towards more stringent requirements on energy efficiency and further carbon reduction (Figure 4). The promotion of energy saving in Hong Kong actually drives more people to pursue carbon emission reduction in tandem.

Table 4: Weights of energy use and carbon emissions directly related criteria in Hong Kong

Issue year / ***Criteria***	***1996***	***1999***	***2004***	***2010***	***2012***
Energy use	*27.12%*	*23.75%*	*29.63%*	*35.00%*	*35.00%*
Carbon emission	*0*	*0*	*0*	*12.5%*	*12.50%*

5. Towards net zero carbon building in Hong Kong

According to the trend shown in figure 3, from 1999 to 2012, the increasing concern with energy use has been promoting the attention paid to carbon emissions. The future development of the weights of EU and CE related criteria in Hong Kong BEAM can correspondingly divided into three scenarios.

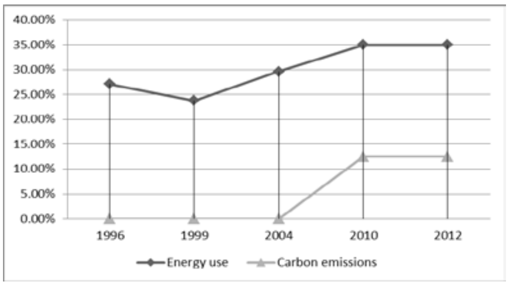

Figure 3: Weights of energy use and carbon emissions directly related criteria in Hong Kong

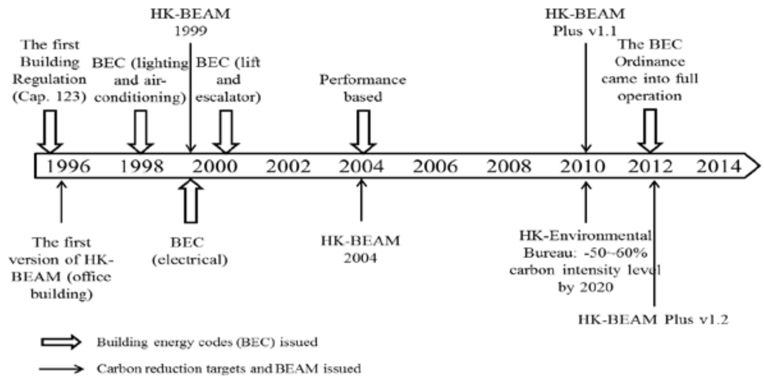

Figure 4: Timelines of BEAM and carbon reduction agenda issued in Hong Kong

Scenario (1) Short-term (polynomial function): After the stable period with static weights of EU and CE criteria, Hong Kong will pay more attention to the carbon emission reductions. Some new low-carbon technologies, such as renewable energy and solar panel, will arise and the industry is gradually adapt to these changes. Eventually the weights of EU criteria, especially the CE criteria, will increase gradually at the smooth speed, preparing for the following rapid development in the second scenario. Hong Kong currently is also moving into this scenario.

Scenario (2) Medium-term (linear function): After scenario 1, more and more new low-carbon technologies will be proposed, popularly adopted and eventually forge a path for the industrial revolution towards zero carbon buildings. The weights of EU and CE criteria thus trend to increase linearly without any adjustment period, indicating that EU and CE criteria are rapidly improving their importance and attracting the public attention.

Scenario (3) Long-term (ladder function): After a long time of development of energy saving and carbon reductions technologies and relevant ordinances, the construction industry needs much time to digest these new technologies and prepare for the possible increase next time. The weight will also increase in this scenario as in scenarios (1) and (2), but the scenario (3) has adjustment period where the weight keeps stable and unchanged, indicating the attention and efforts paid to EU and CE criteria are enough to accelerate the delivery of ZCBs in Hong Kong.

These three scenarios together comprise the comprehensive "Zero-carbon industry life cycle" as shown in figure 5.

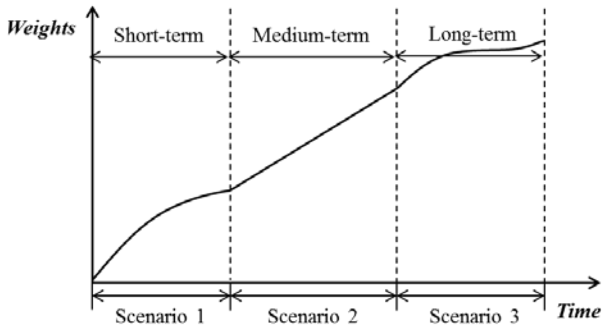

Figure 5: Zero-carbon industry life cycle

6. Conclusions and future research

This paper has explored the co-production between energy use and carbon emission reductions in order to support the delivery of buildings towards sustainability and zero carbon in tandem. The research was conducted through a comparative analysis of the weights of energy use and carbon emission related criteria in seven typical BEA schemes and case study of the evolution of such weights and BEA development in Hong Kong. Based on the time series analysis method and industry life cycle theory, the co-production of energy use and carbon emission reductions in Hong Kong and three scenarios of "Zero carbon industry life cycle" have been identified. These three scenarios are named short term, medium term and long term, based on the use of the polynomial, linear and ladder functions for forecasting. These scenarios together contribute a new perspective of exploring the future of sustainable development of buildings towards zero carbon in Hong Kong. Future research should examine the evolution of the weights of EU and CE related criteria in other BEA schemes. Quantitative examination of multiple cases should validate the co-production functions in a wider context.

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An ecomimetic case study: Building retrofit inspired from the ecosystem of leaf-cutting ants

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Abstract

Ecomimetics is a branch of biomimetics that focuses on the transfer of functions and processes from ecosystems to architectural systems. One goal of this emerging field is to optimize resource use in buildings for climate change adaptation and mitigation. The design method presented here is an iterative and transdisciplinary approach that guides architects, engineers and designers through an ecomimetic exercise. This paper adopts a case study approach to test the performance of the ecomimetic method. Thermoregulatory functions of leaf-cutting ants' thatched nests were studied as a case for inspiring resource use optimization in an existing building in Montreal, Canada. This case study reveals the opportunities for building design innovation, as well as some modifications and improvements to the ecomimetic method.

Keywords: biomimetics, biomimicry, ecomimetics, ecological design, sustainable design

1. Introduction

During the past few decades the fields of engineering and design have seen increased efforts to innovate with nature-inspired solutions (Lepora, Verschure, & Prescott, 2013). Researchers and professionals refer to the process of learning and modeling from nature as biomimetics, biomimicry or bionics (Benyus, 1997; Gruber, 2011), which are used interchangeably in this paper. Despite recent advances and growing interest in the field, biomimetic projects in architecture lack a systematic approach to the design process, and most of the successful examples are a result of haphazard collaborations between biologists and designers. Mimicking biological systems can be done in multiple ways: designers can opt to transfer properties from a single organism or a part of an organism; they can learn from the behavior of a group of organisms; or they can mimic the multiple interactions and processes occurring in an ecosystem (Pedersen Zari, 2007; Garcia-Holguera, et al., 2015b). Most researchers agree that there are two main approaches to biomimetic design: a top-down and a bottom-up (Ayre, 2004; Gamage & Hyde, 2012; Gruber, 2011; Pedersen Zari, 2007; Speck & Speck, 2008). The former starts with a design problem and then looks for a solution in the biological realm, whereas the latter identifies a biological strategy first and then finds the field, process, or product where its properties could be transferred. The research presented here follows a biomimetic top-down approach aiming at transferring properties of an ecosystem into a building system. Ecosystems are complex systems integrating biotic and abiotic components that present multiple interactions and feedback relationships amongst each other. Ecosystems show nonlinear behavior, and in most cases rely solely on sun heat and light as their primary source of energy. Ecosystems are resilient in part because of the redundancy of their components, functions and processes. The property of resilience allows ecosystems to more easily adapt to new or changing conditions, while evolving into new ecological organizations. Like ecosystems, buildings are also complex systems and they as well integrate biotic (e.g. users, plants) and abiotic components (e.g. construction materials). Both buildings and ecosystems are governed by thermodynamics: both are dissipative systems that need constant inflow of high quality energy (i.e. exergy) in order to maintain their structures (Allen, 2001; Fernandez-Galiano, 1991; Kibert, Sendzimir, & Guy, 2000). These commonalities are at the core of the research presented here because they allow abstracting characteristics and properties of ecosystems and transferring them into building systems. The purpose of such endeavor is to address climate change adaptation and mitigation through the optimization of resource use in buildings.

Garcia-Holguera et al. developed a systematic approach to biomimetic design for architects, engineers and designers, referred to as the ecomimetic design method (2015b). The purpose of this paper is to test the usefulness and applicability of the ecomimetic design method, and to identify possible improvements for it as well as to highlight potential challenges and obstacles that designers might encounter. To do so, this paper develops a case study that implements such ecomimetic design method as a step-by-step process for mimicking the thermoregulatory properties and functions found in leaf-cutting ants' nests into a building system.

2. Methods

The ecomimetic design method makes part of a PhD research work, and it is open to improvements and modifications resulting from its implementation in several case studies. The ecomimetic design method uses a top-down approach in that it starts with a design problem and addresses it by following a process of design steps that can be repeated in multiple exercises. Such a design approach is more familiar to engineers and architects than a bottom-up approach. The ecomimetic design method currently consists of six design stages: 1) Architectural design goals; 2) Ecological solution searching; 3) Abstraction and representation of ecological systems; 4) Correlation of architectural and ecosystem components; 5) Transference of ecosystem's principles to an architectural system; 6) Modeling and benchmarking. Each stage will be described in parallel to their implementation in the results section. For a detailed explanation of the ecomimetic method refer to Garcia-Holguera et al., 2015b.

For the purpose of this case study, the ecomimetic design method was applied to an existing building of our selection: Thomson House, a heritage building located in Montreal, Canada. Thomson House was selected due to the fact that audit reports were easily accessible and because of its considerable thermoregulation issues. The following section describes each stage of the ecomimetic design method applied to our selected building.

3. Results

3.1 Stage 1: Architectural design goals

The first stage of the ecomimetic design method consists of identifying one or several design objectives. These must be expressed in thermodynamic language and address resource issues as well as specific contextual environmental concerns of the building (Garcia-Holguera et al. 2015b). Thompson House was built in 1935 and shows deficiencies in energy performance. A recent audit report evaluated roof and wall insulation as well as thermal resistance of windows and found them to be significantly below the required ratings of the New Buildings Code (*Règlement sur l'économie de l'énergie dans les nouveaux bâtiments)* (MMA and BP, 2013). Due to its location in Montreal, Canada, temperature regulation of the building must confront extreme changes in seasonal temperatures as well as significant snowfall. Montreal has a humid continental climate with a low annual average of daily temperatures of 5.3°C. Over an average year, daily minimum temperatures range between -16.5°C and 14°C while daily maximum temperatures range between -6.5°C and 25.7°C. The average yearly precipitation is of 1067.7 mm of which about 228.8 cm is snowfall (Climate, 2015). Thompson House offers study lounges, offices, conference rooms, a restaurant, and a bar and consumes an average of 1 428 434 MJ per year (MMA and BP, 2013). If combining all its sources of energy (i.e. electricity, natural gas and steam), energy is used mainly by the cooking equipment (34%) and for space heating (31%) (MMA and BP, 2013). In consideration of all of the above, the architectural design goal for the building system of Thompson House is to identify one or more strategies inspired by ecological systems that can help reduce the energy use in the building. The next step consists of searching for an ecosystem whose function addresses this design goal.

3.2 Stage 2: Ecological solution searching

The second stage of the ecomimetic design method provides guidance on how to search for the ecosystem to be mimicked. The publicly available and online database AskNature was used for this exercise as suggested by the ecomimetic method (Garcia-Holguera et al., 2015b). The AskNature database catalogs numerous "nature's solutions to human design challenges" through a search function which require an input that refers to an organism's function (e.g. prevent turbulence, process information, break down etc.) (AskNature, n.d.). Different searching approaches on the database provided several results whose strategies are related to the desired goals defined in stage 1.

The nests of South American leaf-cutting ants (*Acromyrmex heyeri*) were selected as the ecosystem to mimic due to their appealing thermoregulatory functions. In accordance to stage 2, we gathered information about this ecosystem in order to acquire a deeper understanding of its thermoregulatory functions. Studies by Bollazzi and Roces describe the performance of the leaf-cutting ant ecosystem (2008; 2010a, b, c). These ant species live in temperate regions of South America and build mound shaped, single-chambered thatched nests on the soil surface that achieve more stable temperatures than those of the environment. Like other leaf-cutting ant species, they cultivate a fungus inside the nest chamber, which constitutes the sole food for their larvae. The fungus' optimal growth requires temperatures between 25-30°C and a high relative humidity. To enable such growth, the ant colony maintains a proper nest climate through various building properties and behaviors. First, according to the authors, it is the thermal properties of the thatch, which largely manage the temperature surpluses inside the nest (Bollazzi and Roces, 2010c). The thatch material consists mainly of plant materials and soil particles providing it with a lower thermal diffusivity than the surrounding soil. These thermal properties of the thatch have been proven to prevent nest overheating by the incoming solar radiation during the day and avoid losses of the accumulated heat into the cold air during the night. Second, temperature surpluses inside the nest are also gained from metabolic heat inputs from ants' work and organic material decay inside the nest. Third, the fungus' high heat capacity also helps in storing heat in the nest. Moreover, a dynamic behavioral process of modifying the thatched nest architecture controls for temperature and humidity inside the nest: the ants open and close nest apertures and add or remove thatch thickness (Bollazi and Roces, 2010a, b, c).

Although the geographical locations of the *Acromyrmex heyeri*'s ecosystem and of Thomson House are not related, the strategies learned from the ecological system can be adapted to the specific climate conditions of Montreal because this exercise relies on the abstraction of functions and processes. The depth and extent of available quantitative information about the thermoregulatory processes of this ecosystem were a major advantage that made us choose this ecosystem over others. Another reason to select this ecological system is that the leaf-cutting ant mounds have more similarities with human constructions than other ecosystem's structures, and a more straightforward approach was preferable considering this is the first case study putting the ecomimetic design method in practice. With an ecosystem selected and information on its functioning gathered, thatched nests' thermoregulatory functions can be abstracted and represented in the following stage.

3.3 Stage 3: Abstraction and representation of ecological systems

Stage 3 consists of understanding the ecosystem's organization and behavior through time. Throughout this design stage, the ecosystem's components, structure and interactions as well as intervening parameters are identified, abstracted and represented with graphic tools used for environmental modeling, engineering and system thinking theories (Garcia Holguera et al, 2012; 2015a; 2015b). The appeal of using these tools lies in their regard for transdisciplinary understanding (Garcia Holguera et al, 2012; 2015b).

The first tool is an Energy System Diagram (ESD), which graphically represents the flows of energy and materials as well as the structural organization of our chosen ecosystem. American ecologist Howard T. Odum developed ESD. ESD's value for visualizing a system's components, organization and interactions has been recognized in several disciplines (Garcia Holguera et al 2012, Odum, 1994, 2007). Figure 1 illustrates the ESD of an *Acromyrmex heyeri* thatched nest. It is worth noting that developing such ESD was an iterative process of which many versions could have resulted.

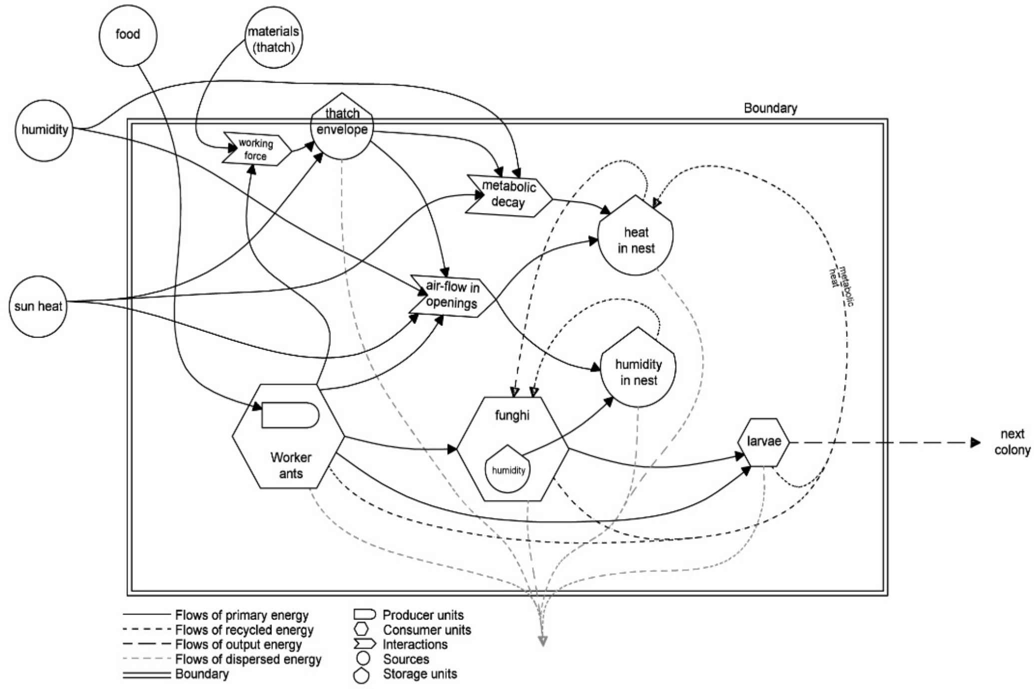

Figure 1: Energy System Diagram of a leaf cutting ant thatched nest

The second tool suggested in stage 3 of the ecomimetic method is STELLA, a software used particularly for environmental modeling. STELLA is a computer simulation tool that helps understanding the dynamic behavior of complex systems and has been proven useful for representing the behavior of both architectural building systems as well as environmental systems (Ford, 2010; Garcia-Holguera et al, 2015a). Figure 2 illustrates the conceptual model built on STELLA of an *Acromyrmex heyeri* colony thatched nest. Each parameter of the model was assigned a quantitative value that defined the initial conditions of the model. Such values were based on a series of informed assumptions and thermodynamic values found on the literature about leaf-cutting ants' nests (a detailed description of such assumptions can be provided by the authors upon request). Simulations of the model were conducted to ensure the modeled and theoretical ecosystem's performance exhibits its real behavior as empirically tested by Bollazzi and Roces (2010 a,b,c). Figure 3 represents the modeled behavior of the ecosystem over time for our final simulation.

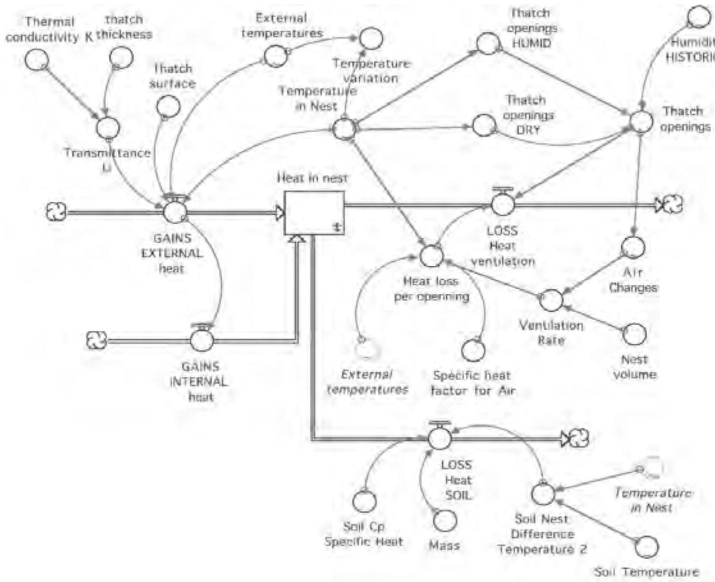

Figure 2: Conceptual model of a leaf cutting ant thatched nest developed with STELLA

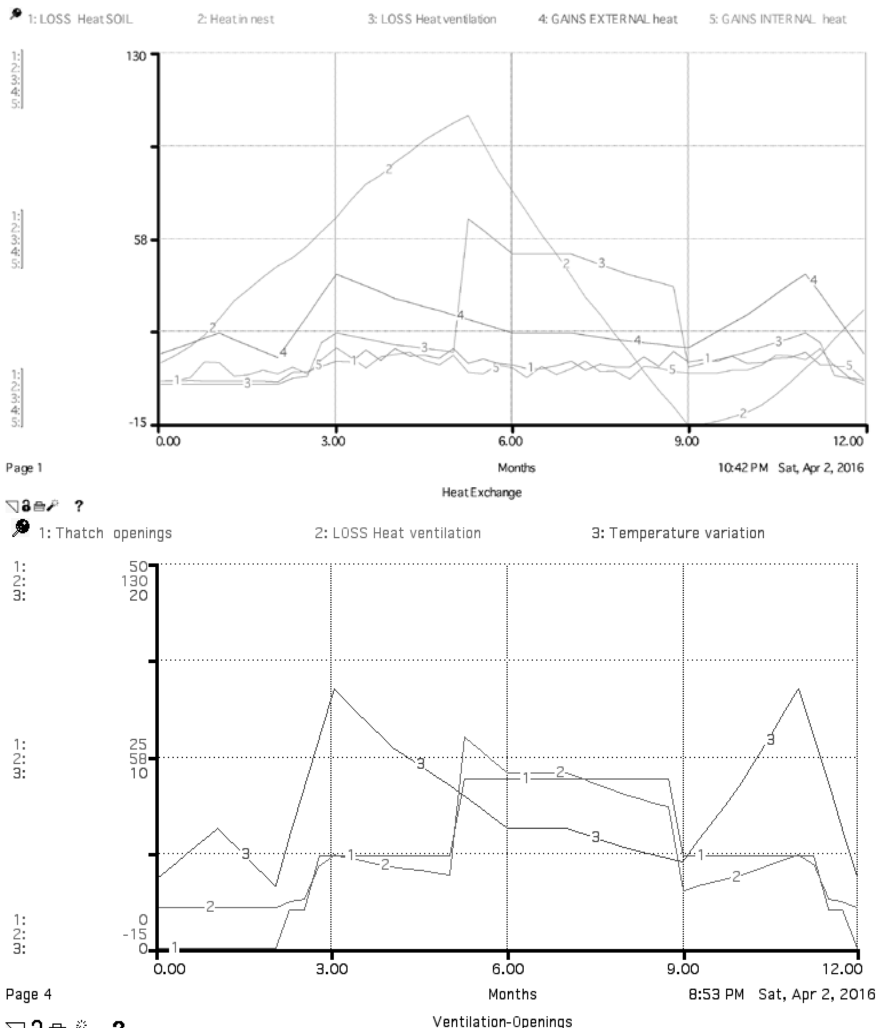

Figure 3: a) Heat exchange of the thatched nest over time; b) Ventilation interactions in the thatched nest over time. For the x axis on both graphs, month 0 and 12 refer to December.

From Figure 3a, we can observe that the heat in the nest has a cyclical variation over a year and that such variation seems to be affected primarily by the heat loss through ventilation. The rapid increase in heat loss by ventilation around May seems to be particularly correlated with a rapid drop of the heat in nest (Fig. 3a: decrease after month 5 in x-axis). This contrasts with the other heat inflows and outflows (i.e. external heat gains, internal heat gains and heat losses through the soil) whose relationship with the variation of nests heat is not as clear. This observation is important as it suggests that the ventilation plays a major role in the thermoregulatory behavior of the thatched nest ecosystem and therefore is a function we could focus on pursuing further in the ecomimetic exercise. With this focus in mind, understanding the influences that contribute to the variation of the heat losses through ventilation becomes of special interest. Figure 3b helps us address such inquiry. It is from this second graph that we can observe that the heat loss through ventilation is closely correlated to the number of thatch openings. Therefore, from this exercise and in consideration of all of our model's assumptions, we are able to suggest that the function of the openings in the thatch are central to the admirable thermoregulation performed in *Acromyrmex heyeri* nests and that such function is therefore a source of inspiration for potential application in human building systems.

These abstractions, representations and simulations have allowed us to recognize the components and their relative contribution intervening in the ecosystem's thermoregulation. In other words, this stage has provided us a thorough understanding of the ecosystem to mimic. We have recognized the components affecting the system and their relationships as well as the feedback loops that support the dynamic thermoregulatory behavior of thatched nests. With this understanding, correlations between the ecosystem and the building can be drawn in the following step.

3.4 Stage 4: Correlation between ecological systems and architectural systems

The goal of stage 4 is to find one or several correlations between the function performed by a component of the ecological system and the function performed by another component in the architectural system. To reach this goal, the ecomimetic method suggests classifying such functions in the form of a table using H.T. Odum's functional typologies of ESD as seen in Figure 1(i.e. source, storage, producer, consumer) (for a detailed description of the symbols of functional categories, refer to Garcia Holguera et al., 2012; 2015b). Table 1 shows the components of the ecosystem associated with corresponding components in the building. The column listing components of the leaf-cutting ant thatched nest was derived from the ecosystem's ESD of stage 1 (Figure 1). For the column of Thompson House, current components were gathered from the Audit Report's description of the building, and the ecomimetic retrofit hypothetical components were listed out of a creative brainstorming process stemming from our understanding of the ecosystem (MMA and BP, 2013).

Table 1. Correlation between components in ants thatched nests and components of both current and hypothetically retrofitted Thompson House

Symbol	Leaf-cutting Ants Thatched Nest	Thompson House Current	 Ecomimetic Retrofit
Source	Thatch material, food, external air humidity, solar radiation	Construction materials, steam, electricity, natural gas, external air humity, solar radiation, municial water, food	Thatched-like envelope materials
Storage	Thatched envelope, heat in nest, humidity in nest, water content in fungus	Building envelope, heat in building, humidity in building	Thatched-like envelope, humidity retention unit/fungus-like component (i.e. contained strucutre with high water content for high heat capacity) (e.g. greenhouse, solarium)
Interaction	Metabolic decay (i.e. microorganisms decomposing nests materials), Air flow through openings	Air-flow ventilation	Air-flow ventilation induced by thatched-like openenings
Consumer	Ant workers, Fungus, Larvae	Plugload equipment (e.g. fan/pump), lighting system, heating system, hot water system, hydraulic system, users (e.g. from adminstration, kitchen, and students)	Programmed ant-like behaviour openings, cooling system, improved control equipment

3.5 Stage 5: Transference of ecosystem's principles to an architectural system

In this stage, the architectural system is modeled and its dynamic behavior simulated so that it mimics the abstracted performance of the selected ecosystem. The goal of this stage is to obtain a set of design guidelines for retrofitting the selected building. The design guidelines may be implemented if the technology exists, however if the technology is not yet available, the design guidelines will constitute a new lead for their research and development. In accordance to this stage of the ecomimetic design method, first, an ESD of Thompson House was developed in order to represent the hypothetical structure and component's organization of the retrofitted building (Figure 4). The ESD of Thompson House is a simplification of the potential architectural system that integrates the various thermoregulatory strategies observed in the thatched nest ecosystem and identified as important in stage 3. The ESD of Thompson House allowed us to gather a broad understanding of the energy flows in the proposed building system.

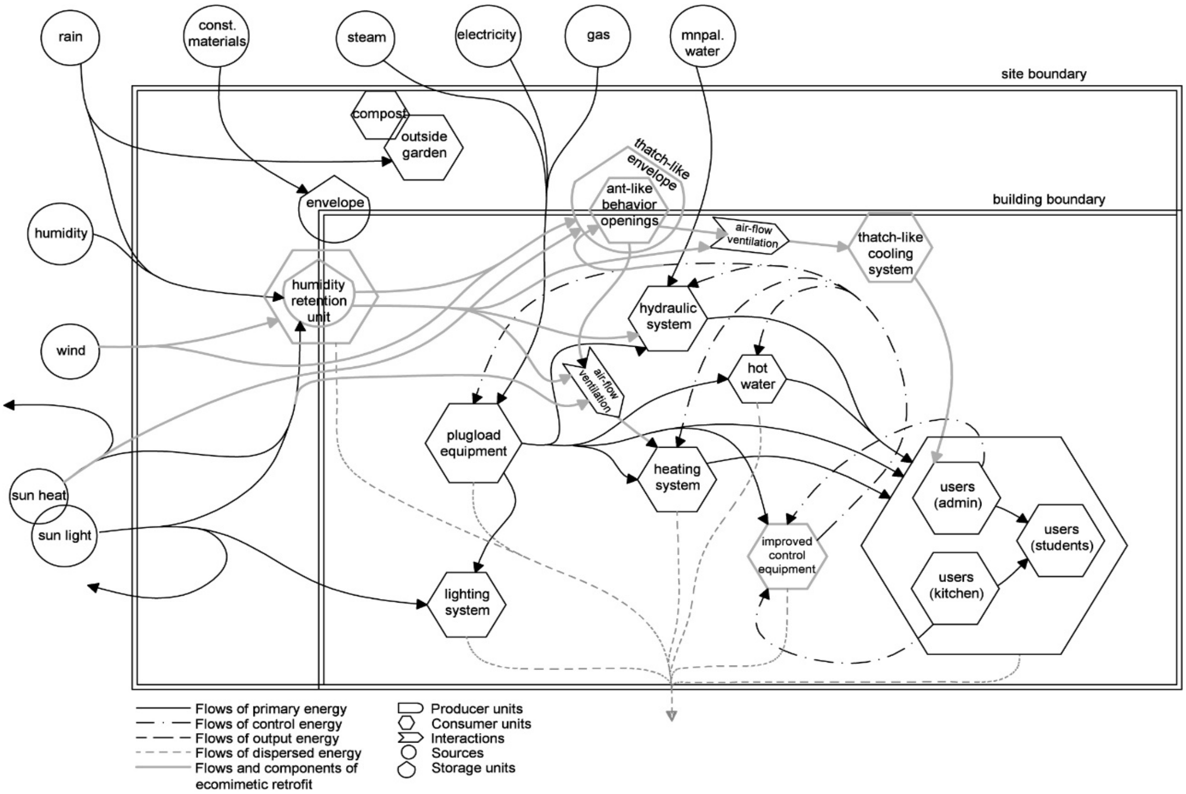

Figure 4: Energy Systems Diagram of a Thompson House hypothetical architectural system based on the leaf-cutting ant thatched nest ESD.

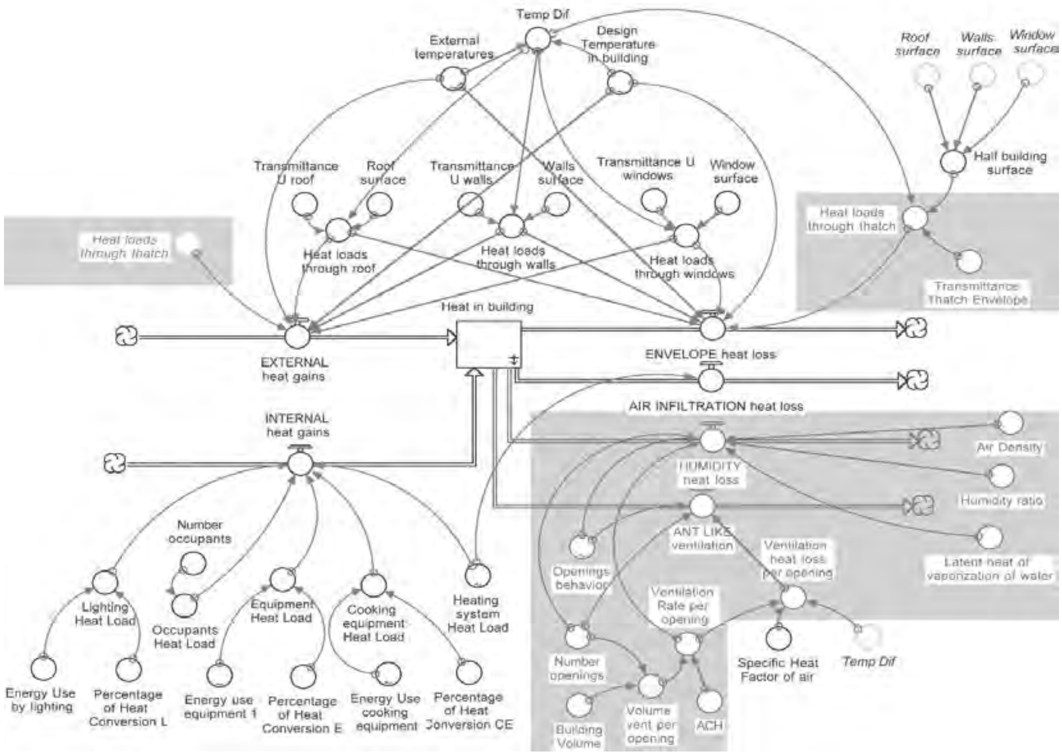

Figure 5: Conceptual model of Thompson House hypothesized architectural system developed with STELLA software. The elements over the grey rectangles represent the new variables for the ecomimetic retrofit (Appendix 2 for a detailed description of assumptions can be provided by the authors)

Then, a dynamic model of the hypothesized Thompson House was conceived in STELLA after multiple iterations (Figure 5). The model integrates different components and their interactions in order to reproduce in the building system the dynamic behavior observed in the selected ecosystem. The STELLA conceptual model presented in Figure 5 shows in black some existing components in the Thompson House building, and also incorporates other proposed components (components with grey rectangles underneath) to mimic a thatched nest. Simulations of the dynamic interactions among these components can be seen in Figure 6.

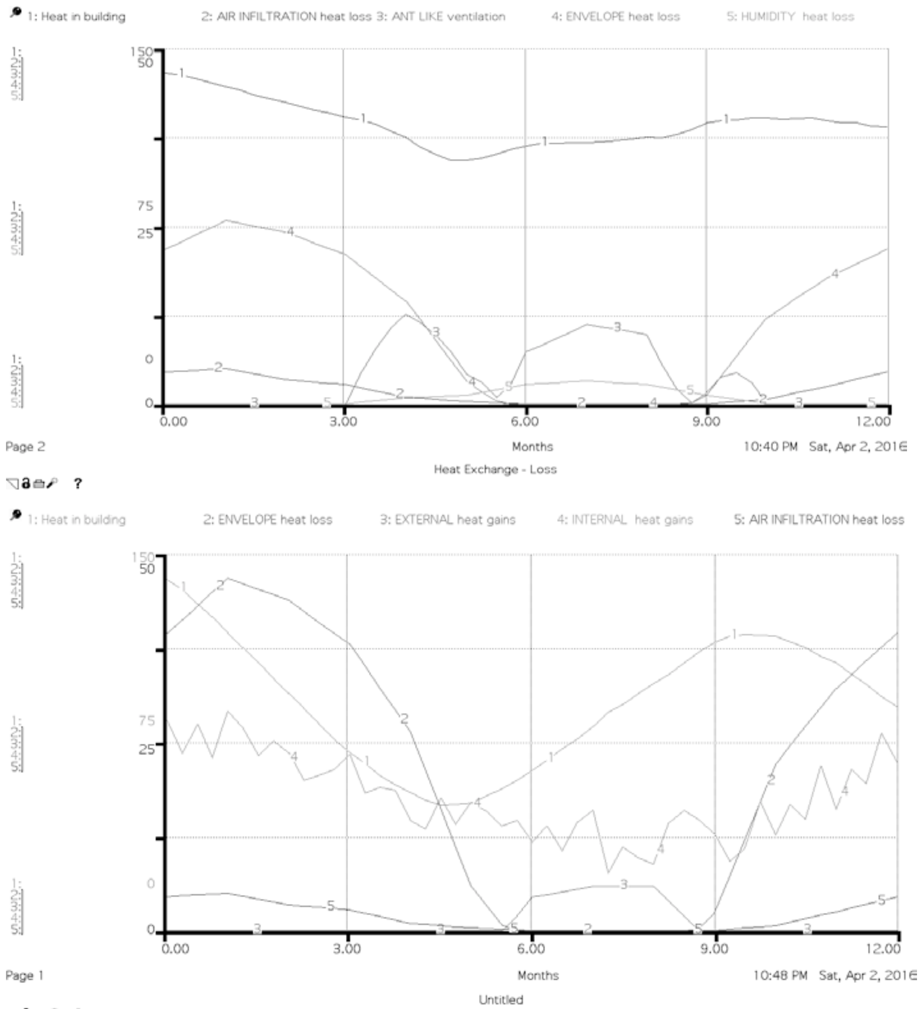

Figure 6: Dynamic behavior of Thomson House with the ecomimetic strategies incorporated: a) Representation of flows of heat losses in Thompson House. b) Detail of the heat losses through the envelope including the 'thatch like' envelope. For the x-axis on both graphs, month 0 and 12 refer to December.

The ecomimetic model of Thomson House reduces the heat losses during the winter months thanks to the thermal properties of the new envelope and reduces the heat gains during the summer season by implementing a ventilation strategy that mimics leaf-cutting ants' behavior of opening and closing thatch apertures. The amounts of 'Envelope heat loss' in the ecomimetic model of the Thomson House (Fig. 6a) are substantially reduced when compared with the 'envelope heat loss' in the model of the existing Thomson House (Fig. 7).

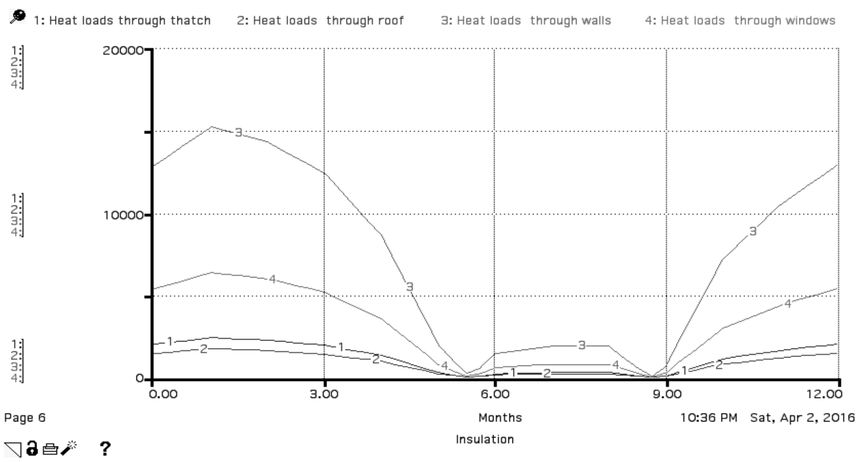

Figure 7: Current annual heat exchange in Tomson House based on data from (MMA & BP, 2013). For the x-axis month 0 and 12 refer to December

A more detailed analysis of the building envelope in Figure 6b shows that the 'thatched-like' envelope displays a substantial reduction in heat losses compared with the existing components of the envelope (walls, roof and windows). The results obtained with the STELLA dynamic model, as shown in Figure 6, are relevant for estimating the expected behavior and usefulness of the proposed ecomimetic strategies.
The set of design guidelines resulting from this stage consist of retrofitting Thompson House with an envelope that has thermal properties similar to those observed on the thatched nest and small apertures whose opening and closing behavior function similarly to those in the thatched nest. This 'thatched-like envelope' would cover the south and southwest facades of the original building because of their higher exposition to sun radiation (the thermal properties of the envelop, for the purpose of this exercise, would be similar to those present in aerogels). In addition part of the thatch envelope's surface will be able to open and close small apertures controlled through artificial intelligence and coded by the administrators of the building. Analogous to the apertures on thatched nests, these openings will react to changes of temperature and humidity in the internal and external environment. Another design guideline drawn from this exercise is to add a 'humidity retention unit' in the building whose main function would be to help regulate the humidity and temperature levels. This component, like the 'thatch-like envelope', may be realized in a variety of ways. One of them could be a vertical garden under the new envelope, which could additionally have the function of supplying food to the kitchen in Thompson House and improving indoor air quality.

Before the set of guidelines are implemented in the architectural project, the ecomimetic design method suggests a modeling and benchmarking exercise as the last stage, Stage 6. In Stage 6, first an architectural model integrating the ecomimetic strategies identified in Stage 5 is built. This model needs to provide enough information to run a performance evaluation of the design. If the evaluation shows that the energy use was optimized then the ecomimetic strategies might be implemented in the construction documents. If the evaluation shows no optimization of resources use, then an iterative process must be undertaken at some stage of the ecomimetic method. Such stage allows comparing the results with building performance standards. Stage 6 is currently under development by the authors so its results will not be covered in this paper.

4. Discussion

We tested the usefulness and performance of the ecomimetic method stages 1-5 under the hypothetical scenario of designing a retrofitted Thompson House. The ecomimetic inspirations were the thermoregulatory properties and processes leaf-cutter ants' thatched nest. The purpose of this discussion is to comment on the challenges and obstacles we encountered using the ecomimetic method, to give recommendations for future users of the method, as well as to identify possible improvements of the method itself.

On stage 1, the main challenge encountered was determining the scope of the design objectives. For our hypothetical scenario, targeting a broad design objective was appropriate enough, but for other cases a better-defined and more specific objective may be needed. We recommend users of the method to, if possible, start with rather open objectives and maintain flexibility in redefining their objective iteratively as they go through other stages.

For stage 2, an important obstacle we encountered was the limited extent of ecosystem options in the AskNature database from which to choose to continue the exercise. The ecomimetic method suggests that the element from nature to be inspired from ought to be an ecosystem. However, the AskNature database does not offer a filter for ecosystems, but rather for options such as: strategies, products, people etc. Therefore, the database results had to be trimmed down by the authors to those that were ecosystems. For example, typing on the search bar "how does nature regulate temperature" yielded 161 results of which only less than 10 were ecosystems (e.g. south american grass cutting ant colonies, mallee fowl nests, hot spring grass & fungus, Honey bees hive vibrations, wood ants nest). Similarly, exploring the database by nature's function for 'resource efficiency' yielded 93 results of which very few were ecosystems (e.g. transvaal savanna, tropical rainforests, dehesa ecosystem, riparian habitat). In addition to the limited ecosystem options offered by AskNature, the selection of the ecosystem was largely restricted by the availability of scientific research about the ecosystem that included thermodynamic quantitative values. A detailed and ideally quantitative thermodynamic understanding of the ecosystem is required for stage 3 and so the lack of such available information seems to largely constrain the application on the ecomimetic method. We recommend users of the method to conduct stage 2 without solely the help of the AskNature database. The ecomimetic method could benefit from refining search approaches beyond the suggested searching tools included in Garcia-Holguera et al. (2015). Another important concern that arose from this step was the appropriateness of our selected ecosystem in being able to inspire a building under very different contextual conditions, particularly climatic considerations. To what extent are *Acromyrmex heyeri* thermoregulatory strategies context dependent and non-transferable into other contexts, such as the context of extreme weather of Montreal? Without the ability to answer this inquiry, here we adopted an attitude of predisposition and openness to learn from the leaf-cutting ants' strategies. However this important consideration ought not to be ignored by users of the method.

As for stage 3, developing the ESD of the ecosystem was a useful tool for clarifying a common understanding of the ecosystem's components, structure and interactions. This leads us to suggest that the value of developing an ESD lies largely in being an exercise for users of the method (e.g. designers, ecologists, architects, etc.) to engage in a common interpretation of the ecosystem. Challenges may arise when categorizing the components of the ecosystem according to Odum's symbols or when identifying feedback loops. It remains pertinent to develop ESDs in an iterative and collective manner and acknowledge that different versions might arise. The validation of the ESD consists in a consensual process among the users of the ecomimetic method.

Developing the STELLA model that performs the desired behavior was the most challenging undertaking of the method both for the ecosystem and the building system on stages 3 and 5. Obstacles were encountered particularly in finding quantitative values for the multiple parameters. STELLA requires all parameters in the system to have quantitative values assigned. Homogenizing units of the multiple values is also imperative for coherent simulations. The lack of available information is a barrier that users of the ecomimetic method will likely encounter at this stage. Assumptions were brought in and the model design was largely an iterative process. The validity of our assumptions ought to be taken with caution. Modeling ecosystems and theoretical buildings require a bundle of estimations, some less refined than others. We recommend users of the method keep a clear record of the following: the assumptions made on the model, the justifications for their relaxation, and the sources from which parameter values were taken from.

Whereas the modeling process requires substantial creativity, the creation of table 1 (Stage 4) was a creative process as well. This is the case particularly for the ecomimetic retrofit column, in which for some desired functions performed in the ecosystem, there were no known associated architectural components. This obstacle calls for up-to-date knowledge on recent innovations and provides clues for innovation opportunities through the development of non-existing components. As for the known components suggested in the ecomimetic retrofit, different ideas might create equally valuable sets of functional components.

5. Conclusions

The ecomimetic method as developed by Garcia-Holguera et al. (2015b) was tested throughout this research. The method has proven to be a useful step by step process for learning from an exemplary ecosystem: leaf-cutting ants thatched nests, and theoretically transfer relevant processes and functions to potentially optimize resource use in a building: Thompson House in Montreal, Canada. The method has facilitated the understanding of our selected ecosystem's structure, organization, components interactions and behavior thanks to the use of abstraction and representation tools. The exercise permitted us to identify openings in the thatch and their consequent ventilation to be a relevant thermoregulatory function in *Acromyrmex heyeri* colonies. We have suggested strategies to implement such ventilation-based approach in our building system alongside other potential additional components that could perform other thermoregulatory strategies in a similar way than in the thatched nests. It has been observed that the design process was enriched by the multidisciplinary collaboration of the researchers involved in this project. Different backgrounds and points of view have facilitated a better understanding of the ecological and building systems.

In the future, the ecomimetic design method will be implemented in at least two more case studies. The second case study will learn from freshwater marshes for optimization of water use in buildings as well as other resource use issues. Further development of this research should address the professional environment and the educational aspects of future users of the design method. First, the method could be tested with the collaboration of architectural and engineering firms throughout the design of a real building to be built. The implementation and construction of the ecomimetic strategies obtained in the design process would represent the most relevant validation of the method and would highlight additional challenges. Second, the method could be integrated in architectural and engineering design courses to better understand the pedagogical obstacles that undergraduate and

graduate students might encounter when developing innovative and multidisciplinary projects. This educational goal would also facilitate the future implementation of the method in the architectural and engineering practices.
In addition, the ecomimetic design method could be used for developing new technologies in collaboration with other researchers. Some strategies identified in the design process are incipient and need further development with the involvement of biologists, ecologists, architects and engineers. Overall the ecomimetic method is a useful tool for innovative design that can help architects and designers optimize resource use in buildings.

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A BIM-based Embodied Energy Calculation Prototype for Life Cycle Energy Analysis of Buildings

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Abstract

Buildings consume approximately 40% of global energy each year in their operation alone. In order to reduce a building's total energy use effectively, a life cycle energy accounting is critical that accounts for both the embodied and operating energy. Embodied energy is consumed in the processes of building material production, transportation, construction, maintenance, renovation and final demolition. Operating energy is consumed in operating the buildings in the processes of air-conditioning, heating, lighting, and powering building equipment. For a comprehensive reduction in a building's total life cycle energy usage, optimizing both the embodied and operating energy is recommended. Computing operating energy is more straightforward than embodied energy due to a lack of a complete and representative embodied energy database. Additionally, while operating energy computation capability has been added to Building Information Modelling (BIM) authoring tools, embodied energy calculation remains isolated. There are commercial software available to estimate embodied energy, however, they are based on secondary data. For an industry-wide application of embodied energy analysis, it is crucial to integrate embodied energy calculation capabilities into a BIM authoring tool.

Among major embodied energy accounting methods are process-based, input-output-based and hybrid methods. The process-based method is product specific but provides incomplete calculation, whereas the input-output-based method is complete but lacks specificity. The hybrid method is a combination of the process and input-output-based methods. According to literature, there is no perfect method currently available to compute embodied energy in a complete manner. In this paper, an improved embodied energy calculation method is proposed and used to compute complete and representative embodied energy of commonly used building materials. A framework to integrate embodied energy data into a BIM authoring tool such as Autodesk Revit Architecture is also proposed. The results of embodied energy computation are validated by comparing them to empirical data.

Keywords: Embodied energy, building materials, life cycle energy analysis, embodied carbon, Building Information Modelling

1. Introduction

The building sector consumes approximately 40% of global energy mostly in building operations (BEDB, 2012). Because most of this energy usage is fossil fuel-based, it contributes to approximately 40% of the global carbon emission annually (BEDB, 2012). A growing consensus in literature agrees on an urgent need to optimize building energy consumption by identifying energy saving opportunities and developing tools to simulate energy performance (Bassett et al., 2013). Additionally, studies (Hernandez and Kenny, 2010; Snow and Prasad, 2011; Dixit and Yan, 2012) emphasized meeting the optimized energy demand through onsite or offsite renewable energy sources so that dependence on fossil fuels can be reduced. Although a great number of studies focused on energy optimization, most of them did not include all life cycle energy components (Paleari et al., 2013). The research community must analyze a building as a system of energy input and output in order to effectively optimize its life cycle energy consumption (NSTC, 2008; Karimpour et al., 2014). This lack of a system's approach hinders efforts to reduce building energy consumption comprehensively (Sturgis and Roberts, 2010). Before we optimize the energy use of a building, there should be a systemic net-energy accounting tool in place covering the entire life cycle of a building (Sturgis and Roberts, 2010; Dixit, 2015).

According to Dixit et al. (2012), the total energy consumed by a building over its service life includes the energy of its construction, maintenance, operations, and final demolition. The sum of all energy consumed in constructing the building is termed initial embodied energy (IEE). IEE includes the energy embodied in construction materials, related onsite and offsite transportation, construction and administration processes (including labor), and other required services such as consultancy, banking, marketing, etc. (Crawford, 2004). When occupied, the building is maintained and renovated using building materials and related processes. The total energy used in these activities is called recurrent embodied energy (REE) (Vukotic et al., 2010; Dixit et al., 2015). During this stage, operating energy (OE) is also consumed in building operations (lighting, HVAC, hot water, power etc.). At the end of its service life, the building is deconstructed and its waste is sorted and hauled for reuse, recycling, or disposal. This end-of-life phase energy usage is termed demolition energy (DE) (Vukotic et al., 2010). The total energy consumed by the building is a sum of IEE, REE, OE, and DE (Dixit, 2015). In order to reduce energy use of a building effectively, one must account for all of these energy components and compute the net-energy requirement of the building (NSTC, 2008; Bassett et al., 2013).

While computing operating energy is straightforward, embodied energy calculation is not (Ristimaki et al., 2013). It is due to a lack of location-specific, accurate, and complete embodied energy data of construction materials (Dixit, 2015). Most existing databases are questionable due to their geographic, technological, and temporal non-representativeness (Khasreen et al., 2009; Dixit et al., 2010). Studies identified an urgent need to establish an embodied energy database for commonly used construction materials (Karimpour et al., 2014; Dixit, 2015). This paper provides a framework of an Application Programming Interface (API) for embodied energy calculation integrated into a building information modelling (BIM) authoring tool.

An improved embodied energy calculation method was used to compute embodied energy values for construction materials. The improved method proposed by Dixit et al. (2015) and Dixit (2015) is referred, which provides material-specific and complete embodied energy values for materials manufactured in the United States.

2. Literature Review

2.1 Embodied Energy and Net-zero Buildings

Buildings consumed over two fifth of the annual energy in 2009 in the United States resulting in approximately 40% of the total carbon emission (USDOE, 2012). Most of this energy consumption originated from a buildings' operation. If the energy embodied in construction is also incorporated, the share of construction industry in the total national energy consumption would reach 48% (Baum, 2007). Literature agrees on applying a systemic approach to reducing energy consumption of the building sector in order to reduce its carbon footprint effectively (Fischer, 2010; Sturgis and Roberts, 2010). One of the approaches suggested in the literature is the concept of net-zero energy building. A net-zero energy building supplies its optimized energy requirements through onsite or offsite renewable energy sources in order to be net-zero in its fossil fuel-based energy usage (Hernandez and Kenny, 2010; Marszal et al., 2011; Dixit, 2015). In order to optimize energy needs substantially, a life cycle-based energy accounting of buildings which focuses on both the embodied and operating energy is important (NSTC, 2008). Optimizing operating energy of a building may affect its embodied energy. For instance, installing better insulation in a building envelope to minimize heat transfer may increase its embodied energy because most insulation materials contain higher embodied energy (Sturgis and Roberts, 2010; Waldron et al. 2013). Similarly, optimizing embodied energy may increase operating energy usage. Calculating operating energy is more standardized and simpler than embodied energy due to the unavailability of complete and reliable embodied energy data (Langston, 2006; Dixit et al., 2013).

2.2 Embodied Energy Calculation: Methods and Issues

Among widely known methods to compute embodied energy are process-based and input-output-based (IO) methods (Crawford, 2004). There are also hybrid methods that combine the process and IO-based methods (Dixit, 2015). The process-based methods involve gathering energy use data from material manufacturers, construction sites, vendors to calculate the total energy embodied in construction materials and processes (Acquaye, 2010). Although some energy use data is easy to collect, some is not due to data confidentiality or unavailability. Therefore, process-based embodied energy calculations are considered reliable but incomplete (Crawford, 2004; Acquaye, 2010). In addition, when process-based embodied energy values of construction materials are used to compute the embodied energy of a building, some processes related to services such as consultancy, inspection, administration, etc. may remain excluded (Ding, 2007).

In an IO-based method, the flow of money from energy sectors to an industry sector manufacturing the material under study is utilized to compute embodied energy (Treloar, 1998). The national IO accounts that include IO tables publish monetary flows annually (Horowitz and Planting, 2009). The IO tables can be used to calculate the direct and indirect input requirements of an industry sector from energy providing sectors. The direct requirements indicate the total energy directly required to produce one $ output of an industry sector. The direct requirements also result in industry-wide indirect requirements. The sum of direct and indirect requirements is termed total requirements of a sector, which indicate its total energy usage (in $) per unit of its monetary output (in $) (Crawford, 2004). The total energy requirements are then converted from monetary units ($/$ output) to energy units (British thermal unit (Btu)/$ output) using energy prices (Crawford, 2004). However, if the energy prices are inaccurate, they may cause serious errors to embodied energy values (Acquaye, 2010). The IO-based embodied energy values, therefore, are complete but may be unreliable due to the uncertainties of energy prices. Because an IO-based method involves calculating the embodied energy of an industry sector with an aggregated output, all products manufactured by the sector have the same embodied energy values, which may not be accurate (Dixit, 2015). According to Treloar (1998), IO-based methods may also count energy inputs more than once resulting in an overestimation of embodied energy.

A hybrid method is either process-based or IO-based (Acquaye, 2010). In a process-based hybrid method, the framework remains process-based and IO data are used to make up for unavailable data (Bassett et al., 2013). Because the main framework is process-based, the process-based hybrid method still carries the limitations of a process-based method (Acquaye, 2010). For instance, using a bill of quantities and embodied energy of construction materials, the embodied energy of a building can be calculated. However, other onsite and offsite processes such as construction, fabrication, administration, transportation, and services are not completely covered (Crawford, 2004). Similarly, when the embodied energy of complex materials such as reinforced concrete is calculated using a process-based hybrid method, the embodied energy of cement, gravel, and steel is multiplied to their respective volumes. This, however, excludes the energy consumed in mixing, placing, and curing the reinforced concrete components (Crawford, 2004).

In an IO-based hybrid method, process data is inserted into an IO framework to make it more reliable (Dixit et al., 2015). For instance, when energy usage is inserted in energy units into an IO model, the embodied energy calculation can avoid the use of unreliable energy prices (Carter et al., 1981). However, the conversion of embodied energy from the unit of Btu/$ to Btu/lb still needs material prices, which may not be reliable (Dixit et al., 2015). In addition, due to the main framework being IO-based, the embodied energy intensity is for the entire industry sector rather than one specific material (Treloar, 1998). Furthermore, this method excludes the energy embodied in labor and capital inputs because IO tables do not cover these inputs (Treloar, 1998). Other issues such as the counting of energy inputs multiple times also remain unresolved (Treloar, 1998). In spite of some limitations, an IO-based method is considered relatively the most complete method (Treloar, 1998; Crawford, 2004; Acquaye, 2010; Dixit et al., 2014).

3. Research Goal and Methods

In this paper, the current version of the IO-based hybrid method is improved to enhance its completeness, reliability, and specificity. The energy embodied in commonly used construction materials is calculated using the improved method. A framework of a BIM prototype is developed to demonstrate embodied energy and BIM integration. First, using the Benchmark Input-Output Accounts published by the United States Bureau of Economic Analysis (USBEA), an IO model is developed using the raw Make and Use tables. The process of creating an IO model can be referenced from Horowitz and Planting (2009). Note that the calculated embodied energy values include all energy and non-energy inputs used in the manufacturing of study materials. These values do not include related transportation or energy embodied in construction. The following improvements were done to the IO-model:

Process/Actual Energy Data Integration: Actual energy use data was collected for each industry sector and integrated into an IO model developed using 2002 United States Benchmark Input Output Accounts using the approach suggested by Carter et al. (1981). This approach does not rely on energy prices, which may be under-estimated or over-estimated. A detailed explanation can be found in Dixit et al. (2015).

Primary Energy Factor (PEF) Calculation and Integration: Treloar (1998) revealed that an IO model may involve counting energy inputs multiple times and suggested using PEFs for each energy providing sector of the IO model. In this paper, all energy and material inputs to energy sectors were removed and PEFs for the energy sectors were calculated and used instead. Dixit et al. (2014) provides a detailed explanation of the PEF calculation.

Calculating and Integrating the Energy of Labor and Capital Inputs: The energy embodied in human labor and capital inputs was quantified and integrated into the IO model to fill any system boundary exclusions related to human labor and capital investment. A more detailed explanation of the calculation can be referred from Dixit et al. (2015).

Sectorial Disaggregation: To compute the embodied energy of a specific material, the aggregated output of an industry sector must be decomposed as suggested by Joshi (1998). In this study, some of the industry sectors that originally had an aggregated output were disaggregated using their input and output data.

The calculated values of embodied energy of commonly used construction materials were comparatively evaluated with the published values. Because embodied energy values of all materials were not available in the referred studies, average values were calculated and used. The referred studies include Chen et al. (2001), Scheuer et al. (2003), Alcorn (2003), and ICE (2011). Note that the referred studies come from different time and may not represent the calculated values temporally. Therefore, a correlation analysis was preferred for comparative evaluation of the results. For comparing the results with published values, a scatter chart (coefficient of determination) was used. A coefficient of determination (r^2) greater than 0.81 and less than 0.81 but more than 0.64 is assumed to show a very strong and strong positive correlation, respectively (Taylor, 1990; Chan, 2003). To demonstrate the integration of embodied energy and a BIM authoring tool (Autodesk Revit Architecture), two approaches were discussed.

4. Results and Discussion

The calculated values of embodied energy of construction materials under study are listed in Table 1. The embodied energy values calculated using the improved IOH model were in MBtu/$ of industry output. Using the appropriate material prices, these values were converted into the unit of MBtu per unit length, area, or volume. The units of embodied energy values are mentioned in the first column of Table 1. Note that the energy embodied in study materials was quantified with a break up of energy sources used in their manufacturing process. Such a calculation is important to accurately determine the carbon dioxide emissions resulting from energy consumption.

Table 1: Calculated values of embodied energy of study materials

		Embodied Energy in kBtu						
Study Material	*Unit*	*Oil & Gas*	*Coal*	*Electricity*	*Natural Gas*	*Petroleum*	*Human & Capital Energy*	*Total Energy*
Carpet (3/8" Thk.), Level Loop	*ft2*	*0.4*	*0.9*	*8.2*	*5.2*	*6.5*	*1.3*	*22.5*
Wood Lumber	*ft3*	*1.5*	*0.8*	*30.6*	*10.9*	*53.3*	*10.6*	*107.8*
Hardwood Plywood & Veneer	*ft3*	*6.6*	*3.8*	*130.2*	*57.9*	*155.1*	*42.4*	*396.0*
Softwood Plywood & Veneer	*ft3*	*0.9*	*1.1*	*58.7*	*24.1*	*46.9*	*12.6*	*144.3*
Paints & Coatings	*gal*	*6.0*	*9.7*	*51.8*	*47.0*	*90.9*	*11.7*	*217.0*
Adhesives	*gal*	*5.8*	*10.7*	*59.9*	*49.5*	*90.7*	*13.7*	*230.3*
Plastic Pipes & Fittings	*ft*	*3.6*	*2.3*	*25.5*	*22.1*	*51.9*	*4.2*	*109.7*
Polystyrene Insulation	*ft2*	*4.7*	*5.6*	*44.2*	*44.7*	*73.6*	*9.0*	*181.7*
Bricks (2 1/4"X3 5/8"X7 5/8")	*No.*	*0.0*	*0.2*	*1.8*	*4.8*	*1.5*	*0.4*	*8.7*
Clay Wall & Floor Tiles (1/4" Thk.)	*ft2*	*0.2*	*0.7*	*11.0*	*14.2*	*6.0*	*3.0*	*35.2*
Vitrified Clay Sewer Pipes (6" Dia.)	*ft*	*0.5*	*2.8*	*23.5*	*67.4*	*24.7*	*9.9*	*128.9*
Glass (1/4" Thk.)	*ft2*	*0.1*	*0.4*	*9.7*	*19.2*	*3.8*	*1.1*	*34.3*
Cement	*ft3*	*0.6*	*111.2*	*81.7*	*17.5*	*70.7*	*8.5*	*290.3*
Concrete	*ft3*	*0.4*	*18.4*	*21.2*	*12.8*	*28.8*	*5.8*	*87.4*
Gypsum Board (1/2" Thk.)	*ft2*	*0.0*	*2.8*	*2.4*	*3.3*	*3.0*	*0.3*	*11.7*
Lime	*ft3*	*0.2*	*20.8*	*14.9*	*23.7*	*24.0*	*3.5*	*87.1*
Stone	*kg*	*0.0*	*0.1*	*1.1*	*0.5*	*1.0*	*0.5*	*3.2*
Mineral Wool Insulation	*ft2*	*0.1*	*1.0*	*9.8*	*9.0*	*3.9*	*1.4*	*25.2*
Virgin Steel	*kg*	*0.1*	*20.5*	*29.0*	*19.1*	*6.1*	*2.1*	*76.9*
Primary Aluminum	*kg*	*4.7*	*0.5*	*130.7*	*13.5*	*29.0*	*2.2*	*180.7*
Copper	*kg*	*0.1*	*3.6*	*29.0*	*15.3*	*6.4*	*2.4*	*56.8*

Figure 1 compares the embodied energy intensities (kBtu/$ industry output) of the industry sector manufacturing the study materials. Apparently, the energy intensity of aluminium was the highest (126 kBtu/$), particularly for electricity usage (91 kBtu/$), which is in agreement with the literature opinion. The second most energy intensive material was lime (112 kBtu/$).

Materials with mostly heating dominated manufacturing processes such as glass (31 kBtu/$), lime (31 kBtu/$), and brick (23 kBtu/$) demonstrated higher natural gas consumption per $ of industry output. Similarly, materials such as cement (36 kBtu/$), lime (27 kBtu/$), and steel (16 kBtu/$) involve a production process that showed a higher coal consumption. The production processes of materials such as paints, adhesives, and plastics consume a significant amount of petroleum products as raw material (feed stock), which was evident in their higher petroleum intensity. The most labor and capital intensive material was lime that consumed 4 kBtu of labor and capital energy per $ of its output. Note that the embodied energy per unit of mass or volume for each of the study material would be quite different than energy intensities due to different product prizes.

The embodied energy results (Table 1) were compared with comparable studies. Figure 2 presents a scatter chart illustrating the correlation of the calculated and published values. A coefficient of determination (r^2) of 0.72 indicates a high positive correlation. It means that the calculated values may be different than the published values but the pattern of change across the study materials is in agreement. A difference in the magnitude of calculated and published embodied energy values is expected due to a wider system boundary covered by the IOH model used in this study.

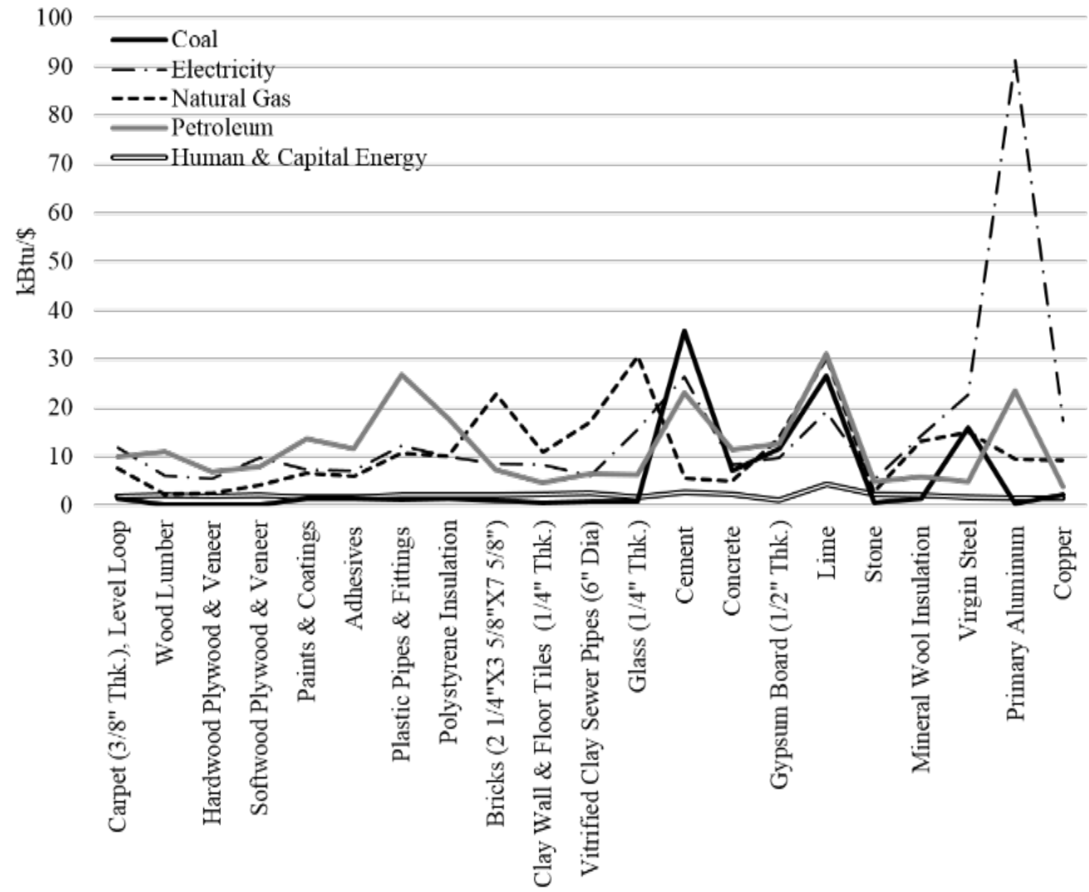

Figure 1: Embodied energy intensities of industry sectors producing study materials

4.1 A BIM-Embodied Energy API Framework

The IOH-based values calculated in this study can be integrated into a BIM authoring tool such as Autodesk Revit Architecture. There are two approaches to BIM-embodied energy integration. In the first approach, embodied energy of construction materials can be manually inserted into Autodesk Revit Architecture using a shared parameter. A shared parameter can be shared across projects within the same organization. As an example, a shared embodied energy and embodied carbon parameter was created in Autodesk Revit Architecture to integrate embodied energy and carbon emission values. The shared parameter then can be converted into a project parameter attached to the Materials category in a Revit project. Using custom parameter option, the values of embodied energy and carbon can be inserted into the Revit material library. Figure 3 shows a generic Revit project with concrete columns, beams, and slabs. The schedule on the left provides the embodied energy schedule of structural columns. Using the same process the total embodied energy of the entire project can be calculated. In the second approach, an Application Programming Interface (API) is developed to access the shared parameter of embodied energy associated with each material in Revit Material Library. Figure 4 demonstrates a framework for a BIM-embodied energy API. An API gets a required parameter (e.g. embodied energy) from a Revit project and finds the right value from a spreadsheet. It also sets the new value to that parameter and returns it to the Revit project. The API is developed using the C-sharp programming language. The spreadsheet includes embodied energy and carbon dioxide emission values for commonly used construction materials.

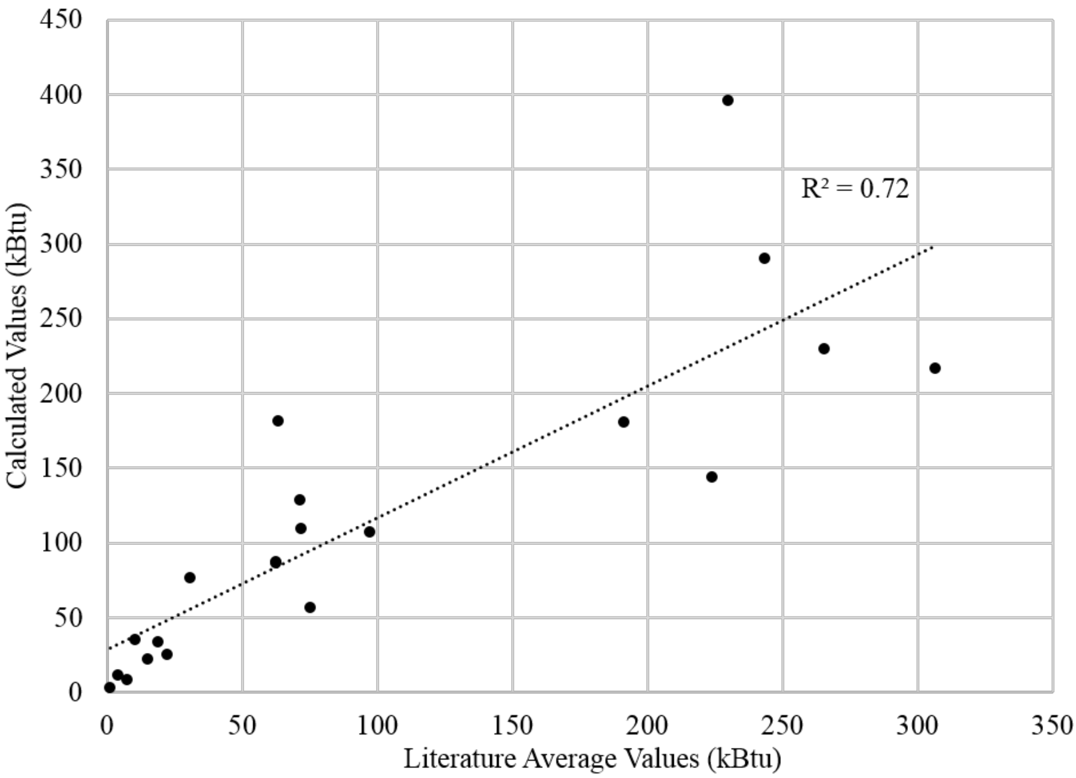

Figure 2: Correlation of the calculated and published embodied energy values

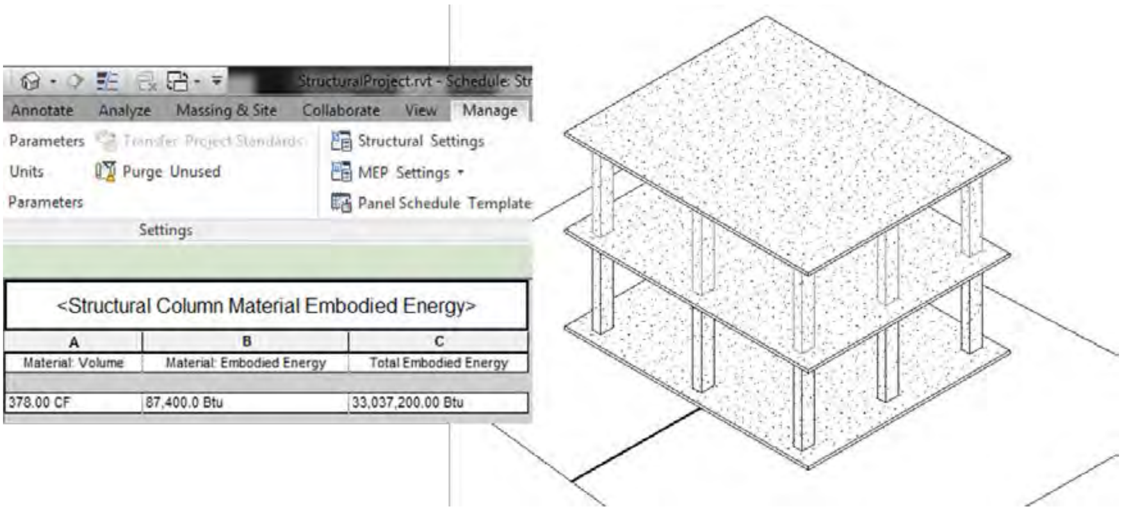

Figure 3: An example of shared parameter being used to pass along embodied energy values

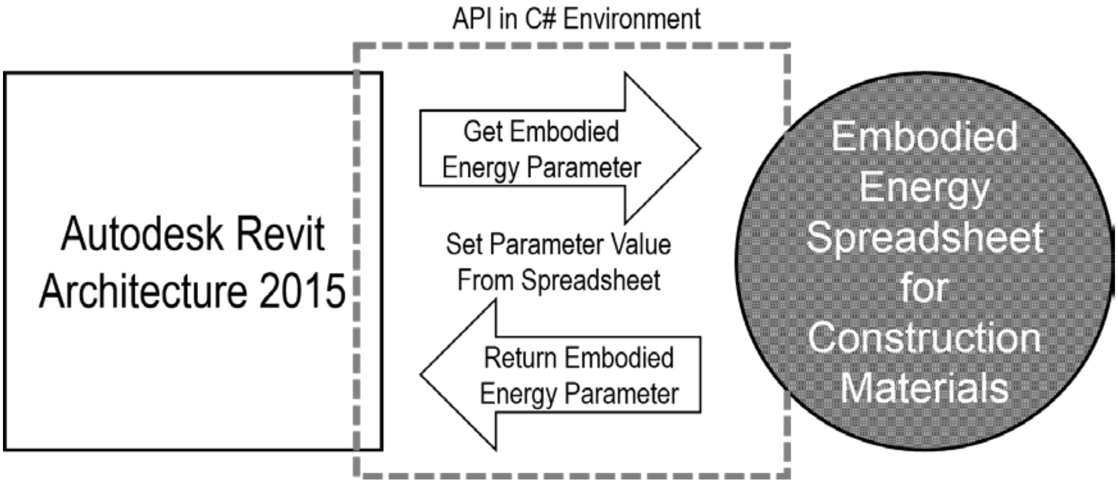

Figure 4: A schematic illustration of API development process

5. Conclusions

This study demonstrates an embodied energy calculation using an improved IOH method to provide more complete and accurate material-specific embodied energy values. Because the fuel or energy source-specific embodied energy is calculated, the calculated energy values can be translated into carbon dioxide emissions more accurately than using an average embodied energy value aggregated for all energy sources. Although the calculated values differed significantly from published values in their magnitude, they were in agreement with the published values when compared using the correlation analysis. Note that system boundary differences across this study and other referred studies would cause embodied energy values to vary. A framework for integrating embodied energy and carbon dioxide values into a BIM authoring tool is also proposed and discussed. One of the key challenges to creating and evaluating a net-zero/carbon neutral building design is the lack of a single integrated tool to assess the life cycle energy and carbon impacts. The author of this study in collaboration with other researchers have already developed two Revit APIs for computing operating energy use and renewable energy generation (see Dixit and Yan, 2012 and Yan et al., 2013). The future research goal is to integrate embodied energy analysis into a BIM-integrated operating and renewable energy assessment tool. Such a tool is expected to simplify the time and resource consuming net-energy analysis process, which currently involves creating separate models and switching back and forth among renewable energy, operating energy, and embodied energy tools.

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An Input-Output-based Hybrid Recurrent Embodied Energy Calculation Model for Commercial Facilities

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Abstract

Built facilities consume a significant amount of energy during their service life contributing considerably to carbon emission. In the United States, buildings alone consume 40% of annual energy causing at least 39% of total annual carbon emission. The total energy consumed by built facilities includes operating and embodied energy. The amount of energy used in the processes of air-conditioning, heating, hot water supply, lighting, and operating building equipment is called operating energy. The embodied energy is used in constructing, maintaining, and deconstructing the facility. A significant portion of the embodied energy comes from construction processes and building materials used during a facility's maintenance and replacement processes. This portion of embodied energy is called recurrent embodied energy. Because the field of facility management involves decisions regarding a facility's operational, maintenance, and replacement performance; it can help reduce both the embodied and operating energy and consequently the life cycle carbon footprint of the facility.

One of the commonly used embodied energy calculation methods is the input-output-based hybrid method, which provides embodied energy intensities per unit of an industry sector's output (in $). The embodied energy intensities of an industry sector representing maintenance and replacement activities can be integrated into a life cycle cost model to compute the recurrent embodied energy of a facility's maintenance and replacement phases. In this paper, a model is proposed to calculate the recurrent embodied energy of a commercial facility. The model is developed based on the United States input-output accounts. The calculated embodied energy values are used to compute carbon emission due to maintenance and replacement activities. The results are discussed and compared with the published studies from literature. Finally, a discussion on the involvement of facility managers during the facility design and construction phases is presented.

Keywords: Embodied energy, recurrent embodied energy, facility management, life cycle energy, life cycle cost model

1. Introduction

Built facilities, in the United States, consume nearly 40% of nation's energy in their operation alone adding nearly 39% of the annual carbon emission (Dixit et al., 2013). If the energy consumed in building construction is added, this percentage may reach 48% of the total national energy supply (Baum, 2007). For a comprehensive and effective reduction in this vast energy and carbon footprint of built facilities, the energy consumed in both the facility construction and its operation and maintenance must be optimized (Bassett et al., 2013). So far, studies have had a unidirectional focus on either the energy of construction or operation (Dixit et al., 2013). However, a need to address total life cycle energy has been strongly emphasized in the relevant literature (Fischer, 2010). A built facility consumes two types of energy over its service life: (1) embodied and (2) operating energy. The embodied energy is consumed in constructing a facility directly through construction, transportation, and related processes. It is also consumed indirectly through the use of construction materials and equipment. Each material or equipment installed in a building consumes energy when it is manufactured and delivered to a construction site. This energy is called its embodied energy (Treloar et al., 2001). The total energy directly and indirectly consumed in a facility's construction is called its initial embodied energy (IEE) (Cole and Kernan, 1996; Dixit et al., 2015). Once constructed and occupied, the facility is operated consuming operating energy. When occupied, the facility is maintained, repaired, and its components are replaced. These processes of maintenance, repair, and replacement consume construction materials and require related processes. The sum of total energy consumed directly and indirectly in these maintenance and replacement processes is called recurrent embodied energy (REE) (Cole and Kernan, 1996; Langston and Langston, 2007).

Unlike IEE, REE is consumed annually and depends largely on a facility's service life (Dixit et al., 2014a and 2014b). This means that the longer the service life of a facility the higher it's REE. In a study of commercial facilities, Dixit et al (2014a) found a very strong and positive correlation between the total REE and the total life cycle embodied energy (LCEE). This strong and positive correlation suggests a strong influence of REE over LCEE. Literature has also indicated that the amount of REE embodied in a facility can constitute a significant portion of the total life cycle embodied energy. For instance, in a study of secondary schools in Australia, Ding (2007) found that the total REE over a 60-year service life can be equal to approximately 72% of the school buildings' total LCEE. Similarly, Cole (1996) determined that for a service life of 25, 50, and 100 years, the REE of these components was 1.3, 3.2, and 7.3 times their IEE, respectively. A strong influence of REE on a facility's LCEE also suggests its importance in optimizing the life cycle carbon footprint of the facility. Dixit et al. (2014a) concluded that by selecting low-embodied energy, durable, and long-service life materials, a facility's total REE can be optimized. Because a majority of maintenance and replacement decisions are made by facility managers, their role in reducing the energy and carbon footprint of facilities could be very important. According to Dixit et al (2014a) and (2015), the field of facility management can influence approximately 10% of the United States' annual carbon emission through REE.

Calculating a facility's operating energy is more straightforward than its LCEE due to a lack of a standard calculation method (Ristimaki et al., 2013; Dixit et al., 2015). Among widely-used embodied energy calculation methods are: (1) process-based method, (2) input-output (IO)-based method, and (3) hybrid methods (Dixit et al., 2012; Ristimaki et al., 2013). Each of these methods cover different extents of system boundaries. A system boundary defines the embodied energy inputs covered by a calculation method (Dixit et al., 2013). Most of the existing versions of the calculation methods do not provide complete, accurate, or reliable embodied energy calculation (Acquaye, 2010). For instance, a process-based method is accurate but is considered incomplete, whereas an IO-based method is unreliable but is regarded as complete. Hybrid methods combine the benefits of the two methods (Crawford, 2004). One of the hybrid methods is the IO-based hybrid (IOH) method, which utilizes the national input-output data (Acquaye, 2010). The output of this method is in the units of energy usage/$ output of an industry sector (e.g. MJ/$). Although an IOH method is considered to provide most complete results, it also requires improvements as suggested by the literature (Acquaye, 2010; Dixit et al., 2015).

In this paper, an IOH model is developed and improved for the United States' industry sectors to compute the IOH intensity of an industry sector involved in the maintenance and replacement activities of non-residential facilities. Using life cycle cost data and IOH intensity, the REE of 88 healthcare facilities is quantified and evaluated.

2. Literature Review

2.1 Embodied Energy Model for Built Facilities

The total Life cycle embodied energy (LCEE) of a facility constitutes its initial (IEE), recurrent (REE), and demolition embodied energy (DE). As shown in Figure 1, the IEE covers the energy embodied in construction materials and processes used in the initial construction of a facility. IEE also includes the energy embodied in various equipment installed in the facility and other processes such as transportation, administration, and consultancy services. After the facility is built, occupied, and used, the activities of maintenance and replacement consume energy and also nonenergy inputs such as building materials, assemblies, and equipment. Also, if any part of the facility is refurbished or a system is retrofitted, energy and non-energy inputs are consumed. Sum of the energy spent directly and indirectly in the use phase maintenance and replacement activities is termed REE (Cole and Kernan, 1996). Because the maintenance and replacement works occur periodically, the amount of REE depends primarily on the facility's service life. It also depends on its materials, assemblies, and systems. For instance, materials or systems with lower embodied energy and replacement ratio (long service life) would result in lower REE. REE also depends on the maintenance requirements of products used in the facility (Winistorfer et al., 2005; Dixit et al., 2014b). Similar to the construction phase, the maintenance and replacement activities require resources such as building materials, labor, and equipment (Dixit et al., 2014a). The processes of construction (e.g. repair), transportation, and management are also needed at this stage. The sum of energy directly and indirectly required to demolish the facility and haul its materials for recycling, reuse, or disposal is called its DE (Cole and Kernan, 1996).

2.2 Embodied Energy Calculation: Major Issues

A process-based calculation, a bottom up approach, utilizes the process-based embodied energy data of construction materials and construction and other related processes (Crawford, 2004; Dixit et al., 2015). An embodied energy database of construction materials with robust data quality, therefore, becomes extremely important in a process-based analysis. Most process-based data comes from material manufacturers and, therefore, considered reliable. However, due to unavailability or confidentiality not all data can be sourced. Apparently, most process-based data may be regarded as incomplete (Ding, 2004; Crawford, 2004). Unlike process-based analysis, an IO-based analysis is a top down approach in which the embodied energy of an entire industry sector is quantified (Crawford, 2004; Dixit et al., 2015). The basic assumption in an IO-based approach is that all of the products manufactured by the industry sector have the same embodied energy intensity per monetary unit of their output. Because all monetary transactions by an industry sector can be traced and translated into energy flows using energy tariffs, IO-based data are considered complete (Dixit et al., 2015). However, due to aggregated output of the industry sector, the results are not specific to a product (Crawford, 2004). Additionally, the unreliability of energy tariffs induces a potential for under estimation or over estimation of embodied energy (Acquaye, 2010). Other issues such as homogeneity and proportionality assumptions also contribute to the unreliability of IO-based results (Crawford, 2004; Dixit et al., 2015). Because none of the two methods is perfect, a hybrid method combines the two methods to improve the quality of embodied energy calculation. Two types of hybrid methods are available: (1) process-based hybrid and (2) IO-based hybrid (IOH). In a process-based hybrid approach, the void of unavailable data is filled by integrating IO data, whereas process-based data are incorporated into an IO model to improve the reliability of calculation in an IOH method (Crawford, 2004).

Although both the hybrid approaches can be further improved, enhancing the reliability and specificity of an IOH method is more straightforward. Studies such as Treloar (1998), and Crawford (2004) improved the current form of the IOH method. In spite of these advances, studies (Crawford, 2004; Acquaye, 2010) suggested further improvements to its system boundary completeness, accuracy, and specificity. A potential incompleteness arises from the energy embodied in labor and capital investment, which may not be included in IO accounts (Dixit, 2015). Additionally, to make the IOH results more material-specific, an industry sector can be decomposed into two sectors using the sector's input and output data (Dixit et al., 2015). Furthermore, if the actual energy usage of all industry sectors of IO accounts can be determined, it can be integrated into the IO model to circumvent the use of unreliable energy tariffs. Treloar (1998), Acquaye (2012), and Dixit et al. (2014 and 2015) also discussed the potential of counting energy inputs multiple times in an IOH method, and suggested using primary energy factors (PEFs) to address this issue.

2.3 Recurrent Embodied Energy

The REE of a facility is consumed primarily in two types of activities: maintenance and replacement. A facility's systems and components may not possess the same service life as the facility, and may require one or multiple replacements over its service life (Winistorfer et al., 2005). These replacements involve material use and construction processes, which contributes to the total REE of the facility (Ding, 2007). In the case of facility maintenance, two types of maintenance activities are common: scheduled and unscheduled. Over 50 years of service life, a facility's REE could be equal its IEE (Cole, 1996). In a study of secondary school facilities in Australia, Ding (2007) found that the REE, over a 60-year service life, was 72% of the school facilities' total LCEE. Building components such as envelope, finishes, and services, which may not contain higher initial embodied energy, require a significant amount of REE (3.2 times the initial embodied energy in a 50-year service life) (Cole, 1996). Likewise, Cole (1996) determined that for a service life of 25, 50, and 100 years, the REE of these components was 1.3, 3.2, and 7.3 times their IEE, respectively. Treloar et al. (2000) and Adalberth (1997) also calculated REE as 45% (50-year service life) and 32% (30-year service life) of IEE, respectively. Pullen (2000) calculated an annual REE of 1% of the total IEE of a facility. This % value agrees with the values calculated by Adalberth (1997b) and Treloar et al. (2000).

2.4 Facility Management and REE

The management of facilities involve decisions regarding maintenance and replacement, which can affect their energy and carbon footprint significantly (Elmualim et al., 2010; Dixit et al., 2014b). The maintenance, repair, and replacement activities consume significant REE directly in construction, transportation, and administration processes and indirectly through the use of construction materials and equipment (Brown and pit, 2001; Dixit et al., 2014b). With an effective maintenance and replacement program, the amount of REE can be significantly optimized by selecting low-embodied energy, locally available, and durable materials or products with a longer service life. Materials with high reuse and recycling potential would also contribute to REE savings (Dixit et al., 2014a). Additionally, facility managers are involved in the operation of building systems such as air-conditioning, heating, lighting, etc., which consume a majority of a facility's total operating energy. With an effective facility management strategy, this operating energy usage can be considerably optimized (Brown and pit, 2001; Elmualim et al., 2010). In a study focused on commercial facilities, Dixit et al. (2014) concluded that approximately 90% of a facility's total life cycle embodied and operating energy can be influenced by facility management decisions.

3. Research Goal and Methods

The main goal of this paper is to develop an improved IOH model for computing the REE of commercial facilities in the United States. The calculated values of REE were quantified with a break up of different energy sources used in the United States. Using the fuel-specific carbon emission factors, the carbon embodied in commercial facilities was calculated. For comparative evaluation, the results were compared with those published in relevant literature.

The process of IOH model development was completed in four steps. First, an input-output (IO) model was developed using the detailed Benchmark Input-Output Accounts published by the United States. The model comprised of a direct requirement and a total requirement matrix of commodities manufactured and used in the United States. Next, to create an IOH model, actual energy consumption by each industry sector (process data) of the IO model was collected, refined, and integrated into the model. Integrating process data of energy use avoided the use of unreliable energy tariffs to translate energy flows from monetary to physical units and enhanced the reliability of the model. In the third step, the energy embodied in labor and capital inputs was quantified and integrated into the model to improve its system boundary completeness. To address the issue of energy double counting, a set of Primary Energy Factors (PEFs) were calculated for five energy sources: (1) electricity, (2) natural gas, (3) petroleum; (4) coal, and (5) crude oil and natural gas. Finally, using the PEFs, the embodied energy intensity of the industry sector involved in maintenance, repair, and replacement activities (NAICS 230201, Nonresidential Maintenance and Repair) was computed. A more detailed explanation of the IOH model and PEF calculation can be found in Dixit et al (2015) and Dixit et al (2014c), respectively. The embodied energy intensity resulted from the IOH model was in the units of MJ/$ output of the industry sector. By multiplying the maintenance and replacement costs and the embodied energy intensity, the total REE of facilities under study was calculated.

3.1 Case Study Facilities

This paper sourced total maintenance cost, current replacement value (CRV), and gross exterior floor area data of 88 healthcare facilities in North America from the Operations and Maintenance Benchmarks Survey for Healthcare Facilities (IFMA, 2009). Most of the facilities were acute care hospitals. Figure 1 illustrates a breakup of study facilities. Although survey included over 150 healthcare facilities, only 88 facilities available with all required data were used in the study. The age of the facilities were in the range of <5 years to >50 years. Because the survey did not provide replacement cost data on these facilities, standard replacement costs for hospital facilities published by the Whitestone Facility Maintenance and Repair Cost Reference was used (Whitestone Research, 2009). Using the three key life cycle data: maintenance cost, replacement cost, and CRV; this paper demonstrated the integration of embodied energy and life cycle cost model.

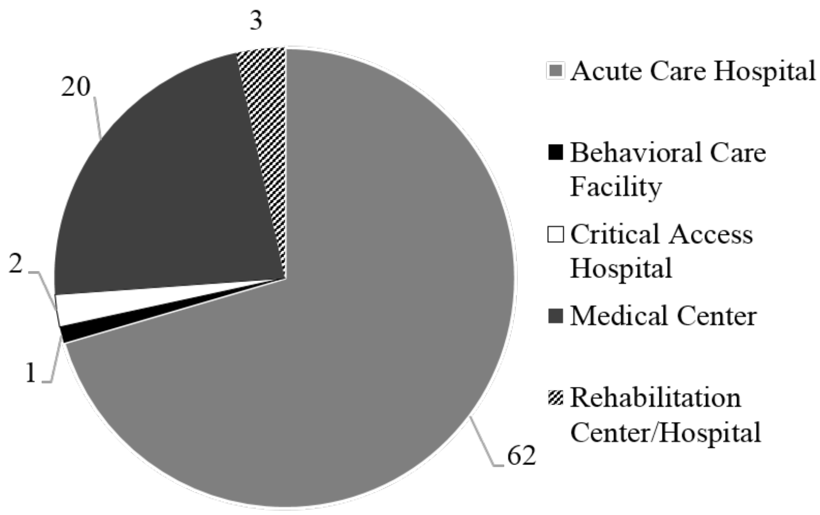

Figure 1: Types of healthcare facilities under study

4. Results

The total embodied energy intensity of the Nonresidential Maintenance and Repair sector was computed as 12.3 MJ/$ of the industry output. This value indicates that for each $ spent on maintenance, repair, or replacement activity, 12.3 MJ of total primary energy is consumed. Approximately 42% of this total energy (5.15 MJ/$) is directly consumed, whereas the remaining energy (7.15 MJ/$) is consumed indirectly through materials and related processes. Table 1 lists the embodied energy and embodied carbon intensities of the Nonresidential Maintenance and Repair sector for each energy source used by the industry sector.

Table 1: Calculated embodied energy and carbon intensity

Intensity of Industry Sector	***Energy Sources Used in the United States***					
	Coal	***Electricity***	***Natural Gas***	***Petroleum***	***Labor & Capital***	***Total***
Embodied Energy (MJ/$)	*0.48*	*2.85*	*1.66*	*5.64*	*1.67*	*12.30*
Embodied Carbon (kg/$)	*0.04*	*0.43*	*0.08*	*0.37*	*0.15*	*1.08*

Figure 2, on its secondary axis, illustrates the total annual REE calculated using the maintenance cost data sourced from the IFMA survey and the replacement cost referenced from the Whitestone Research. The primary axis shows the annual carbon dioxide emissions resulting from the REE consumption. The average annual REE per square meter of the floor area was approximately 1378 MJ resulting in around 11 kg/m^2 of average annual carbon emission. This is significant because when translated over a life cycle of 50 years, the total REE and carbon dioxide emission reaches 68.9 GJ and 560 kg per square meter of the gross exterior floor space, respectively.

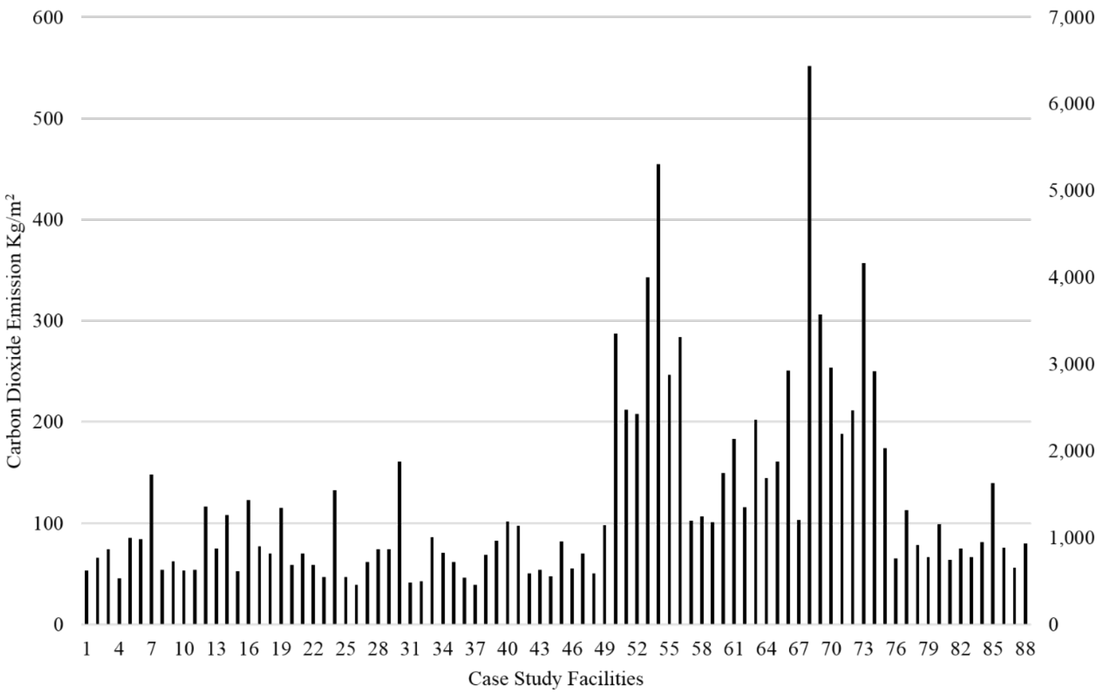

Figure 2: Total annual REE and carbon emission of case study facilities

When analysed by each REE component, the total REE of maintenance and replacement was computed as 950 MJ/m^2 and 428 MJ/m^2, respectively. Figure 3 shows the REE values associated with different maintenance and replacement components. The overall maintenance activities included the maintenance of building exterior, interior systems, roads and grounds, utility and central system, and process treatment and environmental systems. The total REE embodied in external maintenance activities was quantified as 21 MJ/m^2. All of the maintenance related to the facilities' envelope (roof, exterior walls, and ground slab) and exterior signage was included in the external maintenance. The interior system maintenance covered building interior elements (interior walls, doors, ceilings, partitions, finishes etc.), interior signage, and mechanical, plumbing, and electrical systems. The external and interior maintenance activities involved approximately 296 MJ/m^2 of REE.

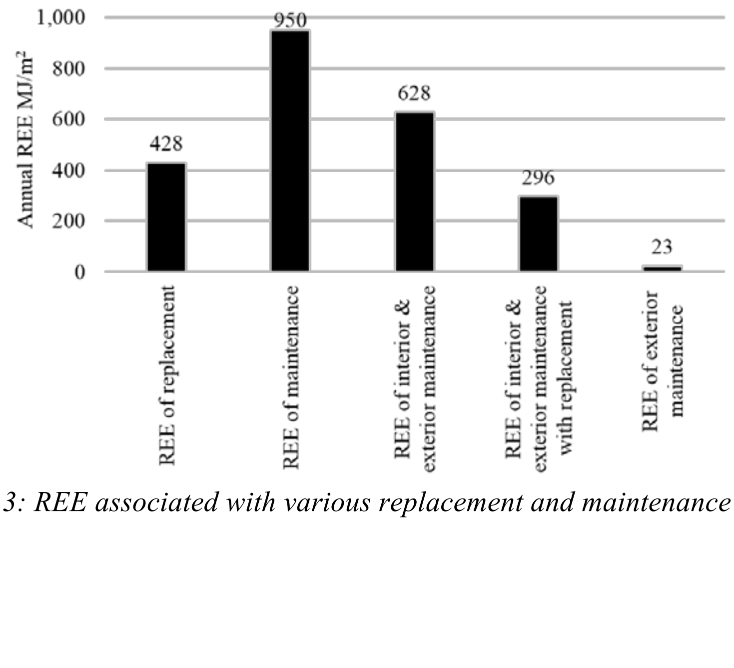

Figure 3: REE associated with various replacement and maintenance components

The calculated values of REE were also compared with those published in related literature. Note that the system boundary differences across these published studies would cause the calculated REE values to vary significantly. Table 2 compares the results of this study with the ones referred from various studies. Because most studies had multiple case studies, there results are displayed under the categories of minimum, maximum, and average. When total REE is compared, the differences with published values were large. One of the reasons for these large differences may be the varying system boundary definitions. Table 2 also provides a brief description of what is included in the referred studies. Some of the larger REE values calculated by Treloar et al. (2001), Suzuki and Oka (1998), Langston and Langston (2007), and Treloar (1993) were due to a wider system boundary covering a majority of building elements. In this study, almost all of the maintenance and replacement expenditure was covered, which may be the primary reason for larger REE values.

Table 2: Calculated embodied energy and carbon intensity

Studies	***Annual REE (MJ/m^2)***			
	Min.	***Max.***	***Average***	***System Boundary Inclusions***
Treloar, 1993	*219*	*219*	*219*	*Envelope & interior components*
Cole & Kernan, 1996	*85*	*103*	*94*	*Envelope, interior, site, services components*
Jaques, 1996	*89*	*89*	*89*	*Only few envelope, interior, services components*
Suzuki & Oka, 1998	*224*	*224*	*224*	*Most envelope, interior, services components*
Eaton et al., 1998	*147*	*153*	*150*	*Structure & HVAC*
Pullen, 2000	*202*	*202*	*202*	*Few envelope, interior, services components*
Treloar et al., 2001	*435*	*435*	*435*	*All envelope, interior, site, services components*
Scheuer, 2003	*88*	*88*	*88*	*Most envelope, interior, services components*
Junnila et al., 2006	*85*	*166*	*125.5*	*Most envelope, interior components*
Page, 2006	*37*	*61*	*49*	*Repainting & replacing some envelope & HVAC components*
Ding, 2007	*49*	*216*	*132.5*	*Envelope, interior, site, services components*
Langston & Langston, 2007	*160*	*262*	*211*	*Most envelope, interior, site, services components*
John et al., 2009	*30*	*73*	*51.5*	*Envelope & interior components*
Fernandez, 2008	*33*	*122*	*77.5*	*Only building maintenance*
Average			*147*	
This study, total REE including maintenance & replacement	*445*	*6307*	*3376*	*All exterior, interior, site, utilities, & other building systems*
This study, total REE of maintenance	*18*	*5879*	*2948*	
This study, total REE of ext. & int. maintenance	*11*	*1148*	*580*	
This study, total REE of ext. maintenance	*0.06*	*167*	*83*	

5. Discussion

The calculated values of REE and resulting carbon dioxide emissions highlight the significance of facility management practices in controlling this extensive energy and environmental footprint of commercial facilities as also discussed by Dixit et al. (2014a). In the United States, the Building Energy Data Book (2014) reported 81.1 billion square feet of commercial floor space in 2010 that is projected to reach 103 billion square feet by the end of 2035. Using the REE and carbon dioxide values calculated in this study, this total commercial floor space represents approximately 10% of the total annual energy consumption in the nation in 2010. When translated into carbon dioxide emissions, the total annual REE results in over 16% of the total annual carbon dioxide emissions. Because facility managers are involved in decision-making regarding maintenance, replacement, and material and product selection, their decisions can greatly impact the total annual energy usage and carbon dioxide emissions of the nation. With the commercial floor space reaching 103 billion square feet in 2035, this impact would be enormous. As discussed by Dixit et al. (2014b), facility managers can help optimize this energy and carbon footprint by selecting durable, long-service life, locally available materials with low embodied energy and high reuse and recycling contents. Durability and long service life would decrease the number of replacement over a facility's service life. Sourcing materials or products from local vendors and suppliers can help reduce transportation distances considerably, which eventually optimizes total REE. Materials or products with low embodied energy and high reuse and recycling potential can assist in recovering initial as well as recurrent embodied energy.

6. Conclusions

The IOH model developed in this paper represents significant improvement to the completeness and accuracy of the current version of an IOH method. The calculation and integration of the energy embodied in labor and capital good filled some incompleteness inherent in an IO-based method. Furthermore, avoiding the use of energy prices enhanced the reliability of the model and its results. Most studies calculated embodied energy as a single energy value, which may be less accurate in determining the resulting carbon emission. In this paper, the values of REE were computed with a breakup of various energy sources, which provided a more accurate calculation of carbon dioxide emissions. The error originating from energy double-counting was also eliminated by apply the approach suggested by Treloar (1998). In spite of these improvements, there remains some potential for further advancement. For instance, the industry sector used in this study represents all nonresidential facilities, which may include other nonbuilding facilities. A sectoral disaggregation process can be applied to decompose the aggregated industry sector to compute facility-specific REE values.

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Artificial Intelligence-Based Models Applied to the Service Life Prediction of Adhered Ceramic Claddings

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Abstract

In Mediterranean countries, ceramic tiles are one of the most common materials for cladding, with a high diversity of dimensions, colours and textures, allowing the execution of decorative panels, which enrich the building stock. Ceramic tiles are also an extremely durable material. Lisbon presents, in old quarters of the city, several examples that witness this durability, showing buildings with more than a hundred years with their ceramic decorative panels intact. However, in recent years, due to changes in the construction methods and the development of new building materials (whose durability is unknown), ceramic coatings present increasing degradation levels, with a wide incidence of defects during their life cycle. Thus, it seems relevant to develop studies focusing the durability and service life of ceramic claddings. In this study, artificial intelligence-based models are applied to the service life prediction of adhered ceramic claddings. For this purpose, 195 ceramic claddings systems (directly adhered to substrate) are analysed, through visual inspections of façades in real service conditions. Artificial intelligence-based models are able to compute reality, emulating the ability of the human mind to learn in an environment of uncertainty and imprecision. These models try to measure real-life concepts using mathematical equations. In this study, two artificial intelligence-based models are applied: artificial neural networks (ANNs) and fuzzy systems. ANNs can be seen as emulations of biological neural systems, and are able to learn through patterns of behaviour, generalizing and adapting to new situations (predicting the behaviour of new case studies). Fuzzy systems combine numerical accuracy with transparency in the form of linguistic rules, describing the relationship between variables by if-then rules. Computationally, artificial intelligence-based models can be described as universal function approximators, achieving better results than classical linear regression models. The results obtained reveal that the proposed models are able to describe and predict the service life of ceramic claddings.

Keywords: Ceramic claddings; Artificial intelligence-based models; Service life prediction.

1. Introduction

Artificial intelligence-based models are able to compute reality resembling to “the remarkable ability of the human mind to reason and learn in an environment of uncertainty and imprecision” (Zadeh, 1992). According to Hernández-Orallo et al. (2016), this concept is based on the anthropocentric confidence that intelligence underlies most human behaviour. Artificial neural networks and fuzzy logic-based models are the most common artificial intelligence-based models, also called as soft computing methods or computational intelligence, with several applications in the construction sector. Jang et al. (1997) refer that neural networks can recognize patterns and are able to adapt themselves to deal with changing environments whereas fuzzy logic systems are able to apply human knowledge in mathematical inference and in decision-making processes. However, the application of these methodologies to service life prediction of building façades is relatively recent (Silva et al., 2013; Vieira et al., 2014). The main advantage of these models is related with their capability of solving problems without a previous knowledge of the specific model, as is the case for the traditional statistical approaches (Krarti, 2003). This study proposes the application of computational intelligence-based models to the service life prediction of adhered ceramic claddings. For this purpose, 195 ceramic claddings systems (directly adhered to substrate) are analysed, based on visual inspections, which evaluate the degradation condition of façades in real service conditions. In this study, two comutational models are applied: artificial neural networks and fuzzy logic-based models. Artificial neural networks act as an emulation of biological neurons and have the capability of reasoning based on a set of degradation patterns, learning with this patterns even when subjected to an environment of uncertainty and imprecision. On the other hand, fuzzy logic systems are able to apply human knowledge in mathematical inference and in decision-making processes. Although these models are very complex, they lead to consistent and reliable results that can be applied in the optimization of maintenance strategies, reducing the environmental and economic costs of these claddings during their life cycle.

2. Evaluation of the degradation condition of ceramic claddings

Mediterranean countries haves a long tradition in the application of ceramic tiles as decorative panels and as building claddings. Ceramic tiles are considered a noble and durable material, with a great diversity of sizes, colours and textures, thus having a significant aesthetic potential when applied as external cladding. Ceramic tiles are also an extremely durable material. Lisbon presents, in old quarters of the city, several examples that witness this durability, showing buildings more than a hundred years old with their ceramic decorative panels intact. In Portugal, ceramic claddings correspond to a small percentage of the façades claddings (present in 5.5% of the buildings built between 1946 and 2001) (Flores-Colen et al., 2008) and their use is often associated with fashion trends. For this reason, the sample analysed (195 case studies) presents a wide range of construction periods and typologies, which starts in the twentieth century until the present day. In the sample analysed, there is a clear peak of using this type of cladding (in the period 1920-1949), which can be explained by socio-economic reasons (Bordalo et al., 2011).

In recent years, due to changes in the construction methods and the development of new building materials (whose durability is unknown), ceramic claddings present increasing degradation levels, with a wide incidence of defects during their life cycle. Furthermore, various authors (Zhi and Wei; 1997; Guan et al., 1997) refer that the most common defects are the result of poor workmanship in tile placement, namely due to poor surface preparation, the presence of voids between the tile and the adhesive, caused by the application of a very thin adhesive layer either by not complying with the adhesive opening time, or due to an inadequate tile setting pressure. In this study, the most common defects detected in ceramic claddings are grouped into four categories (Silvestre and Brito, 2009; Bordalo et al., 2011): i) visual defects - e.g. defects of a strictly aesthetic nature, not compromising the loss of performance of the cladding; ii) cracking - considering three types: glazing cracking (normally caused by the ageing of the tiles); cracking with no predominant direction (usually of superficial nature and affecting large portions of the cladding surface); markedly orientated cracking (usually local, deep and wide); iii) deterioration of the joints - which can jeopardize the performance of the entire cladding, since joints absorb the claddings' deformation and for ensuring the water-tightness of the system; iv) adhesion failure and/or detachment of ceramic claddings - which is the most serious defect, with dire consequences to the built environment and in the safety of users and owners.

To evaluate the overall degradation of ceramic claddings a quantitative index, proposed by Gaspar and Brito (2008), is applied, which expresses the global performance of the façades according to their physical and visual condition, previously assessed by the field work inspections. This quantitative index, called severity of degradation, is obtained through the ratio between the extent of the degradation of the façade, weighted as a function of the degradation level and the severity of the defects, and a reference area, equivalent to the maximum theoretical extent of the degradation for the façade under analysis - equation 1.

$$S_w = \frac{\Sigma\left(A_n \times k_n \times k_{a,n}\right)}{A \times k} \qquad (1)$$

Where S_w is the weighted severity of degradation of the façade (%); A_n is the area of coating affected by an defect, in m^2; k_n is the defect's nth multiplying factor, as a function of its condition (between 0 and 4); $k_{a,n}$ is the weighting coefficient corresponding to the relative importance of each defect based on the cost of repair ($k_{a,n} \in R^+$); k is the weighting factor equal to the highest degradation level in the façade; A is the total area of the cladding, in m^2. Since distinct defects detected in claddings have different levels of severity. The coefficient $k_{a,n}$ takes into account the relative importance of each defect, concerning their repair cost. The cost of repair is calculated as the ratio between the sum of the costs of each operation within the required intervention and the cost of replacing the cladding.

3. Application of artificial intelligence-based models to the service life prediction of ceramic claddings

The use of "intelligent" models - as fuzzy logic systems or artificial neural networks - has been implemented in several knowledge areas, aiming to modelling complex phenomena. In this study, these two approaches are used in the service life prediction models of adhered ceramic claddings.

The durability and the service life of this type of claddings are estimated, according to their age and to the most relevant parameters that explain the loss of performance of this type of claddings. According to a sensitivity analysis performed in this study, the variables with higher influence in ceramic claddings' degradation process are distance from the sea and tiles size. Yiu et al. (2007) refer that external environmental conditions are one of the major causes of degradation of ceramic tiling systems. Claddings exposed to marine environments are subjected to harmful salts that promote the presence of defects such as exfoliations or spalling (Lubelli et al., 2004). Concerning the tiles' size, a study performed by Medeiros (2002) shows that one of the most unfavourable conditions for detachment of tiles stems from the use of ceramic tiles greater than or equal to 20 cm in any direction. Thus, in this study, the tiles' size was categorized according to the lateral sizes of the tile; if at least one size is greater than 20 cm, then the cladding belongs to category "L ≥ 20 cm", otherwise the cladding belongs to category "L < 20 cm".

3.1 Artificial neural networks

ANNs are usually seen as emulations of biological neural systems (Rezeki et al., 2006), being inspired by the basic mechanisms of the human brain functioning, gathering information through a learning process (Kazanasmaz et al., 2009). Typically, ANNs comprise hundreds of simple processing units interconnected through a complex communication network (Lippmann, 1987). ANNs can be "trained" to solve difficult problems, which the numerical solutions are not easily achieved by other more conventional approaches. In this study, a multilayer perceptron model (MLP) is applied, using a back-propagation algorithm in the training sample. The MLP is used to develop an expression to estimate the severity of degradation of ceramic tiling systems. In all runs the global set of patterns is divided into two groups: training (85% of the sample - 166 case studies) and cross-validation (15% - 29 case studies). The sample used for cross-validation is also used to test the networks. To apply this model it is necessary to codify the categorical variables; the variables distance from the sea and size of the tiles have only two possible arbitrary "values" according to the data collected during the field work, which are: i) distance of the building from the sea - less than 5 km, value 1; otherwise, value -1; ii) tiles' size - less than 20 cm for at least one of the sides of the tile, value -1; otherwise, value 1. A 3-4-1 architecture is adopted and the 3 entries are: age of ceramic claddings, distance from the sea and tiles' size, and the output is degradation severity. The degradation severity (S_w) is a function of these variables, as seen in equations (2) and (3). Coefficients h_0 to h_4 and c_{0i} a c_{8i} are presented in Table 1.

$$S_w = h_0 + \sum_{i=1}^{4} h_i H_i \qquad \textbf{(2)}$$

$$H_i = \tanh\left(c_{0i} + \sum_{n=1}^{3} c_{ni} V_n\right) \qquad \textbf{(3)}$$

Where V_1 represents the age of the ceramic cladding, V_2 distance from the sea and V_3 tiles' size.

Table 1: Coefficients of the proposed formula

i	h_i (-)	$c_{,0i}$ (-)	$c_{,1i}$ (-)	$c_{,2i}$ (-)	$c_{,3i}$ (-)
0	2.39E-01				
1	2.58E-02	3.02E-01	3.06E-03	-4.74E-01	3.74E-01
2	9.01E-02	-9.66E-01	2.86E-02	4.72E-01	-3.41E-01
3	1.61E-01	-5.20E+00	1.01E-01	1.62E-01	5.83E-01
4	-7.39E-02	4.15E-01	-7.53E-03	1.69E-01	-2.45E-01

3.2 Fuzzy logic systems

Conventional computational models tend to deal with reality in a binary form, restricting it to only two hypothesis, as “0 / 1”, “yes / no”, “true / false”. These models are therefore unable to deal with ambiguous variables (Mukaidono, 2001). However, the available knowledge about a given reality can be neither absolutely true nor absolutely false and can be sometimes inaccurate, imprecise, incomplete or even unrealistic (Klir and Yuan, 1995). In fact, as stated by Zadeh (1973), the human reasoning is not based on a traditional two value logic but uses instead fuzzy truths and fuzzy rules of inference. According to Rajasekaran et al. (2011), fuzzy logic is one of the modelling techniques most widely used in artificial intelligence and the models produced are based on four basic concepts: i) fuzzy sets; ii) linguistic variables; ii) possibility distributions; and iv) fuzzy IF–THEN rules. In this work, Takagi-Sugeno (TS) fuzzy models are used (Takagi and Sugeno, 1985), which consist of fuzzy rules where each rule describes a local input-output relationship. Furthermore, a fuzzy C-means (FCM) is applied as clustering algorithm.

Concerning the application of fuzzy systems to the 195 ceramic claddings studied, 85% (166 cases) of the sample are used in the model training and 15% (29 cases) as a test sample. The training and test samples are the same that were previously applied in the ANNs models, allowing a more precise comparison between the two proposed models. In the application of this model it is necessary to codify the categorical variables; in this case, the variables distance from the sea and size of the tiles have only two possible arbitrary “values”, which are: i) distance of the building from the sea - less than 5 km, value -1; otherwise, value 1; ii) tiles’ size - less than 20 cm for at least one of the sides of the tile, value 1; otherwise, value -1. The fuzzy rules describing the local input-output relation are presented in equations (5) and (6), with the three explanatory variables: age, size of the ceramic tiles and distance from the sea.

Rule 1: If u_1 is A_{11} and u_2 is A_{12} and u_3 is A_{13} and u_4 is A_{14} then:

$$y_1(k) = -2.59\cdot 10^{-2} u_1 - 2.61\cdot 10^{-2} u_2 + 6.34\cdot 10^{-3} u_3 - 8.80\cdot 10^{-2} \tag{5}$$

Rule 2: If u_1 is A_{21} and u_2 is A_{22} and u_3 is A_{23} and u_4 is A_{24} then:

$$y_2(k) = -8.05\cdot 10^{-3} u_1 - 2.64\cdot 10^{-3} u_2 + 2.43\cdot 10^{-3} u_3 - 2.87\cdot 10^{-3} \tag{6}$$

Where u_1 represents distance from the sea, u_2 size of the ceramic tiles and u_3 age of the buildings. The antecedent fuzzy sets are represented by A_{ij}, where i is the number of the rule and j represents the various variables analysed. In other words, the one-dimensional fuzzy sets A_{ij} are obtained from the multidimensional fuzzy sets defined point-wise in the i^{th} row of the partition matrix by projections onto the space of the input variables x_j.The model output, S_w (severity of degradation of ceramic claddings), is computed by aggregating the individual rules contribution - equation (7).

$$S_w = \frac{\sum_{i=1}^{C} \beta_i f_i(x)}{\sum_{i=1}^{C} \beta_i} \tag{7}$$

In Takagi-Sugeno fuzzy models the discriminant function $f_i(x)$ is defined as shown in equations (5) and (6). The number of rules C, the antecedent fuzzy sets A_{ij}, and the consequent parameters a_i and b_i are determined by means of fuzzy clustering in the product space of the input and output variables. β_i represents the degree of activation of the i^{th} rule.

Figure 1 shows the membership functions for each of the three input variables included in the fuzzy model applied to ceramic tiling systems. The analysis of the variables included in the model reveals that the clustering clearly divides the data between newer and older buildings. In the remaining variables, distance from the sea and size of the ceramic tiles, all the categories give the same contribution to the output of the rules number one and two.

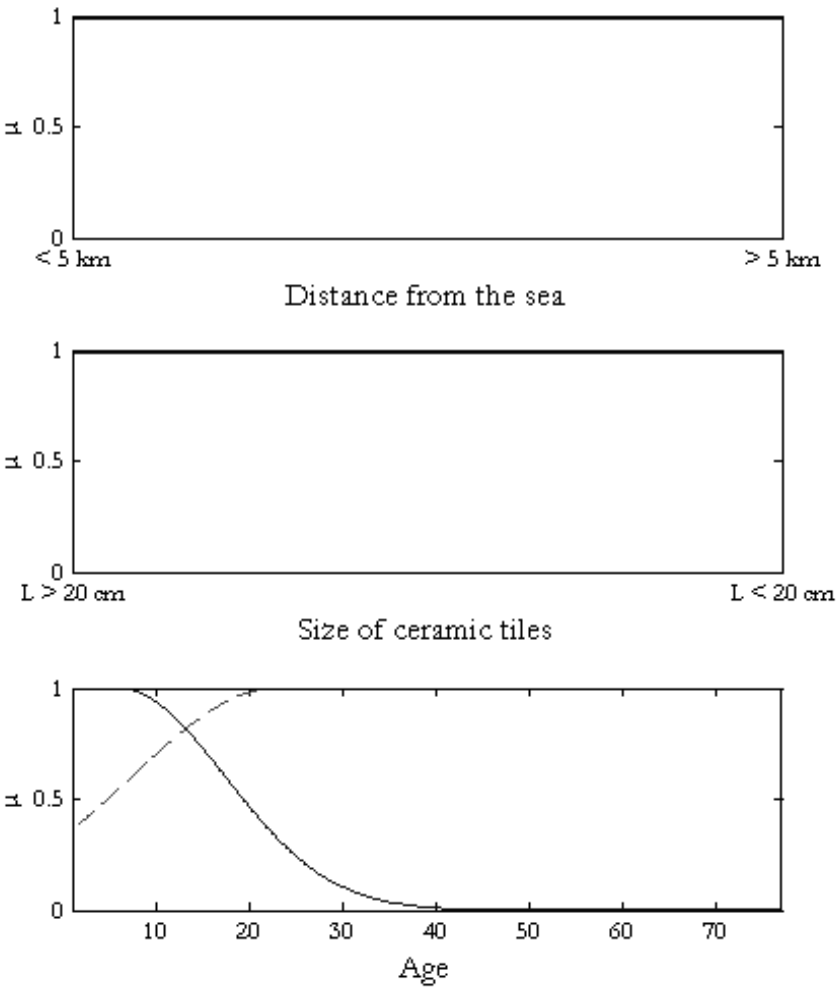

Figure 1: Membership functions for the fuzzy model proposed for ceramic tiling systems

4. Discussion

Table 2 presents some statistical indicators related to the accuracy of the proposed models. Both models present high accuracy levels with a Pearson correlation coefficient of 0.88 and 0.93 for ANNs and fuzzy logic models, respectively, which reveals a very strong correlation between the predicted and the observed values. Furthermore, the models have an MAPE (mean absolute percentage error, which is a statistical measure usually used for evaluating the performance of predictive models) lower than 10%, thus showing a potentially very good predictive capacity. Likewise, the percentage of patterns with APE (absolute percentage error) greater than x = 10%, x = 20%, and x = 30% is analysed, concluding that the errors of the models are relatively low, considering the complexity of the degradation phenomena of ceramic tiling systems.

Table 2: Statistical indicators used to evaluate the accuracy of the proposed models

Model	*r*	MAPE	APE > 10%	APE > 20%	APE > 30%
ANNs	0.93	5.2%	17.2%	0%	0%
Fuzzy systems	0.88	7.4%	31.0%	0%	0%

The proposed models lead to coherent and physical credible results. Figures 2 and 3 show the cumulative distribution function of the estimated service life values obtained by ANNs and fuzzy logic models, respectively.

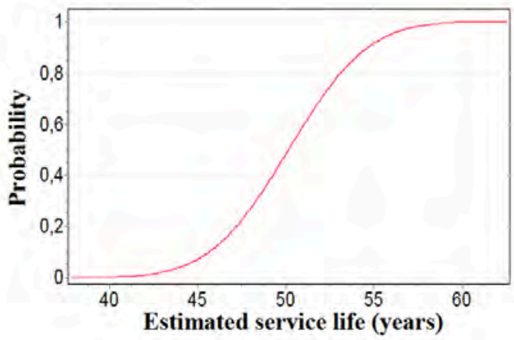

Figure 2: Cumulative distribution function of the estimated service life obtained by ANNs

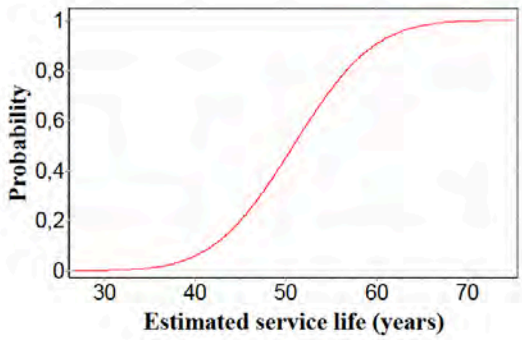

Figure 3: Cumulative distribution function of the estimated service life obtained by fuzzy model

From the application of the ANNs model an average estimated service life of 50.2 years is obtained, with a standard deviation of 3.52 years. From the analysis of the results presented in Figure 2, it is possible to conclude that an ESL of 44 years has a probability higher than 95% of being exceeded and an ESL of 56 years presents a probability higher than 5% of being exceeded. In this model, the estimated service life of ceramic claddings ranges between 39.8 and 53.5 years, with high prevalence of values between 50 and 55 years (86% of the sample). Using the Takagi-Sugeno fuzzy model, an average estimated service life of 50.8 years is obtained, with a standard deviation of 6.8 years. According to the results presented in Figure 3, an ESL of 39 years has a probability higher than 95% of being exceeded and an ESL of 62 years presents a probability higher than 5% of being exceeded. These results are in accordance with the values proposed in the literature; various authors (Tam et al., 1993; Galbusera et al., 2014) quantify the expected service life of external ceramic claddings as 50 years; the BMI (*Building Maintenance Information*) suggests an expected service life of 45 years for claddings using metallic elements for fixation (with a range of values between 25 and 55 years).

Figure 4 shows an analysis of the average estimated service life according to the variables included in the models applied to ceramic tiling systems. The results reveal that claddings located nearer the coast (< 5 km from the sea) are more prone to degradation, with lower estimated service lives (when the ceramic tiles have the same size). Smaller ceramic tiles (L < 20 cm) tend to deteriorate slower, having higher estimated service lives (for the same conditions concerning their proximity from the sea). The most favourable situation corresponds to a cladding located at more than 5 km from the sea and with smaller tiles (with an average ESL of 61 and 54 years according to fuzzy and ANNs models, respectively). The most harmful situation corresponds to façades in coastal areas with larger tiles (L ≥ 20 cm), with an average estimated service life of 45 and 40 years according to fuzzy and ANNs models, respectively. In intermediate situations, it is not possible to identify a clear degradation pattern, i.e. it is not clear which is the most influential variable, distance from the sea or tiles' size, in the degradation process of ceramic claddings. The results obtained by fuzzy model are usually more optimistic.

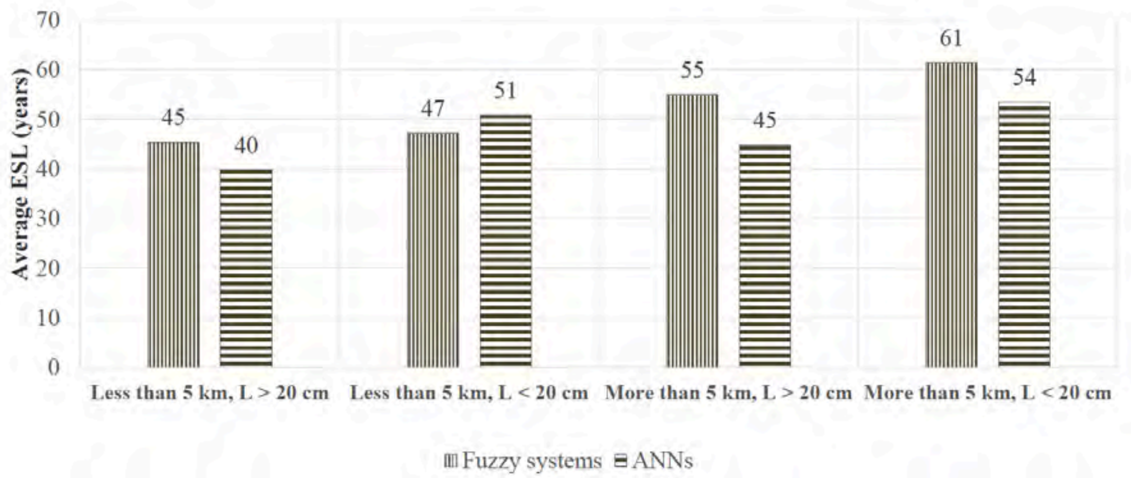

Figure 4: Analysis of the average estimated service life according to the variables included in the proposed models

Table 3 shows real examples (within the sample analysed) of the four possible combinations of the two variables included in the proposed models. As referred before, the results obtained by the ANNs and fuzzy logic models are close to field work data. These results are consistent and coherent with the empirical perception about the degradation phenomenon of ceramic tiling systems.

Table 3: Examples of the application of the proposed models to real case studies

Description of the case study		Observed values	Predicted values by ANNs	Predicted values by fuzzy logic model
	Ceramic cladding with 28 years, located at less than 5 km from the sea and with L < 20 cm.	**S_w = 7.7%** **ESL = 47.3 years**	S_w = 7.9% ESL = 50.8 years	S_w = 8.7% ESL = 47.4 years
	Ceramic cladding with 35 years, located at less than 5 km from the sea and with L ≥ 20 cm.	**S_w = 18.5%** **ESL = 36.6 years**	S_w = 13.8% ESL = 39.8 years	S_w = 18.3% ESL = 37.8 years
	Ceramic cladding with 34 years, located at more than 5 km from the sea and with L < 20 cm.	**S_w = 7.4%** **ESL = 55.7 years**	S_w = 6.4% ESL = 53.5 years	S_w = 7.5% ESL = 54.2 years
	Ceramic cladding with 42 years, located at more than 5 km from the sea and with L ≥ 20 cm.	**S_w = 15.8%** **ESL = 47.2 years**	S_w = 15.6% ESL = 44.8 years	S_w = 17.8% ESL = 45.6 years

5. Conclusions

In this study, the application of artificial intelligence-based models is analysed, namely artificial neural networks and fuzzy logic systems applied to the service life prediction of ceramic claddings. These methods seek to combine knowledge-based on human reasoning with mathematical inference, which may support decision-making processes, i.e. these approaches are able to learn from a set of behaviour patterns (in an uncertainty and imprecision environment), adapting to model and explain new cases and examples hitherto unknown to the model.

Artificial neural networks are able to acquire empirical knowledge from a set of learning data for a given problem. Therefore, these models is able to learn and generalize from experiences and examples (using for this a training sample), adapting to new situations. This is an extremely important capability because it allows solving complex problems whose analytical or numerical solutions are difficult to achieve by more conventional approaches. However, the models based on artificial neural networks are still regarded as “black box” models, since the model is defined using thousands of synaptic weights whose logic interpretation may be complex.

The fuzzy logic models are described in the literature as “grey box” models; the operation process is known, however, the results obtained depend on the sample used. Like the artificial neural networks, these models are able to learn and generalize based on experiments and examples. Furthermore, fuzzy logic models combine numerical precision with transparency in the form of linguistic rules. Fuzzy logic models can deal with the uncertainty associated with complex phenomena - such as degradation of construction elements - with higher precision and better performance than the classical linear models. In fact, fuzzy logic models are known to be able to effectively model inaccurate data, and even if the sample presents some outliers or influential points, these case studies do not contribute to bias the results. However, the complexity associated with such models can constrain their use in modelling the service life of ceramic claddings, since they can become difficult to understand by users who are not familiar with this type of mathematical approaches.

The proposed models react to data that are used in their definition (as any statistical or prediction model), being in principle more reliable and precise with the increase in the number of available data or by increasing the representativeness of the samples. Regardless of their benefits and limitations, artificial intelligence-based models are able to conveniently describe the degradation of ceramic claddings. In the case of artificial neural network models an estimated service life of 50 years is obtained and using the fuzzy logic systems an estimated service life of 51 years is obtained. These values seem realistic (in the same order of magnitude of the values present in the literature), with small deviations and errors. A high correlation between the observed values during the field work and the values predicted by the proposed models is also observed. Fuzzy logic models lead to the most optimistic results, but still reliable with regard to its physical sense. Finally, it should be noted that these models allow obtaining the estimated service life for each case study (within the test sample), making it possible to estimate the dispersion associated with the results obtained, as well as set histograms describing the behaviour of the data, that can be used to define probability distributions. This information is very useful in the definition of maintenance plans, giving information concerning the risk associated with the failure of ceramic claddings.

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Environmental Life Cycle Impacts of an Industrial Building in Finland

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Abstract

Buildings and construction activities account for a notable share of total energy consumption, greenhouse gas emissions, waste production and use of virgin materials over their life cycle in Finland and globally. Legislation and regulation concerning these issues is becoming stricter and the industry is also developing voluntary actions to tackle these problems. Life Cycle Assessment (LCA) is a tool that helps quantifying the environmental impacts over the whole building life cycle, without burden shifting.

The main objective of this research is to quantify the environmental impacts caused by an industrial building over its whole life cycle using process LCA. The results show, that the overall lifecycle greenhouse gas emissions - expressed in global warming potential - of the case study building reach 2.68E+07 kg CO_2 eq. 79 % of these are building operation related, and 21 % are embodied in construction materials. The results are in line with previous research assessing residential and office buildings.

LCA industry has developed multiple software tools that can be utilized to calculate environmental life cycle impacts of goods and services. The industrial case building material production impacts were calculated using three available LCA software tools, to find out whether the selection of the tool significantly affects the results. Even though the selected tools all use different database and have varying features and abilities, the results obtained are of the same magnitude for the whole building as well as the main building elements.

Keywords: Life Cycle Assessment (LCA), industrial building, environmental impacts, LCA tools

1. Introduction

1.1 Motivation for the Research

Sustainability related issues have gained more importance in the real estate and construction (REC) industry. In the European Union (EU) buildings account for 42 % of final energy consumption, 35 % of greenhouse gas (GHG) emissions, use of over 50 % of all extracted raw materials and 30 % of overall water consumption (European Commission, 2012). Legislation and regulation concerning these issues is becoming stricter and the industry is also developing voluntary actions to tackle these problems. The awareness of industry actors is rising when demand from clients and authorities for more sustainable solutions is becoming stronger (Malmqvist, et al., 2011).

Buildings are products with long service life over which they cause emissions and other waste flows into the environment (Junnila, 2004). Building life-cycle starts with extraction of raw materials and production of construction materials that are assembled together to form a building in the construction phase. After the building has been commissioned, the emissions extend over a long service-life, usually at least 50 years, over which substantive amount of energy is consumed in form of heat and electricity. Also other resources, like water and virgin materials required for building operation, maintenance and repairs are consumed continuously and waste is generated. The function of buildings might change several times requiring larger retrofits and hence even more resources. The end-of-life (EOL) phase continues to cause environmental impacts when the building is demolished and materials are processed and recycled, reused or disposed to landfills.

Environmental impacts, like GHG emissions that are contributing to climate change, are becoming more widely known and studied within the REC industry. Life Cycle Assessment (LCA) is a tool that enables quantification of environmental impacts generated during a product's life cycle from raw material extraction, production and use phase to end-of-life, like in a buildings' case, demolition (SFS-EN ISO 14040, 2006). One of the most important qualities of LCA is that so called burden shifts or trade-offs can be avoided when the whole product system is modelled and environmental impacts are assessed over the whole life cycle (Wolf, et al., 2012). Burden shifting means that improvements achieved in some part of a product system or at some stage of life cycle would bring about negative impacts in another part of the system or at another point in time.

When measured in gross floor area, industrial buildings cover approximately 11 % of the total Finnish building gross floor area making industrial buildings the second most important building type after residential buildings in Finland (Official Statistics of Finland, 2014). Several studies have been made where environmental life cycle impacts of buildings have been quantified and analysed. Most of these LCAs have been executed for residential buildings (Saari, 2001)(Blengini, 2009) (Ortiz-Rodriguez, et al., 2010) (Pasanen et al., 2011) (Passer et al., 2012) (Rossi, et al., 2012). There are also examples of studies analysing office buildings (Junnila, 2004) (Junnila, et al., 2006) (Wallhagen, et al., 2011) (Kofoworola & Gheewala, 2008) and public buildings (Chang, et al., 2012) (Scheuer, et al., 2003). Though environmental life cycle impacts of residential, office and public buildings have been studied rather widely, industrial buildings have so far not been addressed.

1.2 Scope of the Research and Used Methods and Materials

The main objective of this research is to quantify the environmental impacts caused by an industrial building over its whole life cycle. The results will be put in context of previous research to find out whether industrial buildings cause similar impacts as residential and office buildings. The material related embodied impacts are calculated using three different existing LCA software tools; SimaPro, 360Optimi and ILMARI. This is done in order to reveal possible difference in results and to find out why they might occur. This is important when new LCA tools are constantly being developed.

So to sum up, the aim of the study is to:

1. Quantify the environmental life cycle impacts of an industrial building in Finland;
2. See how the results settle in line with existing results obtained from studies assessing residential and office buildings;
3. Find out whether the impacts differ when calculated using different LCA software tools.

The empirical part of this research is a quantitative life cycle assessment of a case building. Cradle-to-grave process LCA is conducted for an industrial building using 360Optimi LCA software tool. The emissions caused by material manufacturing are also calculated using two other LCA tools: SimaPro and ILMARI. The obtained results are compared and reasons behind possible differences are analysed. All life-cycle stages from construction material production, building operation and maintenance to end-of-life are included in the case building LCA. Only the construction installation process on site is left outside the scope. The service life used in calculations is 60 years. The results are expressed in global warming potential (GWP) value in carbon equivalents.

Building elements that are included in the calculations include foundations, structural elements, building envelope, structural floors and ceilings, roof assemblies, structural wall assemblies, and interior non-bearing walls. Excluded items include all external site elements like paved areas, and site equipment, interior finishes as well as building service elements; plumbing, air conditioning, electrical, data transfer and mechanical elements and elevators. When assessing the operational life-cycle impacts, the studied building operations include space cooling and heating, service water heating, elevators, pumps and fans and other building services required to maintain desired indoor conditions. User related electricity, like lighting and receptacle equipment is also included.

2. Building Life Cycle Assessments

Typical building life cycle consists of the stages presented in figure 1 below (SFS-EN 15978, 2011). The product stage (modules A1 to A3) takes into consideration the cradle to gate processes for the construction material production from raw material extraction to the factory gate. The construction process stage (modules A4 to A5) covers the processes from the factory gate to the completion of the construction works, including all transportation, storage and installation. The use stage (modules B1 to B7) covers the building usage and operation from completion of construction works to the point of time when the building is demolished. This stage includes building services (heating, ventilation, air conditioning, cooling, lighting, water supply, etc.), maintenance and cleaning and other operations-related activities. The end of life stage (modules C1 to C4) covers building deconstruction and preliminary on-site sorting of materials, transport of materials to final disposal or recycling site and waste processing activities for reuse, recovery or recycling.

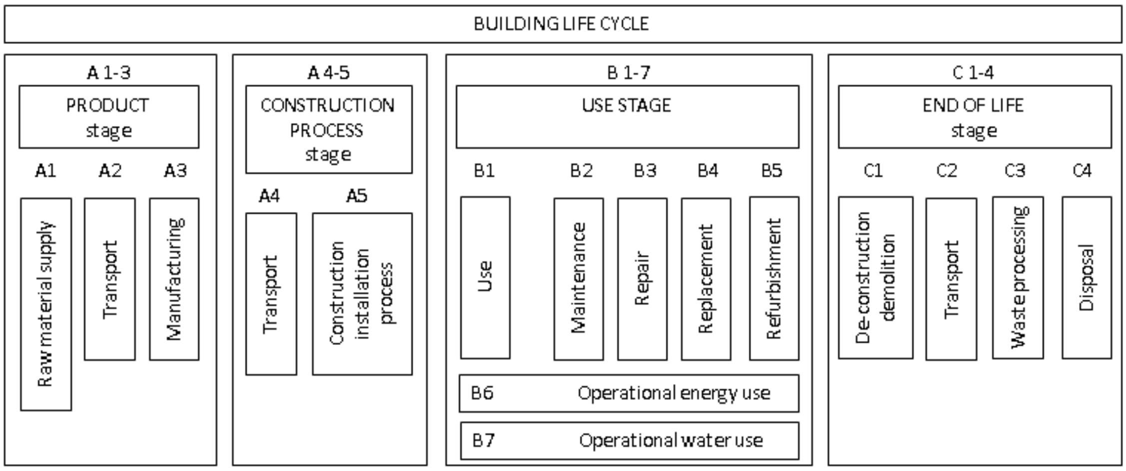

Figure 1 *Display of modular information for the different stages of building assessment (figure modified from SFS-EN 15978, 2011)*

As is often the case when studying buildings, process life cycle assessment is applied in this study. In process analysis, environmental impacts generated over a product life-cycle are assessed through flows of material, energy and emissions to and from the studied system (Pandey, et al., 2011). The system can be modelled to the required detail and specific products within the process can be studied. The inclusion and exclusion of processes is a subjective choice made by the person conducting the study which results in a problem with the system boundary definition (Suh, et al., 2004). The problem of system boundary selection and the incompleteness of LCA results (if all relevant processes are not included in the modelling of the studied system) is called truncation error (Lenzen, 2000). The influence of truncation error in overall LCA results can be as high as 50 %.

Total life-cycle environmental impacts of buildings consist of two types of emissions: embodied and operational (Ramesh, et al., 2010). Embodied emissions are caused by all processes of construction material production, transport, onsite construction activities and maintenance and renovation of the building while operational emissions take place in the use phase and are caused by energy consumption required to maintain the desired indoor environment through heating, cooling, lighting and other building services and appliance operation (Dixit, et al., 2012). After having assessed the LCA results of 73 case studies, Ramesh et al (2010) concluded that in average the operational energy accounts for 80-90 % and embodied energy for 10-20 %

of total building life cycle energy use and that the generated emissions are in line with energy consumption. Junnila (2004) studied three office buildings and stated that operation of the building causes 70-85 % of climate change impact over the building service life while embodied impacts account respectively for 25-30 %.

In this research, carbon equivalents are used to assess the negative environmental impacts caused over the life cycle of an industrial building. By the definition of ISO, greenhouse gases are "gaseous constituents of the atmosphere -- that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds" (SFS-EN ISO 14064-1, 2006). The most known greenhouse gas is carbon dioxide (CO_2), but there are other gases like methane (CH_4) and nitrous oxide (N_2O). When talking about the GWP, the radiative forcing impact of one mass-based unit of these gases is compared to an equivalent unit of CO_2 over a given period of time.

3. Life Cycle Assessment of and Industrial Building

3.1 Presentation of the case building and used tools

The case building is a 12 547 gross square meter vehicle repair centre situated in Southern Finland. At the time of this research, the project was at its implementation design phase. The building consists of approximately 7200 m^2 of industrial space and 4300 m^2 of office space. The remaining area is either storage or technical space. The building frame is mainly executed as precast reinforced concrete element construction. Some characteristics of the case building industrial areas include high ceilings and long spans. There are no intermediate floors or walls in the industrial spaces and surfaces are left unfinished. On the other hand, the load bearing floor slabs are thicker than in regular office or residential buildings because they need to support large vehicles indoors. The building is connected to the local district heating network. Heat is distributed through radiators in office space and floor heating and air-circulation heating in industrial areas.

As one goal of this study is to find out whether the embodied impacts differ when calculated using different LCA software tools, three LCA software tools, that are capable of calculating the initial embodied impacts, were chosen: SimaPro, 360Optimi and ILMARI. SimaPro is widely known and one of the most used LCA tools (Pré, 2014). It is developed by Dutch Pré Consultants. 360Optimi is a fairly recent and building specific LCA tool developed by Finnish Bionova (Bionova, 2015). ILMARI carbon footprint calculation tool has been developed by the Technical Research Center of Finland (VTT) and Pöyry Finland Oy. It should be stated that within this research, the licence of 360Optimi used covers only LEED (Leadership in Energy and Environmental design) environmental certification system compliant LCA. So it is unclear whether other licences of the same software include more features.

In order for the results obtained from these different tools to be somewhat comparable, the LCA modelling was executed as similarly as possible with all the three tools. However, the tools are somewhat different by nature. SimaPro, for example, allows for a considerably more detailed analysis with option of developing own assemblies. SimaPro also features several options for life cycle impact assessment method, such as CML, EDIP, ReCiPe, TRACI, EPS and IMPACT. For this study, CML 2 (2000; v.2.05) is chosen, because it is also used within 360Optimi. ILMARI doesn't specify which methodology is used in calculations.

Within SimaPro, the Ecoinvent database is used. Ecoinvent includes data for most common construction products, like concrete and rebars. However in many cases when using SimaPro, construction materials are not ready in the database. The user has to know the material ingredients of construction materials, like insulation boards, which is not always evident. ILMARI and 360Optimi are building-specific LCA tools and include hence large material library of construction products. They both have information ready for whole structural elements, like hollow core slabs which are commonly used in Finnish construction projects. In SimaPro, the user has to "construct" these structural elements so information about their ingredients is required. The data in ILMARI is mainly collected from the Finnish Building Information Group's environmental declarations and secondly from public databases and most important Finnish manufacturers' EPDs (Häkkinen, 2011). 360Optimi contains emissions data from mainly Nordic and Central European construction material manufacturers.

3.2 LCA process

The bill of quantities used in the study was generated from the architectural and structural building information models using Solibri Model Checker and the structural types of the building. At the time of this research, the model was still incomplete, so some information was added to the materials list manually, such as the amount of steel reinforcement in prefabricated concrete elements. After the actual amounts of construction materials were determined, the amounts were submitted in all three LCA tools. Secondary data available in the built-in databases of the three used software tools was used in the inventory because actual material and product manufacturers were not known at the time of the LCA study. When possible, however, the data quality was estimated based on age of the data, geographical specificity, technology coverage and third party verifications.

As always in building life cycle assessments, set of assumption and simplifications were made during the study. As construction materials bill of quantity was compiled in volume, average densities were used in order to calculate the mass of different materials. Material densities were collected from literature and material manufacturer's technical product descriptions. Material losses that are expected to occur at the construction site were taken into consideration. The losses were estimated based on a study by Sirje Vares (2001). Transportation to the construction site was also estimated based on manufacturing plant location of biggest Finnish material manufacturers. Because the LCA was executed before the building construction began, actual distances could not be acquired. Transportation covers the distance from product or material manufacturing plants to the project site.

Operational impacts were calculated by hand using yearly electricity and district heat consumption values and average Finnish emission factors. Energy simulation of the case building was executed using IDA Indoor Climate and Energy software, IDA ICE. Yearly electricity and district heat consumption determined through energy simulation at design stage are assumed to stay equal during the 60 years which is of course not likely in reality. The emission factors used in this study are based on carbon neutral vision of Finnish Energy Industries. In the vision (2010), it is estimated that emissions caused by electricity production in Finland drop from 280 to 30 g CO_2 eq/kWh between 2010 and 2050 and respectively emissions from district heat production drop from 220 to 25 g CO_2 eq /kWh.

3.3 Results

In the actual research, six environmental impact indicators were studied but in this paper, only GHG emissions are presented. The case building total embodied GHG emissions expressed in carbon equivalents reach 5.51E+06 kg CO_2 eq. As the building gross floor area is 12 547 m^2, the normalized results are respectively 439 kg CO_2 eq/m^2. Embodied impacts consist of material production, transportation to the building site, maintenance and material replacements, and end-of-life stage including demolition and material processing. Embodied emissions in different life cycle stages are presented in table 1 below. Within the embodied impacts, material manufacturing causes almost 85 %; end of life little over 9 % and the rest (transportation and maintenance) together a little over 6 %. Global warming potential was chosen as reference indicator because so far it has been the most addressed environmental impact indicator within existing literature and previous research. Additionally, it is the only indicator that can be calculated using ILMARI software.

Table 1 *Embodied global warming potential of different life cycle stages of the case building*

Building life-cycle stage	Global Warming Potential	Share of total impacts
	kg CO2 eq	%
A1-A3	4,66E+06	84,60 %
A4	1,37E+05	2,49 %
B1-B3	5,20E-02	0,00 %
B4-B5	2,11E+05	3,83 %
C1	5,87E+04	1,07 %
C2	2,94E+04	0,53 %
C3-C4	4,12E+05	7,48 %
Total	**5,51E+06**	100

The building consumes annually about 2 210 MWh electricity and 990 MWh district heat energy. When multiplied with the average Finnish emissions factors, the total operational GHG emissions of the case building reach 2.13E+07 kg CO_2 eq over the 60-year study period. These values translate into normalized emissions of 1697 kg CO_2 eq /m^2 and 29.3 kg CO_2 eq/m^2,year.

When the operational emissions are added up with the embodied emissions discussed earlier and presented in table 1, the overall global warming potential of the studied building expressed in CO_2 equivalents reach 2.68E+07 kg CO_2 eq meaning 2136 kg CO_2 eq /m^2 and 35.6 kg CO_2 eq/m^2,year. As can be seen in figure 2, over the whole building life cycle, the operational energy use causes most emissions: 79 % of the overall emissions. Construction material production and the transportation of materials to the site together account for 18 %. The maintenance and material replacement and end-of-life phase both have a share of 1 % of the total emissions.

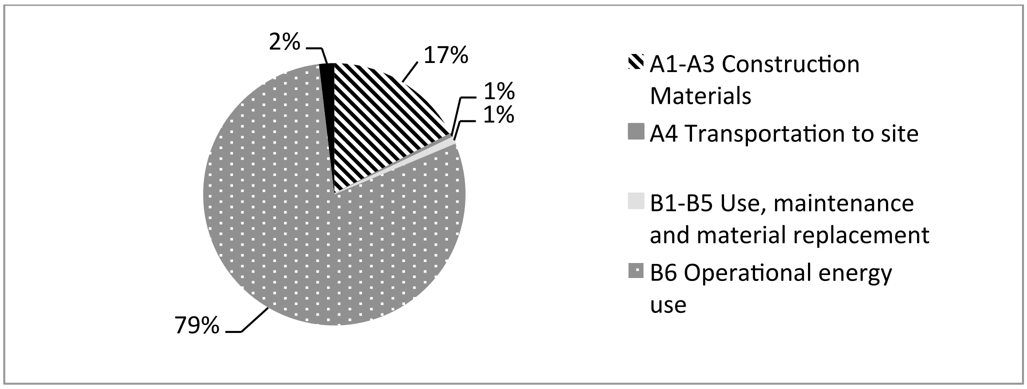

Figure 2 *The share of total GWP caused in different building life-cycle stages.*

As construction materials account for the largest share of embodied GHG emissions, 85 % for the case project, the building life-cycle stages A1-A3 are looked into in more detail. Material production related emissions were calculated using the three previously mentioned LCA tools. The results obtained for different building elements using the three tools are presented in table 2 below in carbon dioxide equivalents. As ILMARI automatically totals the emissions caused by transport of materials to the construction site with the emissions caused by materials manufacturing processes, the life-cycle stage A4 is also included in the case of ILMARI.

Table 2 *Greenhouse gas emissions in kg CO_2 eq caused by construction materials*

Building element	SimaPro	360Optimi	ILMARI
Foundations	5,98E+05	4,99E+05	7,15E+05
Ground floors	1,68E+06	8,16E+05	1,18E+06
Structural frame	1,65E+06	1,97E+06	1,88E+06
Facades	4,11E+05	5,40E+05	3,76E+05
Roofs	1,70E+05	4,58E+05	6,28E+05
Internal dividers	1,81E+05	3,70E+05	4,24E+05
Total	**4,69E+06**	**4,66E+06**	**5,20E+06**

As can be seen in table 2, building frame and ground floors cause most emissions according to results obtained using all three tools. Building frame causes most emissions according to 360Optimi and ILMARI, but the results obtained using SimaPro suggest that the ground floor causes slightly higher emissions. Due to the function of the building as large vehicle maintenance centre, the building ground floor needs to support heavy loads of truck and bus traffic inside. The reinforced concrete floor slab in the industrial spaces is partly even 300 mm thick. Foundations are the third most important element accounting for approximately the same share of GWP emissions (11-14 %) regardless of the tool. Also the share of internal dividers is relatively close (4-8 %) when calculated with all three tools. Most variance happens for the share of ground floors which for 360Optimi is 17 % and for SimaPro 36 %. Roofs and internal dividers seem to account for the smallest part of environmental impacts over the whole building life cycle regardless of selected tool.

4. Discussion

To answer the first research question of environmental life cycle impacts of an industrial building in Finland, the overall lifecycle greenhouse gas emissions of the case study building reach 2.68E+07 kg CO_2 eq. The material related embodied impacts are 5.51E+06 kg CO_2 eq and operational impacts 2.13E+07 kg CO_2 eq. Embodied life cycle impacts proved to present 21 % of overall life cycle impacts of the case building while operational impacts cover 79 %.

In figure 4, the embodied life cycle global warming potential of the case building is presented together with GWP of 19 other case buildings assessed in nine existing research studies. Since, there were no examples in previous research of an industrial building LCA, the results obtained in this study are compared with those of office and residential building LCAs. As can be seen in figure 4, the results of the study seem to be in line with previous research. Both the GWP value of 439kg CO_2 eq/m^2 for embodied impacts and the 29.3 CO_2 eq/m^2 ,year for operational impacts settle in the mid-range of the chart.

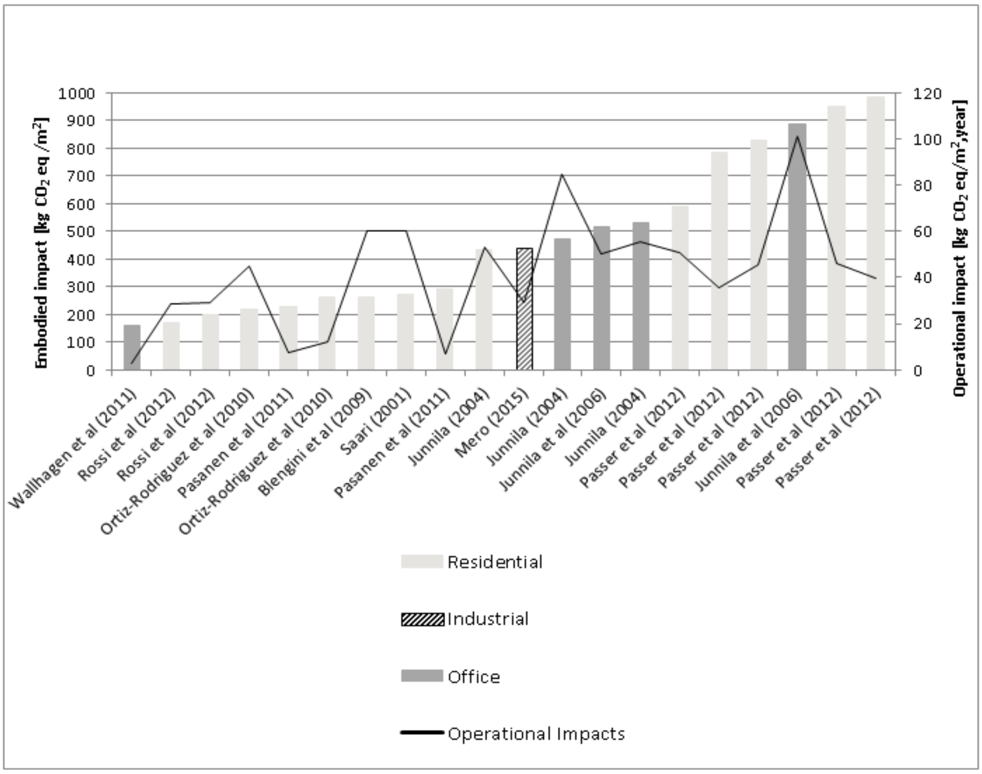

***Figure 3** Results of industrial building LCA in comparison with residential and office buildings*

It must be kept in mind that the studies are not comparable due to the differences in their scopes and the differences in studied buildings. Multiple reasons may explain why the results between studies vary. Scope of each LCA is determined to serve the goal of the study. Also the type of reported building area varies when some discuss net floor area (Passer, et al., 2012) (Blengini, 2009), others gross floor area (Junnila, 2004) and few heated area (Pasanen, et al., 2011).

As the LCA of the case building was conducted as process LCA, there are some fundamental limitations to the preciseness of the results obtained mainly due to the earlier mentioned truncation error and the decision made to exclude some of the building systems from the analysis. To recapitulate the main issue in truncation error is that the system boundary is limited when it comes to upstream activities in supply chain of construction materials production. Another issue in result preciseness is representativeness of the data in the three databases compared to the actual case building.

5. Conclusions

Based on the research results, industrial building life cycle impacts are similar to those of office and residential buildings. Most important when assessed in global warming potential are the use phase operational impacts followed by construction material production. In order to reach lower environmental impact over the whole building life cycle, most attention should hence be paid on efforts reducing operational energy use or the emission intensity of energy production. Of construction materials, most important elements are the building frame and ground floors followed by foundation structures. The share of embodied and operational emissions of the overall emissions is in line with previous research as was visualized in figure 4. Industrial buildings seem to prove no exception to office and residential buildings.

The LCA software industry has developed multiple software tools to calculate environmental life cycle impacts of buildings. Not all tools require extensive knowledge on LCA. Three LCA software tools were utilized in this study to quantify embodied environmental impacts of an industrial building. Considering the third and final research question, the results obtained using those three different tools proved to be similar but to still include some differences. The construction material production emission results varied from 4.66E+06 obtained using SimaPro to 5.20E+06 kg CO_2 eq obtained using ILMARI.

All tools prove same building elements to cause biggest impacts even though there are differences whether the building frame or ground floors cause higher emissions. As the same bill of quantity of construction materials was applied in each tool, difference in results can be concluded to be caused either by differences in the database each software tool uses or their impact assessment methodology. For example the greenhouse gas intensity of material production of different construction materials vary between the databases the tools use. It seems that the variances between databases for different materials are evened out when the whole building is analysed. Difference in greenhouse gas intensity of production of construction material might also be due to the selection of material within the database each tool uses.

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Carbon Emissions of Deluxe Hotels: An Empirical Investigation in Hong Kong

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Abstract

Hotels, which are part and parcel of the tourism industry, utilize resources for their round-the-clock operations. Deluxe hotels, in particular, consume substantial resources in order to satisfy the demands of upmarket patrons. Aimed at investigating the greenhouse gas emissions (commonly known as "carbon emissions") of deluxe hotels and their relations with the hotels' maintenance costs, a study was conducted based on empirical facilities management data. To gather reliable data of hotels' characteristics, utilities consumptions and maintenance costs, face-to-face interviews were held individually with the representatives of 12 hotels in Hong Kong. Based on the Hong Kong government's guidelines on quantification of carbon emissions, the collected data were processed to determine the emissions arising from resources consumptions of the hotels. Indirect emissions resulted from the use of electricity purchased from power companies dominated the carbon emissions of the hotels. Emissions due to the use of water and the associated waste water treatment were negligible. Among the characteristic parameters, gross floor area was found to be a better normalization factor for the emissions. Carbon emission was negatively correlated with capital project cost, implying that appropriate input of resources for facilities improvement could mitigate the emission. While these findings are useful information for hotel operators and facilities managers, further effort is needed to include more hotels in the analysis in order to obtain more representative results.

Keywords: Carbon, energy, greenhouse gas, hotel, maintenance cost, resources.

1. Introduction

Buildings are major consumers of energy (IPCC, 2007; WBCSD, 2009). With a remarkably high density of buildings, Hong Kong is among the energy-intensive cities. In parallel to the rise in energy use and resources consumptions for activities in buildings, the greenhouse gas emissions (GHGs) of Hong Kong have continued to increase (EPD, 2012), exceeding the levels of many developing countries (IEA, 2009).

In order to help the quantification of GHGs (commonly known as “carbon emissions”) of buildings, the Environmental Protection Department and the Electrical and Mechanical Services Department have jointly published a set of guidelines (EPD-EMSD, 2010). Unlike some overseas places where reporting of carbon emissions has become a regulatory requirement, it is not mandatory for building owners or facilities managers to report the carbon emissions of their buildings in Hong Kong (Lai, 2014). In fact, implementation of carbon audits has not been a common practice (Lai et al., 2012).

Around the world there have been various studies on carbon emissions of hotels (Filimonau et al., 2011). Besides purely theoretical studies, some empirical research works have been carried out using record data of buildings. In the study of Jiang and Tovey (2009) where nine commercial buildings in China were covered, the yearly carbon emissions associated with their electricity consumptions were around 158 kg/m^2. In Singapore, Wu et al. (2010) analyzed the carbon emissions of 29 hotels and showed that their carbon intensity ranking is sensitive to the denominator used for normalization. The study of Huang et al. (2015), which considered scope 1 and scope 2 emissions under the GHG Protocol (WRI-WBCSD, 2004), found that the annual average carbon emission level of Taiwanese luxury hotels was 132 kg/ m^2. In Hong Kong, a pilot carbon audit was carried out on a typical hotel (Lai et al., 2012) and the hurdles to making the audit complete include: lack of proper record of resources consumed by facilities; optional reporting of carbon emissions due to mobile combustion sources; and unavailability of record data pertaining to commercial tenants in the hotel.

Despite the difficulties in empirical carbon audits, a detailed comparative study covering not only GHG emissions due to energy use but also those arising from the use of other resources was conducted on three archetypes of hotels (Lai, 2015), each of which being an archetype of its own class: 5-star, 4-star and 3-star. In order to further investigate the carbon emissions of hotels, an extended research project was commenced. And because maintenance costs are often not fully understood (Chimack et al., 2006), their effects on reducing carbon emissions were examined under the project. As reported in the following, facilities management data of 12 hotels were collected. After describing the research methodology of the project, analyses made on the data collected are explained and discussed. At the end of this article are conclusions drawn from the analysed results and further works needed in the future.

2. Methodology

2.1 Scope and data collection

The scopes of carbon emissions covered in the study are summarized in Table 1. For Scope 1, the emissions are due to combustion of stationary and mobile sources. Scope 2 embraces emissions resulted from consumptions of purchased electricity and gas. Whereas the guidelines of EPD-EMSD

(2010) provide that it is optional to report other indirect emissions, Scope 3 emissions due to the use of water and associated treatment of waste water were included in the scope of the study. Quantification of such emissions necessitates record data of the corresponding utilities consumptions.

Table 1: Scopes of carbon emissions covered

Classification	*Emission activities*
Scope 1	• *Stationary sources combustion* • *Mobile sources combustion*
Scope 2	• *Consumption of purchased electricity* • *Consumption of purchased gas*
Scope 3	• *Consumption of fresh water* • *Treatment of waste water*

In order to identify the amounts of maintenance expenditures of the hotel buildings and investigate if such expenditures affect the volumes of the buildings' carbon emissions, cost items including those for engaging maintenance staff, covering repair and maintenance works, and financing capital projects such as renovation or improvement works (e.g. for replacement of energy inefficient equipment) were required. Because utilities consumptions and maintenance costs are often regarded as sensitive information (Lai et al., 2008), it is important to build up trust with representatives of the hotels before requesting them to provide the needed data. As such, a face-to-face interview was held with each of the representatives in order to collect reliable data. For utilities consumptions, the data collected include the hotels' annual consumptions of electricity, town gas, diesel oil and water. For maintenance costs, the interviewees were requested to provide their annual total maintenance expenditures, with breakdowns of staff payroll, repair and maintenance cost, and capital project cost. In addition, characteristic information about the hotels, including their class, building age, gross floor area, number of guestrooms, occupancy rate and number of guests, was collected.

2.2 Quantification of carbon emissions

The procedures and formulas used for calculating the amounts of carbon emissions of the hotels, which are based on the above-mentioned guidelines (EPD-EMSD, 2010), are described in the following.

Similar to the steps taken in an earlier study (Lai, 2015), the amount of carbon dioxide (CO_2) emitted from stationary and mobile sources of fuel combustions, which belong to Scope 1 carbon emissions, were obtained by inputting the amounts of fuels used and the emission factor of CO_2 for the respective fuel types into equation (1). Based on the same amounts of fuels used and by equations (2) and (3), the emitted amounts of methane (CH_4) and nitrous oxide (N_2O) were calculated.

$$E^{C}_{CO_2} = \sum_{f=1}^{f=F} \sum_{t=1}^{t=T} A_{f,t} \times F_{(CO_2)f} \tag{1}$$

$$E^{C}_{CH_4} = \sum_{f=1}^{f=F} \sum_{t=1}^{t=T} A_{f,t} \times F_{(CH_4)f} \times G_{(CH_4)} \tag{2}$$

$$E^{C}_{N_2O} = \sum_{f=1}^{f=F} \sum_{t=1}^{t=T} A_{f,t} \times F_{(N_2O)f} \times G_{(N_2O)} \tag{3}$$

Referring to the amount of electricity purchased from the respective power company (i.e. Hong Kong Electric Company or China Light and Power Company) during the reporting period, the corresponding amount of carbon emissions under Scope 2 was determined by equation (4). Likewise, the amount of emission due to the use of gas (i.e. town gas supplied by The Hong Kong and China Gas Company Limited) was calculated using equation (5).

$$E_{CO_2}^{E} = \sum_{t=1}^{t=T} A_{(E)t} \times F_{(E)t} \tag{4}$$

$$E_{CO_2}^{G} = \sum_{t=1}^{t=T} A_{(G)t} \times F_{(G)t} \tag{5}$$

For Scope 3 carbon emissions, the amounts of CO_2 emitted from the use of electricity for processing the fresh water consumed were determined by equation (6). Similarly, those emitted from the use of electricity for processing the resultant sewage were calculated by equation (7), where the default emission factor is dependent on whether the water was used by restaurants or for catering services (equation (8)).

$$E_{CO_2}^{W} = \sum_{t=1}^{t=T} A_{(W)t} \times F_{(W)t} \tag{6}$$

$$E_{CO_2}^{S} = \sum_{t=1}^{t=T} A_{(W)t} \times F_{D|(W)t} \tag{7}$$

$$F_{D|(W)_t} = C_a \times F_{(S)t} \tag{8}$$

The total maintenance cost of the hotels, consisting of maintenance staff cost, repair and maintenance cost, and capital project cost, was calculated using equation (9).

$$C_T = \sum_{t=1}^{t=T} C_{(S)t} + C_{(R)t} + C_{(P)t} \tag{9}$$

Notations for the above equations:

$A_{(E)t}$ = amount (kWh) of electricity used in the t^{th} period
$A_{f,t}$ = amount (litre) of the f^{th} type of fuel used in the t^{th} period
$A_{(G)t}$ = amount (unit; 1 unit = 48 MJ) of gas used in the t^{th} period
$A_{(W)t}$ = amount (m^3) of fresh water used in the t^{th} period
C_a = activity-dependent factor (0.7 for restaurants and catering services; 1.0 for other commercial, residential and institutional purposes)
$C_{(P)t}$ = capital project cost (HK$) in the t^{th} period
$C_{(R)t}$ = repair and maintenance cost (HK$) in the t^{th} period
$C_{(S)t}$ = maintenance staff cost (HK$) in the t^{th} period
C_T = total maintenance cost (HK$)
$E_{CH_4}^{C}$ = CH_4 emission (kg) due to stationary or mobile sources of fuel combustions
$E_{CO_2}^{C}$ = CO_2 emission (kg) due to stationary or mobile sources of fuel combustions
$E_{CO_2}^{E}$ = CO_2 emission (kg) due to use of purchased electricity
$E_{CO_2}^{G}$ = CO_2 emission (kg) due to use of purchased gas
$E_{CO_2}^{S}$ = CO_2 emission (kg) due to processing of sewage
$E_{CO_2}^{W}$ = CO_2 emission (kg) due to use of fresh water
$E_{N_2O}^{C}$ = N_2O emission (kg) due to stationary or mobile sources of fuel combustions
$F_{(CH_4)f}$ = emission factor of CH_4 for the f^{th} type of fuel

$F_{(CO_2)f}$ = emission factor of CO_2 for the f^{th} type of fuel
$F_{D|(W)t}$ = default emission factor (kg/m^3) of electricity consumed associated with the amount of sewage processed in the t^{th} period
$F_{(E)t}$ = emission factor of electricity used in the t^{th} period (specific for individual power companies)
$F_{(G)t}$ = emission factor (kg/unit) of gas used in the t^{th} period
$F_{(N_2O)f}$ = emission factor of N_2O for the f^{th} type of fuel
$F_{(S)t}$ = emission factor (kg CO_2-e/kWh) of electricity consumed associated with the amount of sewage processed in the t^{th} period
$F_{(W)t}$ = emission factor (kg CO_2-e/m^3) of electricity consumed associated with the amount of water used in the t^{th} period
f = 1, 2, …, F (assigned to the f^{th} type of fuel; F = total number of fuel types)
$G_{(CH_4)}$ = global warming potential of CH_4
$G_{(N_2O)}$ = global warming potential of N_2O
t = 1, 2, …, T (assigned to the t^{th} period; T = total number of time periods)

2.3 Correlation analysis

After the above calculations of carbon emissions and maintenance costs, the Pearson product-moment correlation coefficient (r), which is a measure of the correlation between different pairs of independent variable (X) and dependent variable (Y) under investigation, was computed using Equation (10), where each of the tested datasets [(x_1, ..., x_n); (y_1, ..., y_n)] contains n items. The value of r ranges between -1 and +1, with -1 indicating total negative correlation, 0 for no correlation, and +1 for total positive correlation.

$$r = \frac{n\sum_{i=1}^{i=n} XY - \sum_{i=1}^{i=n} X \sum_{i=1}^{i=n} Y}{\sqrt{[n(\sum_{i=1}^{i=n} X^2) - (\sum_{i=1}^{i=n} X)^2][n(\sum_{i=1}^{i=n} Y^2) - (\sum_{i=1}^{i=n} Y)^2]}} \quad (10)$$

3. Results and Discussion

3.1 Characteristics and utilities consumptions

Data of 12 deluxe hotels were collected and the major characteristics of the hotels are summarized in Table 2. None of the hotels was newly completed; on average the hotels were about 15 years old, with the newest and the oldest being 2 and 27 years old respectively. Ranging from 14,975 to 60,493 m^2, the mean gross floor area of the hotels was 46,533 m^2. In total, there were 5,300 guestrooms in the hotels. The mean (442) and median (457) number of guestrooms were comparable. Reflecting a generally high user demand, the mean annual occupancy rate was 82.6% and the rate of the most popular hotel was as high as 90.0%. In terms of number of guests, the lowest was 74,241 per year while the highest amounted to 378,815 per year, or 1,038 per day.

Table 2: Age, scale and occupancy of the hotels

	Mean	*Median*	*Min.*	*Max.*	*S.D.*
Age (year)	*15.3*	*16.5*	*2*	*27*	*8.8*
Floor area (m^2)	*46,533*	*48,783*	*14,975*	*60,493*	*12,215*
Guestroom (nos.)	*442*	*457*	*113*	*602*	*135*
Occupancy rate (%)	*82.6*	*84.4*	*65.0*	*90.0*	*7.8*
Guests per year (nos.)	*265,420*	*270,027*	*74,241*	*378,815*	*85,860*

The main energy sources of the hotels were diesel oil, town gas and electricity. Seven of the hotels used diesel oil for cooking or heating purposes and the mean annual consumption was 313,422 litres (Table 3). Town gas was used for the same purposes in all the 12 hotels. Varying from 10,757 to 1,152,438 units (1 unit = 48 MJ), the mean annual consumption level of town gas was 280,460 units. The last, but not the least, energy source was electricity. All the hotels used it for running electrical installations and, on average, 16,558,556 kWh was consumed per year per hotel. In addition, water is an indispensable utility for all the hotels. Altogether they consumed over 2.1 million m^3 of water a year, with the smallest annual consumption being 43,305 m^3 and the largest being 297,000 m^3.

Table 3: Annual utilities consumptions of the hotels

	Mean	*Median*	*Min.*	*Max.*	*S.D.*
Diesel (litre)	*313,422*	*26,615*	*0*	*1,081,260*	*423,608*
Town gas (unit)	*280,460*	*221,692*	*10,757*	*1,152,438*	*299,540*
Electricity (kWh)	*16,558,556*	*15,304,937*	*4,434,537*	*30,305,782*	*7,113,756*
Water (m^3)	*175,567*	*181,618*	*43,305*	*297,000*	*67,544*

3.2 Carbon emissions

Scope 1 carbon emissions consist of direct emissions resulted from combustion of diesel oil and town gas at stationary sources in the hotels. The amounts of such direct emissions, which cover various greenhouse gases (CO_2, CH_4 and N_2O), were determined using Equations (1) to (3). As summarized in Table 4, the annual amount of carbon emission due to the use of diesel oil varied from over 2.8 million kg CO_2-equivalent (CO_2-e) to nil (where diesel oil was not used). Town gas was used in all the hotels and the resultant amount of carbon emission under Scope 1 was on average 716,017 kg CO_2-e per hotel.

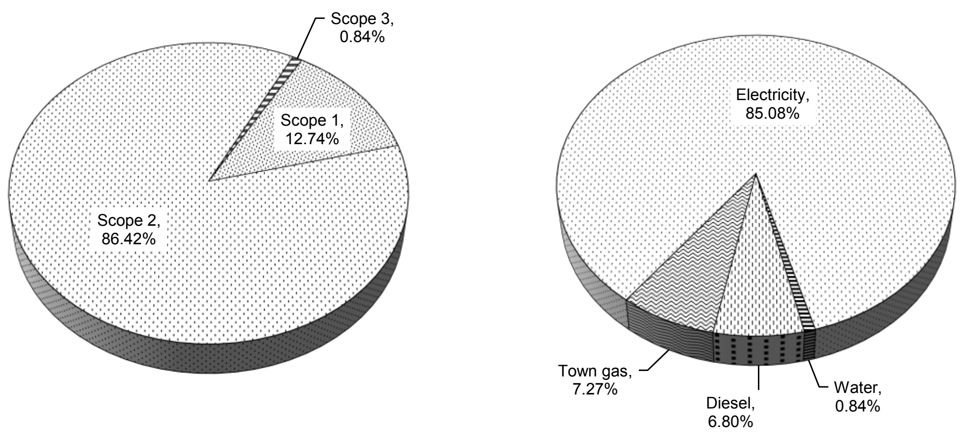
Belonging to Scope 2 (i.e. energy indirect emissions) are carbon emissions due to consumption of purchased electricity and town gas, which were determined using Equations (4) and (5) respectively. Clearly, electricity was a dominant energy source for the hotels; its consumptions gave rise to a mean annual emission level of over 10.2 million kg CO_2-e, and the median level among the hotels, exceeding 10.1 million kg CO_2-e, was comparable. When compared with the Scope 1 counterpart, the carbon emissions due to consumption of purchased town gas under Scope 2, between 6,176 kg CO_2-e and 661,591 kg CO_2-e, were significantly less.

Table 4: Summary of annual carbon emissions (in kg CO_2-e)

	Mean	*Median*	*Min.*	*Max.*	*S.D.*
Scope 1- Diesel	*820,160*	*69,645*	*0*	*2,829,437*	*1,108,496*
Scope 1 - Town gas	*716,017*	*565,980*	*27,464*	*2,942,179*	*764,728*
Scope 2 - Electricity	*10,262,336*	*10,143,168*	*3,503,284*	*17,171,440*	*4,226,174*
Scope 2 - Town gas	*161,007*	*127,269*	*6,176*	*661,591*	*171,960*
Scope 3 - Water	*101,864*	*105,374*	*25,126*	*172,319*	*39,189*

Emissions resulted from the use of water, under Scope 3, were obtained using Equations (6) to (8). Ranging between 25,126 kg CO_2-e and 172,319 kg CO_2-e, the mean and median levels of this category of emissions have the same order of magnitude as those of town gas under Scope 2.

Based on the total amounts of carbon emissions of the hotels, the proportions of the three scopes of emissions were worked out, as shown in Figure 1(a). Scope 2 emissions, representing over 86% of the total emissions, were dominant. In contrast, the proportion of Scope 1 emissions was small, and that of Scope 3 was even less. When categorized by energy source type, most (over 85%) of the carbon emissions were resulted from the use of electricity. The proportion of emission due to consumption of town gas, at about 7%, was a distant second. A slightly lower proportion (6.8%) of the total emission was produced from using diesel oil. The use of water added a negligible amount to the total emission.



(a) *(b)*

Figure 1: Proportions of carbon emissions

3.3 Normalization of carbon emissions

As observed from the major characteristics above (Table 1), the sampled hotels varied in age, scale and occupancy. Making direct comparisons between the amounts of carbon emissions of hotels with different ages would not be fair because their facilities' conditions and hence their required amounts of resources consumptions may be different. For hotels with different sizes, it is obvious that comparing their raw amounts of carbon emissions would not be fair. Likewise, a hotel with a higher occupancy is expected to consume more resources than one with a lower occupancy. As the former hotel would have a larger amount of carbon emissions, it would be unfair to compare its carbon emission with that of the latter hotel.

For the above reasons, it is necessary to identify an appropriate parameter for normalizing the amounts of carbon emissions before they could be compared and analysed further. To this end, an initial step was taken to figure out the proportions of the three scopes of carbon emissions normalized by different factors that are of potential influence on the amounts of emissions. As the results in Table 5 show, the proportions for the case where the emissions were without normalizations (i.e. the base case) were: 12.74% (Scope 1), 86.42% (Scope 2) and 0.84 (Scope 3). For the cases where the emissions were normalized by floor area and number of guestrooms of the hotels, the proportions were not largely different from those of the base case. The largest differences from the base case values were found with the case where annual number of guests was used as the normalization factor. But such differences, ranging from -6.5% (Scope 1) to +1.0% (Scope 2), were not substantial.

Table 5: Proportions (%) of normalized carbon emissions

	Normalization factor			
	None	*Floor area (m^2)*	*No. of guestrooms*	*Annual no. of guests*
Scope 1	*12.74*	*12.71*	*12.31*	*11.91 [-6.5%]*
Scope 2	*86.42*	*86.47*	*86.88*	*87.28 [+1.0%]*
Scope 3	*0.84*	*0.83*	*0.81*	*0.81 [-3.6%]*

Note: Values in square brackets are differences from the base case values.

Further to the above step, a series of trials were carried out by preparing scatter plots of the hotels' total carbon emissions against their ages, scales and occupancies. Not different from the anticipated result, the total carbon emissions of the hotels generally increase with their number of guestrooms (Figure 2). Nevertheless, the R^2 value of the best-fit trend line for this scatter plot was low, at 0.2445 only. Another scatter plot, as shown in Figure 3, was made by showing the distribution of the total carbon emissions against the hotels' gross floor areas. An upward trend similar to that in the preceding figure was noted. Whereas both number of guestrooms and gross floor area can represent the scales of the hotels, the goodness of fit of the trend line for the scatter plot based on gross floor area was significantly higher (R^2 = 0.4507).

A further trial of scatter plot was made by showing the total carbon emissions of the hotels against the numbers of guests they received (Figure 4). Although this plot exhibits also an upward trend, the rise in the emissions with increase in number of guests was relatively gentle and the R^2 value of the trend line was only 0.1745. Given that occupancy rate is an alternative parameter that can reflect user demand, data of the hotels' occupancy rates as well as their total carbon emissions were used to prepare another scatter plot. But as shown in Figure 5, no apparent trend was observed.

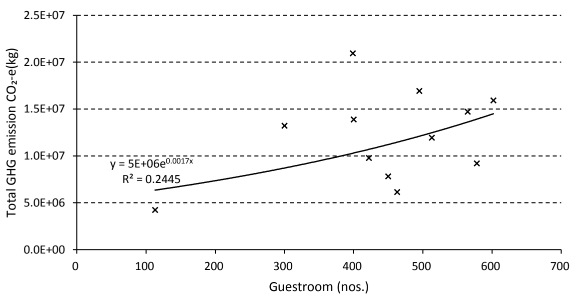


Figure 2: Total carbon emission against number of guestrooms

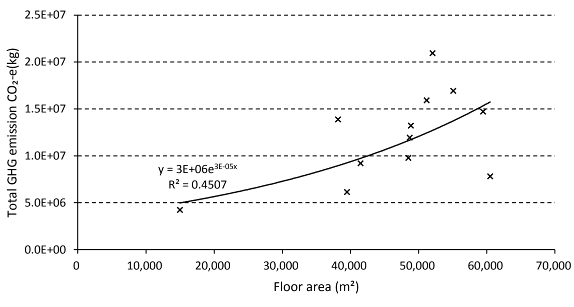


Figure 3: Total carbon emission against gross floor area

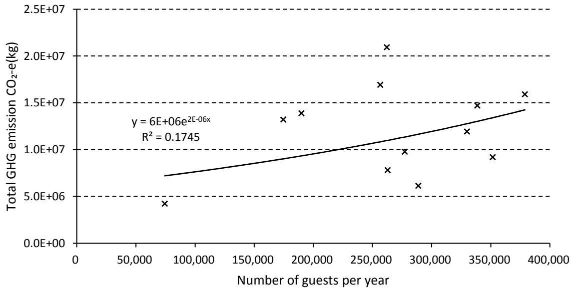


Figure 4: Total carbon emission against number of guests

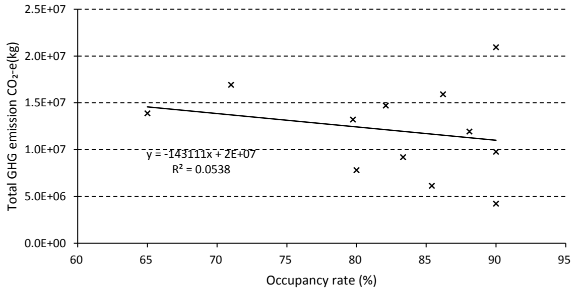
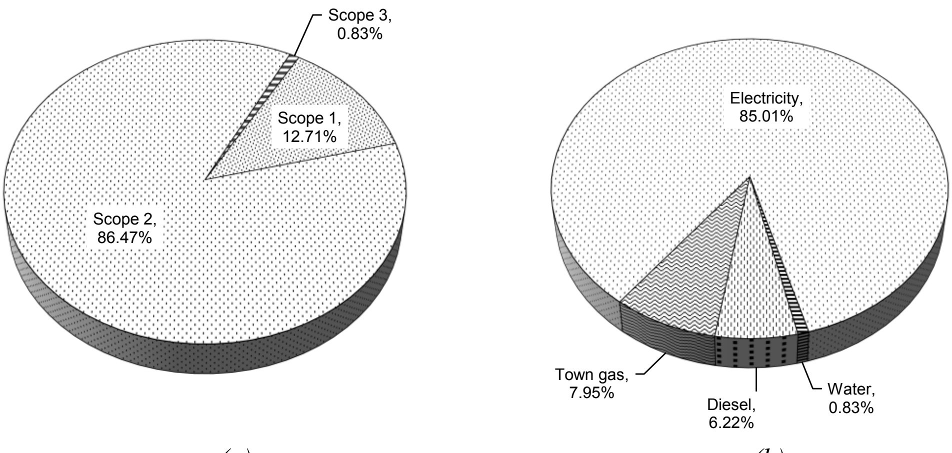


Figure 5: Total carbon emission against occupancy rate

From the above trials, it can be concluded that the total carbon emissions of the hotels vary more closely with their gross floor areas than the other three parameters (i.e. number of guestrooms, number of guests, and occupancy rate). On this basis, gross floor area was selected as the parameter for normalizing the carbon emissions, and the normalized emission values were used in the ensuing analyses.

Based on the total amounts of carbon emissions normalized by the gross floor areas of the hotels, proportions of the three scopes of emissions were calculated. Emissions belonging to Scope 2, as shown in Figure 6(a), contributed to over 86% of the total emission, which is almost the same as that shown in Figure 1(a). The contribution due to Scope 1 activities was comparatively small, at about 12%. The proportion of Scope 3 was negligible.

As for the normalized carbon emissions categorized by energy source, the proportion resulted from the use of electricity was dominant, at about 85% (Figure 6(b)). Similar to the results shown in Figure 1(b), the proportions of emissions due to the use of town gas, diesel oil and water were relatively small.



(a) *(b)*

Figure 6: Proportions of normalized carbon emissions

3.4 Maintenance cost and its relation with carbon emission

Of the 12 hotels, 11 provided data of maintenance staff cost and repair and maintenance cost. Data of capital project cost for covering improvement work (e.g. installation of energy saving devices) were available from eight of the hotels. On average, the capital project cost and the repair and maintenance cost, at about 9.8 million and 9.6 million respectively, were comparable, and they made up the majority of the total maintenance cost. But the minimum, maximum and standard deviation values show that the variations in capital project cost were larger.

Table 6: Annual maintenance costs (HK$) of the hotels

	Mean	*Median*	*Min.*	*Max.*	*S.D.*
Repair & maintenance [n=11]	*9,641,863*	*7,900,000*	*1,700,000*	*18,414,369*	*5,426,597*
Capital project [n=8]	*9,849,487*	*6,937,611*	*1,191,000*	*23,000,000*	*7,765,165*
Maintenance staff [n=11]	*6,731,237*	*6,240,000*	*4,287,780*	*12,000,000*	*2,349,788*
Total maintenance [n=8]	*26,357,122*	*28,281,514*	*13,813,362*	*35,000,000*	*7,130,428*

In order to test whether the amounts of carbon emissions were dependent on the resources spent on maintenance for the hotels, Equation (10) was used to compute the Pearson product-moment correlation coefficient (r) for different pairs of maintenance cost items and scopes of carbon emissions. For this part of computations, values of normalized maintenance costs (HK$/$m^2$) and normalized carbon emissions (CO_2-e/m^2) were used. The results, as summarized in Table 7, show that there was no perfect correlation between any pair of the parameters. The only case where a significant correlation was found was between capital project cost and Scope 3 emission (r = -0.7096). The correlation was negative, meaning that the amount of Scope 3 emission decreased with increase in capital project cost. This suggests that the capital projects probably covered improvement work for reducing water use, thus leading to drop in Scope 3 emission (Equations 6 to 8).

Table 7: Pearson r coefficients between maintenance costs and carbon emissions

	Scope 1 emission	*Scope 2 emission*	*Scope 3 emission*	*Total emission*
Repair & maintenance	*0.1302 [0.7028]*	*0.1281 [0.7074]*	*0.0173 [0.9598]*	*0.1462 [0.6680]*
Capital project	*-0.1746 [0.6793]*	*-0.3743 [0.3609]*	*-0.7096 [0.0487*]*	*-0.3644 [0.3749]*
Maintenance staff	*-0.2366 [0.4836]*	*0.3796 [0.2496]*	*-0.1535 [0.6522]*	*0.2876 [0.3911]*
Total maintenance	*0.2307 [0.5825]*	*0.3966 [0.3306]*	*-0.0603 [0.8873]*	*0.3891 [0.3408]*

*Notes: Figures in square brackets are significance values; *correlation is significant at the 0.05 level (2-*tailed).

On the other hand, it was anticipated that a larger input of resources for repair and maintenance work would help improve the performance of facilities in the hotels, leading to reduction in the corresponding carbon emissions. Likewise, maintenance staff with a higher remuneration would perform better in operating the facilities, thereby minimizing the amounts of resources used and hence their carbon emissions. But these anticipations were not supported by the above results, as there were no significant correlations between the remaining pairs of parameters.

4. Conclusions

Reliable data of 12 deluxe hotels were collected through face-to-face interviews with the hotels' representatives. Among the three scopes of carbon emissions studied, Scope 2 emissions dominated as the hotels relied heavily on the use of electricity purchased from power companies. On average, the amounts of emissions resulted from the use of town gas and diesel oil were comparable. Water consumptions and the associated sewage treatment accounted for a negligible portion of the total carbon emissions.

Using different factors to normalize the carbon emissions led to different results. When compared with number of guestrooms, number of guests and occupancy rate, gross floor area was found to be a better normalization factor for the emissions.

The cost of capital projects and that for repair and maintenance accounted for the majority of the hotel's maintenance expenditures. The finding that there existed a significant, negative correlation between capital project cost and carbon emission shows that appropriate input of resources for improving the facilities in the hotels could mitigate carbon emission. As the representativeness of the above results is limited by the number of hotels covered so far, it is necessary to include more samples in the analysis in future.

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Part I: Environmental Opportunities and Challenges

1. Sustainability Assessment
2. Nature and Outdoor Conditions

Building community resilience within involuntary displacements by enhancing collaboration between host and displaced communities: A literature synthesis

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Abstract

Improving resilience through empowerment of communities is becoming a much sought after strategy for community level disaster preparedness. Community resilience is the ability of a community to bounce back to its operational equilibrium after a hazardous stress. This ability builds up over time based on many underlying factors such as community's age distribution, food supply, livelihood, population stability, indigenous knowledge, and communication capacity. Often, these factors make communities different from one another and define their level of resilience to disasters and other hazardous stresses.

Involuntary relocations alter the equilibrium position and stress absorbing ability of a community by merging two (or more) communities with different resilience equilibrium positions. In this case, resilience of these communities towards potential disasters could be disturbed. Therefore, when involuntary relocations are to be exercised, maximising the potential and collaboration of the communities is essential to enhance the overall resilience of the communities involved. Accordingly, this paper aims to develop a conceptual model to integrate possible mechanisms to build community resilience within involuntary settlements by enhancing collaboration between host community and displaced community.

This study was conducted through a comprehensive literature review to investigate the research question: 'How involuntary settlements alter the resilience of the communities in Sri Lanka?' It has been found that the operational equilibrium of host and displaced communities would make a shift immediately after relocation, because introduction of a new community will alter the context of all the influencing factors of a community's resilience. That shift would also be higher for the displaced community compared to the host community.

Consequently, the prospects for the people who have been expelled from their habitual residence are often uncertain as they are forced to live in a place among people with different culture and behaviour. Furthermore, economic status, social settings and psychological aspects could also act as stress factors that affect the resilience of the community. It is challenging to build community resilience between two communities, which are different from one another. Besides, time and financial constraints often act as barriers for resettlement planners to consider such aspects during relocation planning. Therefore, an integrated approach to build community resilience needs to be incorporated in the policy design and decision-making of relocations by drawing possible linking mechanisms that facilitate collaboration between communities

Keywords: Community resilience, Involuntary relocations, Host communities, Displacements

1. Introduction

The rate of Internally Displaced Persons (IDPs) who have been displaced within national boundaries is increasing considerably without drawing much attention of the world. International Organization for Migration (2004) defines IDPs as ‘persons or groups of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalized violence, violations of human rights or natural or human-made disasters, and who have not crossed an internationally recognized State border’ (pp.32-33). Major reasons for the internal displacements are conflicts, consequences of change in the land usage, and natural disasters (Betts, 2009). People without the ability and/or wealth to move away from any of these three situations are known as trapped population (Foresight, 2011). The government, relevant local authorities, or non-governmental organisations relocate this trapped population to safeguard against the negative effects of disruptive events. In contrast to the voluntary displacements, these involuntary relocations are not self-selected or self-motivated (Cao, Hwang, & Xi, 2012).

Generally, involuntary relocations aim at improving the lives of the trapped population. Also, ‘Guiding principles on internal displacements’ (United Nations, 2004) states in its Principle 7 that, the authorities undertaking such displacement shall ensure, to the greatest practicable extent, that proper accommodation is provided to the displaced persons, that such displacements are effected in satisfactory conditions of safety, nutrition, health and hygiene, and that members of the same family are not separated. However, involuntary relocation often acts only as a temporary relief and fails to ensure IDPs’ long-term modes of livelihood (Perera, Weerasoori, & Karunarathne, 2012).

Immediate consequences of involuntary resettlements have an effect on both displaced community and host community. Host community is defined herein as the community in whose neighbourhood the displaced people are relocated (Kabra & Mahalwal, 2014). For example, social disintegration and severe impoverishment are some of the immediate consequences of involuntary displacements, which affect the economy of the region (Cernea, 1995). According to Cernea (1995), IDPs have higher possibilities to experience eight negative consequences: landlessness, joblessness, homelessness, marginalisation, food insecurity, increased morbidity, social disintegration, and loss of access to common resources (Xi, Hwang, & Drentea, 2013). Therefore, the host community often blames the IDPs for their economic losses.

Further, cultural, regional, and ethnic differences between host and displaced communities often trigger discrimination and racism in their day-to-day life (International Committee of the Red Cross, 2011). Consequently, the prospects for the people who have been expelled from their habitual residence are often uncertain as they are forced to live in a place among people with different, culture and behaviour (Berry, 1997). Furthermore, economic status, social settings and psychological aspects could also act as stressors that affect the resilience of the community.

Every community has a level of resilience towards disasters. In general, resilience refers to the ability of a system to return to its equilibrium position after a disturbance (Proag, 2014). The term community resilience refers to the capacity and the ability of a community to return to its equilibrium position using community resources after unexpected disruptive events (Magis, 2010). Resilience of a community builds up based on many underlying factors over the time. Those factors include the community's age distribution, food supply, livelihood, housing stock construction quality, population stability, indigenous knowledge, infrastructure availability, and communication capacity (Cutter, Ash, & Emrich, 2014). These factors make communities different from one another.

Involuntary relocations make a community to displace involuntarily and another community to host involuntarily (Kabra & Mahalwal, 2014). Operational equilibrium of these communities would make a shift immediately after relocation, because introduction of a new community will alter the context of all the influencing factors of a community's resilience. Also, that shift would be higher for the displaced community compared to the host community. It is challenging to build community resilience between two communities, which are different from one another. Besides, time and financial constrains often act as barriers for resettlement planners to consider such aspects during relocation planning (Perera et al., 2012).

Sri Lanka is a country that experienced all types of displacements (Das, 2008). According to the Ministry of Resettlement Reconstruction and Hindu Religious Affairs Sri Lanka (2015), around 45,000 IDPs are yet to be resettled in Sri Lanka. On the contrary, Internal Displacement Monitoring Centre (IDMC), an international non-governmental humanitarian organisation stated that, as of 2015 around 73,700 IDPs remain to be resettled in Sri Lanka. These figures show that a considerable number of IDPs are yet to be resettled in Sri Lanka, although the actual number has not been established owing to practical difficulties.

A number of case studies in Sri Lanka (Das, 2008; Manatunge, Herath, Takesada, & Miyata, 2009; Perera et al., 2012; Takesada, Nakayama, & Fujikura, 2009) also provided evidence to the effect that the incompatible community integration would affect the community resilience and slow the rate of recovery process. Therefore, the importance of collaboration between the host and displaced communities needs to be drawn upon in addressing the economic, social, cultural and psychological consequences of involuntary relocation projects in Sri Lanka. Furthermore, an integrated approach to community resilience by drawing mechanisms to facilitate collaboration between communities needs to be incorporated in the policy design and decision-making.

2. Literature Review

This study was conducted through a comprehensive literature review to investigate the research question: 'How involuntary settlements alter the resilience of the communities in Sri Lanka?' Peer reviewed journal papers, official reports, conference proceedings, and books have been referred in order to gather the data for this study. Collected data were analysed and synthesised to draw conclusions.

2.1 Disaster-induced relocations

Disasters have been defined in different ways depending on the contexts and disciplines. Combs, Quenemoen, Parrish, and Davis (1999) defined disasters as 'a time and place specific event that originates in the natural environment and the resulting disruption of the usual functions and behaviours of the exposed human population' (p.1125). However, this definition doesn't reflect the severity of the event. United Nations International Strategy for Disaster Reduction (UNISDR, 2009) defines disasters as 'a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources' (p.9). This definition represents the same as Comb's with a special emphasis on severity of the event. Drawing from the above definitions, disasters can be defined as disruptions that put the community in need for external assistance for recovery. For the purpose of this research, UNISDR's definition has been adopted as the definition for disasters.

EM-DAT: The International Disaster Database (2015) classifies the disasters based on its technicality as natural disasters and technological disasters. It further subdivides the natural disasters into geophysical, meteorological, hydrological, climatological, biological, and extra-terrestrial. As well as, it subdivides the technological disasters into industrial accidents, transport accidents, and miscellaneous accidents. However, an older classification by Robinson (2003) suites this article more as it is classified based on the time taken for the displacement. Robinson (2003) classifies the disasters into two main types: natural disasters and man-made disasters. It can be further divided into five subcategories (Refer Table 1). Among these types, sudden impact disasters and complex emergencies trigger immediate displacements, whereas the other types of disasters give time for a planned relocation. These categories need to be handled differently, because the people who have been displaced due to sudden impact disasters and complex emergencies might live in temporary shelters soon after the disasters. Therefore, government needs to pay immediate attention in order to reduce their vulnerability and to ensure their wellbeing.

Table 1: Disaster types that induce displacements

Natural Disasters	*Sudden impact disasters*	*Flood, earthquake, storm, volcanic eruption, landslide, tsunami*
	Slow-onset disasters	*Drought, famine, environmental degradation, deforestation, pest infestation, desertification*
	Epidemic disasters	*Cholera, measles, dysentery, respiratory infections, malaria*
Man-made Disasters	*Industrial/technological disasters*	*Activities that lead to pollution, spillage of hazardous materials, explosions, and fires*
	Complex emergencies	*War, internal conflict, human rights violation*

Source: (Robinson, 2003)

Disaster types recommended by Robinson (2003) can be categorised as shown in the Figure 1 depending on the urgency for displacement. Disaster types that are written in the grey box (Figure 1) could trigger immediate displacement or eventual displacement depends on the severity. People who have been displaced because of disasters that trigger immediate displacement would move to temporary shelters. If resettling in the same habitual residence is impossible, relevant authorities relocate them to another location permanently or semi-permanently.

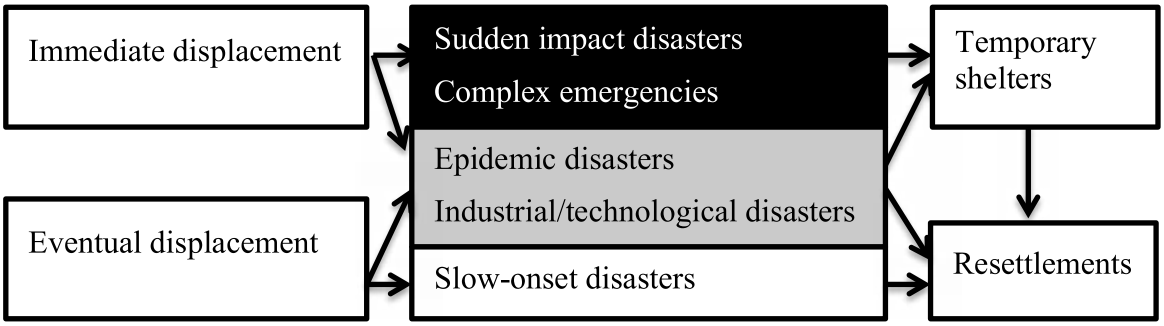

Figure 1: Urgency of displacements and disaster types

However, there are so many challenges associated in planning and implementing relocation programmes. Time is often not sufficient for proactive planning and community consultations, as it requires immediate decisions (Badri, Asgary, Eftekhari, & Levy, 2006). On one hand, living and adopting a new environment is always a challenge for the displaced persons and on the other hand hosting a new community is a challenge for the host population.

2.2 Community Disaster Resilience

Literature on disaster management is intertwined in multi-discipline approach bringing together scholars from different areas (Beggan, 2011). Progressively, the knowledge and practices of disaster resilience have been highlighted in recent past. Community disaster resilience is the ability of a community to bounce back to its operational equilibrium, while retaining its structure and identity, using common resources after an unexpected hazardous stress (Magis, 2010). However, Manyena, O'Brien, O'Keefe, and Rose (2011) argue that, the community will be in the same vulnerable state at which it has already been before the disaster, if the community bounced back to its same operational equilibrium position. Therefore, disaster resilience should be the ability of the community to bounce forward to a better position. Similarly, Aldunce, Beilin, Handmer, and Howden (2014) stated that, bouncing back to the same position is almost impossible, because disasters alter some of the characteristics which determines the equilibrium position of the community. Based on those arguments, community disaster resilience can be defined as the ability of a community to bounce forward and adopt changes within the possible minimum time using common resources while returning its essential attributes after a hazardous stress.

Generally, resilience is a system which build upon several subsystems (Holling, 1973). Similarly, disaster resilience of a community also builds up over time based on several subsystems such as social, economic, institutional, infrastructure and built environment, and community capital (Cutter, Burton, & Emrich, 2010). Researchers have identified four dimensions (4Rs) of resilience that build the properties of subsystems' resilience (Bruneau et al., 2003; Cimellaro, Reinhorn, & Bruneau, 2010). They are Rapidity, Robustness, Redundancy, and Resourcefulness (Refer Table 2).

Table 2: Four dimensions of resilience

Rapidity	*The capacity to meet priorities and achieve goals in a timely manner in order to contain losses and avoid future disruption*
Robustness	*The capacity to meet priorities and achieve goals in a timely manner in order to contain losses and avoid future disruption*
Redundancy	*The capacity to satisfy functional requirements in the event of disruption, degradation, or loss of functionality*
Resourcefulness	*The capacity to identify problems, establish priorities, and mobilize resources when conditions exist that threaten to disrupt some element, system, or other unit of analysis*

Source: (Bruneau et al., 2003, pp. 737-738)

Proag (2014) illustrated operational equilibrium/ desired functionality level as a steady state in his study. However, functionality of a community is not an outcome but a process (Cox & Hamlen, 2015). Therefore, the community's operational equilibrium cannot always be illustrated as a steady state. Because, the factors that build up the resilience will keep on changing over the time and space. Based on these facts it can be presumed that the resilience of a community cannot be equally distributed among the whole community. Further, Berkes, Colding, and Folke (2003) stated that, considering resilience within a particular time span, a single steady state is impossible whereas multiple stable states are possible. These multiple states can be the level of resilience in different aspects such as economic resilience, social resilience, ecological resilience, and built environment related resilience of a community. Within a given time, the equilibrium of a particular sector of resilience can be a single steady state. It can be illustrated as shown in the Figure 2. The recovery curve that is the equilibrium curve after the disaster can be altered depends on several factors such as intensity of the disaster, availability of resources, construction recovery, and amount of business interuption. Cimellaro et al. (2010) argues that, it is difficult to predict the tendency of recovery as it depends on several factors subject to the type of disaster, level of interuption, and state of the commuinity. Also, any forms of alterations in the community would change the tendency of their recovery.

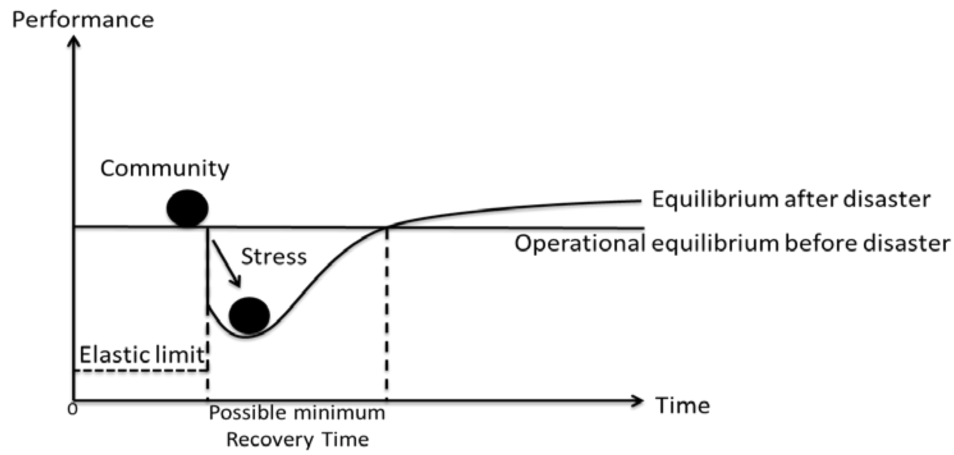

Figure 2: Resilience of a particular sector of a community

2.3 Involuntary relocations and community disaster resilience of Sri Lanka

Involuntary relocation alters the equilibrium position and stress absorbing ability of a community by introducing another community, which has a different equilibrium position. In this case, resilience of these two communities towards potential disasters could be disturbed (Refer Figure 3). Therefore, maximising the potential and collaboration of the communities is essential to enhance the overall resilience of the communities. Therefore, this research focuses on building community resilience within involuntary settlements by enhancing collaboration between host community and displaced community in Sri Lanka. Sri Lanka experienced a variety of displacements. Recent Sri Lankan case studies (Das, 2008; Manatunge et al., 2009; Perera et al., 2012; Takesada et al., 2009) encountered different issues that slowed the process of recovery after involuntary resettlement.

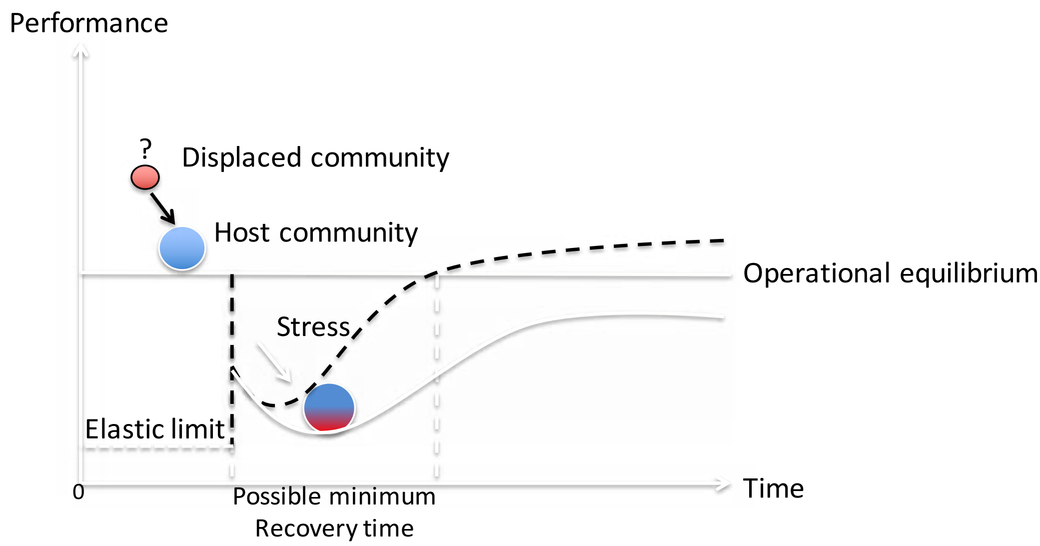

Figure 3: Resilience of a particular sector of a community after the relocation

Case 1

In 1977 the Government of Sri Lanka accelerated the Mahaweli multipurpose project to generate hydroelectric power, store and divert water for irrigation, downstream water regulation for flood control, develop human settlements, and provide physical and socio-economic facilities to settlements. This project forced around 3400 families including 900 families who are from areas prone to earth slips to relocate (Manatunge et al., 2009). However, settlers did not express satisfaction about the arrangements for more than two decades, which is a very slow recovery (Takesada et al., 2009). Takesada et al. (2009) claim that the inequality between host and displaced communities as the obvious reason for the slow recovery. Because, 60% of the settlers received only marginally productive tea plots, inexperience of the settlers within the tea plantation created a big difference in income between non-settlers and settlers shortly after relocation. This difference preventing them from acting as a community and the displaced population expressed dissatisfaction in common engagements.

Case 2

Similarly, in 2005, 1083 Tsunami affected households were relocated in Hambantota under the Siribopura resettlement-housing programme. Perera et al. (2012) stated that the income of the settlers after resettlement did not show considerable improvement. Further, the authors identified that, owing to resettlement as well as market failure generated by the absence of formal land right, 30% of the settlers lost their jobs especially farming related jobs and self-occupation. Moreover, the authors claim that the socio-cultural values were insufficiently linked with the economic and real estate aspects, which is the basis for the sustainable resettlement (Perera et al., 2012). Therefore, account has also to be taken of the change in living environment leading to conflict between the life style of the displaced and the changed environment in which they have been relocated.

Case 3

Recently, the Government of Sri Lanka entered into an agreement with the Government of India to build a coal power plant in Trincomalee and it is expected to be completed by 2017 (Ceylon Electricity Board, 2013). The project requires around 2795 acres of land, which may contribute to involuntary relocations in future, of which a substantial fraction could be in new and hitherto unfamiliar built environments.

3. Discussion

Case studies show that Sri Lankan resettled communities experienced certain issues that slow the process of their recovery. According to the case studies, the major reason is incompatible community integration. Consequently, this affects successful community integration and community resilience. However, the relocating agents have often overlooked these issues owing to time limitations, drawbacks in the policies, and financial unpreparedness (Magis, 2010). Also, potential future relocations identified in Sri Lanka through recent statistics (IDMC, 2015;

Ministry of Resettlement Reconstruction and Hindu Religious Affairs Sri Lanka, 2015). Therefore, need exists within Sri Lankan context to integrate compatible community collaboration to build community resilience. Government of Sri Lanka made several legislations and policies to execute the relocations legally and effectively. However, governments/relocation agencies adopt a top down approach by following certain procedures considering the laws, regulations, and expectations from the communities. These procedures do not include any measures to ensure the resilience of the community as a whole.

Cernea (1995) described eight economic consequences of displacements, which leads to impoverishment of the displaced persons. They are landlessness, joblessness, homelessness, marginalisation, increased morbidity, food insecurity, loss of access to common property, and social disarticulation. However, in planned relocation programmes relocating agents provide land and houses for the re-settlers. Therefore, landlessness and homelessness problem cannot exist in this context. The likely occurrence of other problems is subjective to specific cases. However, the poverty of the displaced persons cannot be denied. As Maldonado (2012) stated, IDPs suffer economically, even though all their losses have been restored.

From the study conducted by Nicassio and Pate (1984) based on the relocation of Indochinese refugees, some of the severe social problems of re-settlers can be related with planned relocations. They are, painful memories of disaster and departure, job skills and placement related issues, lack of ethnic support, cultural difference, and difficulty in practicing religion. These issues for the IDPs cannot be as severe as identified by refugees. However, it is relevant up to a certain extent depends on the level of difference between both the communities.

In some cases displaced community's economic, social characteristics affect the host community. In 1990, around 100,000 people from a particular ethnic community have been expelled from the north of Sri Lanka to the district called 'Puttalam' due to ethnic strife. Over the time, some cultural and social practices of the IDPs such as dowry system, dressing styles, have begun to influence the host community (Thalayasingam, 2009). Thalayasingam (2009) further states that the educational performance of IDP children was higher compared to the host children. Also, IDPs of Puttalam gave more importance to the education and that encouraged the local host community children to follow secondary and territory education.

However, displaced and host communities developed some clashes among themselves and displaced community has been marginalised by the host community out of fear of losing resources, government job allocation and educational quota (Brun, 2009). A common tendency can be observed based on the case studies (Brun, 2009; Thalayasingam, 2009) is, host community welcome the displaced persons at the beginning and by the time they withdraw their assistance owing to the fear of loosing resources. The reason being, migration process can be a benefit for a certain group and a loss for another group. It is difficult to identify the people who are vulnerable and who are in need. Therefore, all the assistance and benefits are given for all the displaced persons without any discrimination. This might create an imbalance in the society and lead to tension and jealousy among local people (Brun, 2009). These issues restrict both communities to act as a community and make them vulnerable to future disasters. Furthermore, disaster resilience of the community in terms of availability of temporary shelters, food supply, and evacuation plans might get affected and make both communities vulnerable to future disasters.

4. Conclusions

Disasters sometimes make lands unfit for human habitation and forces its residents to move away from it. It is government's responsibility to relocate the trapped population to another safe environment. Disaster-induced involuntary relocations are rather common in Sri Lanka. However, displaced and host communities face many problems related to economic, social, and cultural incompatibilities that could slow the recovery process. (Das, 2008; Manatunge et al., 2009; Perera et al., 2012; Takesada et al., 2009). Also, this can alter the equilibrium level of the community and disturb the disaster resilience of the community. Governments/relocation agencies adopt a top down approach by following certain procedures considering the laws, regulations, and expectations from the communities. Whereas, the ideal approach is the bottom up in which communities engaged in the decision-making. Following the ideal approach is often not practical as the government is given only limited time and resources. Therefore, finding a middle ground by connecting both the mechanisms is necessary to reduce relocation failures and to enhance quick recovery.

A conceptual model (Refer Figure 4) was developed integrating the top down and the bottom up approaches in order to find out the middle ground.

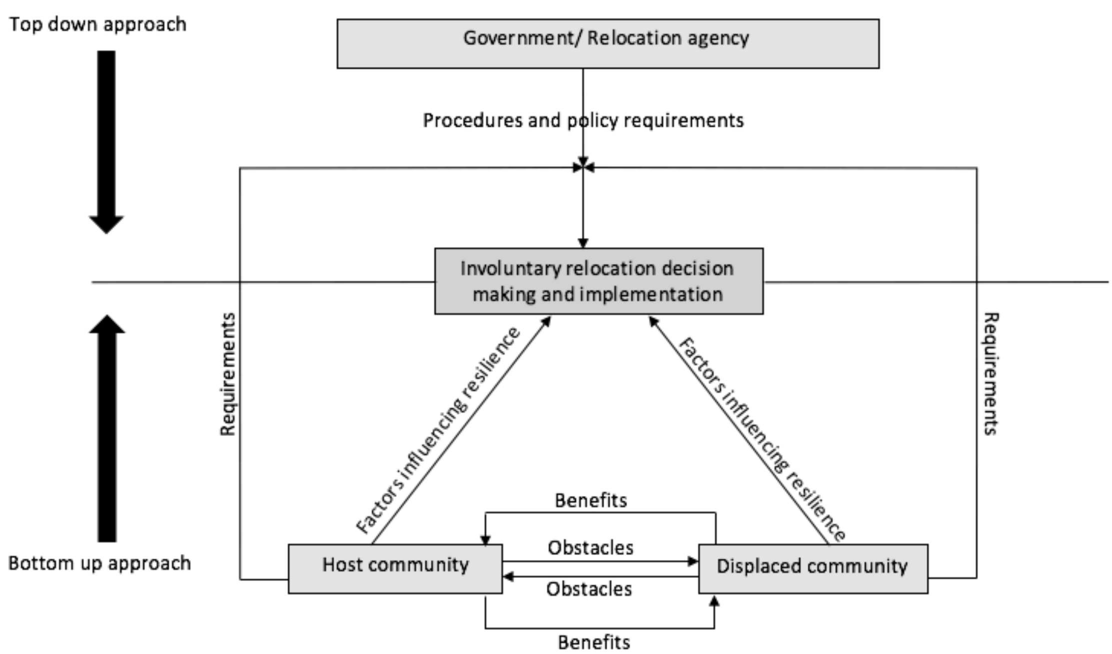

Figure 4: Conceptual model

The model shows that how relocation decision has been taken (top down approach) and how it is expected (bottom up approach). The government or the relocation agencies usually have procedures and policy requirements that needed to be followed during relocations. Also, they will consider the requirements of the communities up to a certain extend as the time and financial constraints restrict them. Similarly, host and displaced communities may have their own expectations towards the government. Also, they may have benefits and obstacles for having another community in their midst. Both the approaches have their own pros and cons. In order to achieve the benefits of both the approaches, a middle ground approach, compromising both the parties, need to be taken for a successful implementation of relocations, and to build a resilient community.

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Impact of living plants on the indoor air quality in a large modern building

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Abstract

The purpose of this paper is to investigate the use of living plants in enhancing the indoor air quality (IAQ) and the general indoor environment within a large modern open-plan office building with a central atrium design and a building management system (BMS) in place. Poor indoor air quality was measured within the building, primarily due to the low relative humidity during the winter months. Previous literature suggests that the incorporation of plants in buildings helps to regulate relative humidity whilst also bringing perceptual benefits and potentially reducing short-term sickness absence.

The investigation was developed through quantitative and qualitative data. The quantitative element involved the use of experimental and control zones within the building, selected on the basis of orientation, user density and users' work roles. Plants were selected based on the transpiration rates of various commercially-available species. Relative humidity was continuously monitored using data loggers with half-hourly logging intervals for a duration of six months. Carbon dioxide gas concentration was measured using a dedicated hand-held sensor. Qualitative user perception data was gathered through the use of a structured questionnaire distributed to staff members working in each of the experimental and control zones.

Initial findings suggest that the plants have not instigated the positive effects on IAQ that were expected. The recorded data on relative humidity displayed only non-significant variations between the experimental and control zones. These findings are attributed, in part, to the atrium design, which results in a substantial volume of air within the building, leading to cross-contamination and excessive dilution of the introduced humidity as a result of plant transpiration. The study extends the previous, mainly laboratory-based, investigations to a real working environment. However, this introduces a range of other experimental factors, thus impacting the results.

Implications for further research and practice include the extension of this research approach to consider a wider selection of buildings studied over a longer period of time, taking further account of seasonal fluctuations and the impact of additional variables present in real working environments. The practical value of this study is evident through the sustainability aspect provided by the potential of indoor plants to reduce carbon emissions of the general built environment through the elimination or reduction in use of energy and capital-intensive humidification air-conditioning systems.

Keywords: relative humidity, thermal comfort, air quality, indoor plants

1. Introduction

Over the past three decades, the indoor air quality in commercial and domestic buildings has been widely investigated with studies focusing on respiratory irritants such as nitrogen and sulphur dioxides and carcinogens such as asbestos, formaldehyde and other volatile organic compounds (VOCs). A number of authors have also investigated the percentage relative humidity (%*RH*) in indoor air which represents the ratio of the percentage of water vapour held by the indoor air to the equivalent saturation level at a given temperature. Arundel et al. (1986) and Nagda and Hodgson (2001) reported that indoor humidity is not typically classified as an indoor contaminant. However, a number of studies (Wyon et al., 2002; Wolkoff and Kjaergaard, 2007; Wan et al. 2009) and building design guides (CIBSE, 2005&2006) recommend an indoor %*RH* in the range of 40 to 60%. Humidity levels below 40%*RH* are undesirable due to negative health implications whilst humidity levels above the maximum recommended value are undesirable due to a combination of health and building damage implications. As reported by CIBSE (2006), humidity levels lower than 30%*RH* could only be acceptable for limited periods of time. CIBSE also reported that at these humidity levels, occupants could be prone to allergies and respiratory illnesses due to dust and other airborne particles.

At significantly low levels of indoor humidity, Bron et al. (2004) reported a change in the precorneal tear film in humans which results in a slight discomfort in the eye (dry eyes) while Doty et al. (2004) reported a sensory irritation of the upper airways. Wyon et al. (2002) reported that human skin exposed to 15%*RH* was significantly drier than the same skin exposed to 35%*RH*. Wyon et al. associated the latter health symptoms with the classic definition of sick building syndrome. More recently, Wolkoff and Kjaergarrd (2007), reported that the health implications of indoor humidity are complex and have not been widely investigated. This is due to the fact that the influence of the relative humidity on the combined impact of VOCs and other indoor contaminants is not well-understood. Low humidity levels are also associated with the susceptibility to electrostatic shocks. This is due to the fact that the body voltage is a function of the indoor air %*RH*. Therefore a drop in the %*RH* results in an increase in the body voltage (CIBSE, 2006). CIBSE reported that carpeted office buildings equipped with underfloor heating could be susceptible to electrostatic shocks due to significantly dry carpets. Hence, a lower limit of 55%*RH* is recommended for such buildings.

Higher levels of humidity are mostly the result of poor ventilation and significant evaporation from moisture sources such as bathrooms, kitchens and indoor plants. Such levels of humidity could lead to condensation on the internal walls, which could result in mould, microbial and house dust mite growth (CIBBSE, 2005). In colder climates, as typical to countries in Northern Europe, heated only buildings could experience prolonged periods where the indoor humidity falls below the recommended lower value of 40%*RH*. This happens as the ability of air to hold water vapour is a direct function of the temperature. Therefore, as the outdoor air is heated to the indoor room temperature, the ability of this air to contain water vapour is enhanced with a resultant drop in the percentage relative humidity. Consequently, humidification systems are incorporated in heating systems to top-up the resultant indoor %*RH*. However, in most European Union countries, the maintained indoor %*RH* levels are not stipulated through statutory laws or regulations and therefore, due to financial implications, most buildings do not make use of humidification systems.

The humidification of indoor air is typically achieved through mechanical means whereby water is heated to steam and mixed with the supply air to the building. This could result in a significant financial outlay with a further negative impact on the building's carbon footprint. In fact, for each 10kg of water vapour per hour required for humidification, circa 7.22kWh of gas is consumed, with an equivalent carbon footprint of 1.61 $kgCO_2$ (DEFRA, 2015).

As reported by Lee et al. (2002) the indoor air quality is also a strong function of the indoor carbon dioxide (CO_2) concentration. Humans exhale CO_2 and therefore, occupied indoor spaces are characterised with concentrations of CO_2 gas which are higher than the concentrations found in the outdoor air. Usha et al. (2012) reported that high levels of indoor CO_2 concentrations are associated with a poor indoor air quality which could lead to health issues such as headaches and mucosal irritations, slower work performance, and increased employee absence. Moreover, Wargocki et al. (2000) concluded that the perceived air quality in an office building was reported to improve with higher ventilation rates. This in turn yielded an improved occupant perception of the indoor air freshness, thus yielding better employee productivity levels as a result of the feel good factor and the reduced sensation of mouth and throat dryness. For this reason CIBSE (2006) recommended a fresh air supply per person between 5 and 8 litres per second which gives an internal CO_2 concentration in the range of 1000 and 1350 ppm. Intriguingly, Fang et al. (2004) reported that the impact on the perceived indoor air quality with lower ventilation rates (10 to 3.5 litres per second) can be counteracted with a reduction in the indoor air temperature and relative humidity (23^{o}C/50%*RH* to 20^{o}C/40%*RH*).

2. The use of indoor plants in buildings

Wolverton (1996) explained that during photosynthesis, plants absorb carbon dioxide from the atmosphere through the stomata (tiny openings on the leaves), while the roots absorb moisture from the soil. Chlorophyll and other tissue in the leaves absorb radiant energy from a light source, which is used to split water molecules into oxygen and hydrogen. Hydrogen and carbon dioxide are used by the plant to form sugars, while oxygen, a by-product of photosynthesis is released into the atmosphere.

Costa and James (1995) reported that plants such as Rhapis palms and Marantas, which need regular misting, or plants with high moisture content could benefit offices with low humidity. Their study found that plants can increase the relative humidity of a non-air-conditioned building by about 5%, although the density of planting required to achieve this was higher than would normally be provided for a commercial office environment. Wolverton and Wolverton (1996) suggested that plants may be used instead of humidifiers to add moisture to homes and offices through transpiration.

Smith et al. (2011) undertook a plant trial in a large open plan office, finding that short-term sickness absence reduced by approximately 50% in the planted experimental area compared to a control area in which absence increased slightly, calculating a net saving for the organisation of approximately £40,000 (GBP). However, they also acknowledged that this trial was limited to one building and, while the results supported the theory of live plants reducing absence rates, they suggested that the true effect of plants is likely to be somewhat less than the near 50% reduction noted in that trial, recommending further research in that regard. To date, we have not unearthed any significant further research investigating the effect of plants on sickness absence.

Some evidence suggests that plants in buildings may help to reduce ambient noise levels although it is unlikely that they would act as efficiently as construction elements in this regard. Costa and James (1995) contended that they may offer acoustic quieting by absorption. Freeman (2008) also reported that plants may absorb, diffract and reflect sound and this effect will be determined by variables such as the size, species and shape of the plant, as well as its container, top dressing, compost and positioning within the room. Costa and James (1995) also recommended that increased planting densities than those currently used in the industry would be required for indoor plants to be more effective in this regard.

Considerable attention in environmental psychology research has been given to the role of nature. For example, outdoor natural environments and vegetation have been shown to provide several psychological benefits including positive feelings (Sheets and Manzer, 1991), environmental concern (Lutz et al., 1999) and enhanced cognitive functioning in children (Wells, 2000). Whilst it may be impossible to have natural environment settings at many office buildings, research has considered that natural environment views from windows can provide restorative effects from mental fatigue (Kaplan, 1993) and the negative effects of job stress (Leather et al., 1998). Bringslimark et al. (2011) assessed whether office workers compensate for lack of nature views and found that workers in windowless offices were approximately five times more likely to bring plants into their workplace. Plants in the workplace have been associated with improved attentiveness (Lohr et al., 1996), task performance (Shibata and Suzuki, 2001) and reduction in symptoms of sick building syndrome (Gou and Lau, 2012).

3. Methodology

The building considered in the present study is the head office building of a Local Authority in the UK, located in southwest England. This detached building was constructed in 2011 and consists of three floors with a total floor area of circa 10,300 square meters of office space. The latter is predominantly arranged in an open floor design surrounding a central atrium (figure 1) with the main entrance located at the ground floor level. The building has an energy performance operational rating of 'C' with an annual gas and electricity consumption of 73 and 72 kWh/m^2/year respectively. 13.3% of the former and 0.4% of the latter is attributed to renewable forms of energy. Gas is the main fuel used for heating whilst electricity is used for lighting and all other power requirements typical to an office building. The building services are fully linked to a central Building Management System (BMS) which controls the ventilation, heating and the opening and closing of apertures. The building design allows a significant percentage of the required ventilation to be achieved through natural stack ventilation through the atrium. Strategically located CO_2 sensors monitor the indoor air quality with the mean indoor CO_2 concentration maintained at circa 700 ppm. A central HVAC system, located on the roof top, provides heating and supplemental ventilation through floor level diffusers with the winter and summer indoor set point temperatures set at 22^{o}C. No cooling or humidification systems were available. As illustrated in figures 1&2, the double skin south facing façade offers sound insulation from the high-traffic road running along the south side as well as shading to minimise the solar gains during the peak summer months. There were circa 1000 adults working in the building with typical office hours between 8 am and 7 pm whilst the services offered were predominantly of a back office type.

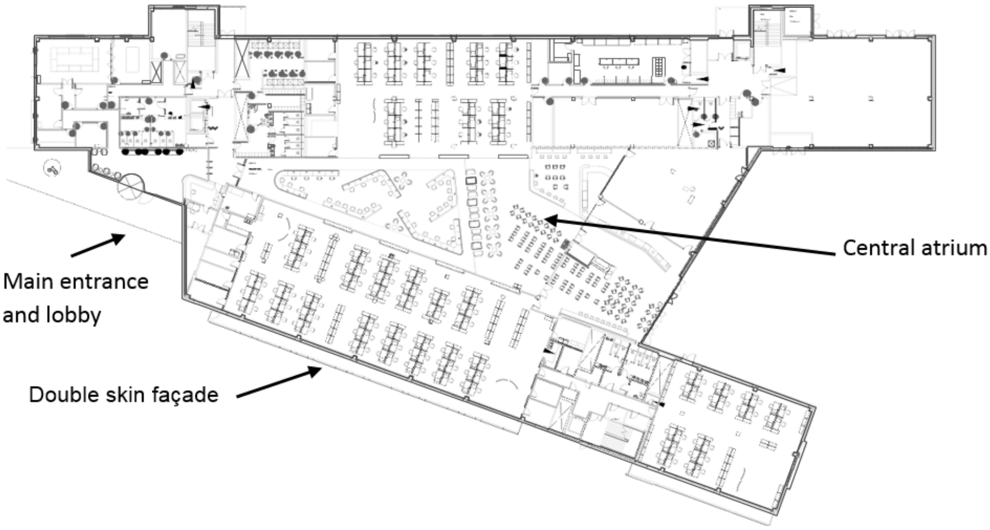

Figure 1: Plan design schematic for the ground floor

Figure 2: Central atrium design and south facing shaded façade

Live indoor plants were installed in this building within the first floor southern section of the building for a period of six months from December 2014 to June 2015. A further two control areas were designated in the ground floor southern section (directly below the experimental zone) and the first floor northern section (across the open atrium from the experimental zone). Following a similar methodology to that of Smith et al. (2011), these areas were selected due to them being of similar size and occupied by approximately the same number of people, doing similar jobs.

The plants used were selected mainly for their transpiration rate, according to Wolverton (1996) as well as factors such as ease of maintenance, light requirements, size, shape and general aesthetic qualities (Smith et al., 2011) as advised by a professional indoor planting company. They supplied and maintained the plants throughout the trial period for the reason that previous research has shown that the plants must be in the optimal condition for them to be successful in regulating the indoor climate within buildings (Costa and James, 1995; Smith and Pitt, 2011).

The plants used are detailed in table 1 and these were installed at a density a little greater than under normal commercial conditions, leading to the experimental zone being relatively densely planted.

These included 30 floor-standing plants as well as a range of 24 smaller desk bowls, mainly positioned on shared furniture such as filing cabinets. The plants were all soil-grown and provided without top dressing. According to the advice of the planting company, total transpiration for the experimental zone was expected to be around 21 litres of water per 24 hours. Maintenance of the plants including watering, dusting and pest control (using natural products) was undertaken every 2 weeks.

Table 1: Plant species installed in the experimental zone

Number	*Container*	*Plant*	*Plant height (m)*
12	*Plastic trough (40cm x 18cm)*	*Spathiphyllum Sensation (Peace Lily)*	*0.35*
12	*Plastic trough (40cm x 18cm)*	*Nephrolepsis (Boston Fern)*	*0.40*
20	*Round plastic (40cm x 43cm)*	*Areca Palm*	*1.80*
10	*Round plastic (40cm x 43cm)*	*Dracaena Janet Craig*	*1.80*

3.1 Relative Humidity

The relative humidity, measured by two column-mounted HOBO UX100-003 humidity sensors in each zone (six sensors in total) with accuracy of ±3.5%, represents the ratio of the actual water vapour density to the saturation vapour density given in equation (1). Readings were taken at half-hourly intervals at each logging point. As illustrated in figure (3), the saturation vapour density is a strong function of the air temperature. Therefore, a unit increase in the air temperature results in an exponential rise in the capacity of air to hold water vapour. Hence, if no extra water vapour is added to the heated air, the %*RH* drops.

$$\%RH = \frac{\rho_{actual}}{\rho_{saturation}} \qquad \textbf{(1)}$$

where ρ is the density at actual and saturation conditions in kg/m^3

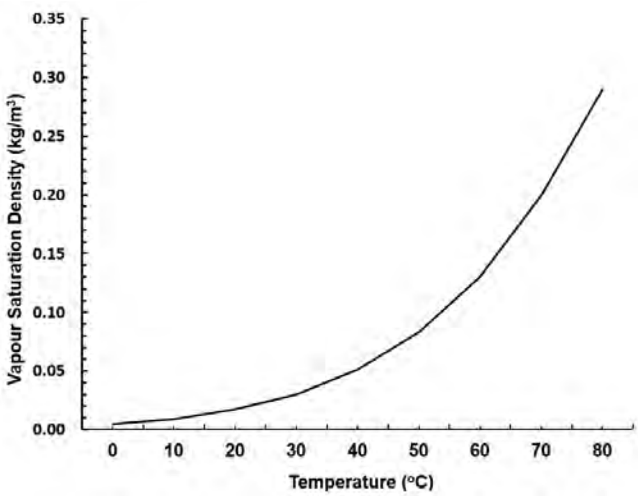

Figure 3: Vapour saturation density with temperature

3.2 Employee perceptions

Employee perceptions were tested using an online questionnaire, which was completed by occupants of the experimental zone as well as the two control zones. The questionnaire asked respondents to consider whether any of the following issues have changed since the beginning of the plant trial with options of improved, stayed the same or got worse:

- Humidity;
- Temperature;
- Background noise levels;
- Light levels;
- Personal space;
- Work area design and layout;
- Privacy;
- Work environment aesthetics.

The questionnaire remained open for a period of two weeks towards the end of the trial in June 2015. Of the respondents who completed the questionnaire, 61 (55.45%) were located in the two control zones, while 49 (44.54%) were located in the experimental zone, giving a total of 110 respondents.

4. Discussion

Figure 4 illustrates the data for the indoor relative humidity and temperature in relation to the outdoor conditions. The total water supplied to the plants over the experimental period was measured as 3822 litres. With a total foliage area of circa 40m^2, this results in a transpiration rate of circa 21.8 g/hr m^2. Contrary to the expectations of the present study, no significant differences in the relative humidity were measured in the experimental and control zones. This could be attributed to the building design which resulted in significant cross-contamination of the indoor air. Therefore, the open plan atrium design resulted in the mixing of the air in the experimental and control zones. This yielded a significant dilution of the water vapour transpired by the indoor plants located in the experimental zone. Therefore, considering the building design adopted in the present study, our data shows that it will be necessary to populate all the indoor areas with plants in order to achieve tangible results for indoor humidity levels. Furthermore, the recorded mean indoor CO_2 gas concentration was in the range of 850 to 1000 ppm. As reported by Lee et al. (2002) and Usha et al. (2012) such concentrations are considered as indicative of good indoor air quality levels. In fact, CIBSE (2006) recommends a ventilation rate yielding an indoor CO_2 concentration in the range of 1000-1350 ppm. Therefore, our data shows that the results of the present study cannot be attributed to overventilation.

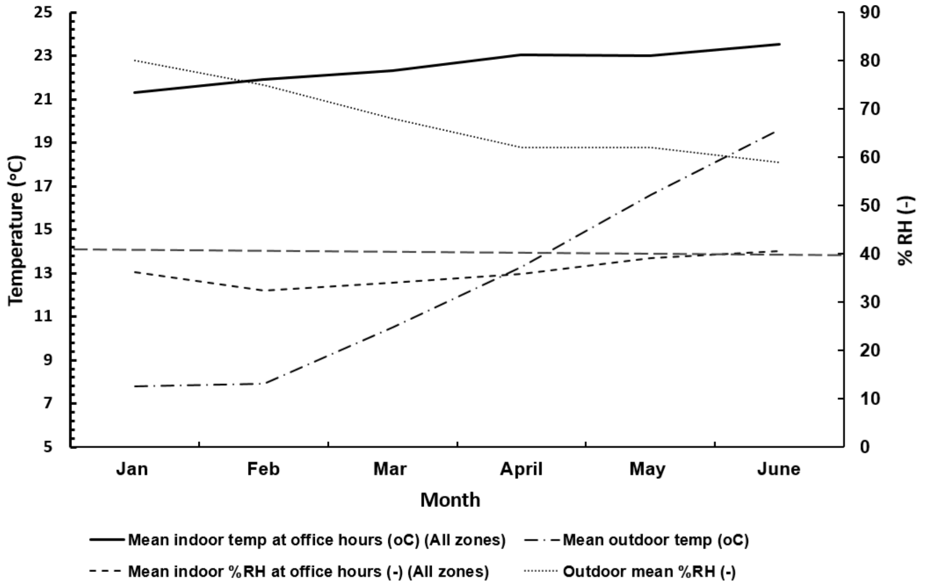

Figure 4: Indoor and outdoor temperature and %RH with the target 40% indoor RH highlighted by the horizontal dotted line

Figure 4 illustrates the trend where the lowest relative indoor humidity levels were recorded during the month of February whilst the highest indoor humidity levels were recorded during the late spring months. As illustrated in figure 3, this trend can be directly related to the relevant outdoor temperatures. Hence, during the month of February, the outside cold air could only hold a small fraction of water vapour at saturation conditions, and therefore, the warming up of this air to room temperature resulted in a significant drop in the indoor relative humidity. As reported by Wan et al., 2009 and CIBSE 2005, the indoor humidity levels should be in the range of 40-60 %*RH*. Therefore, it is evident that during the first four months of the year this minimum threshold was not satisfied.

As anticipated, the qualitative data from the staff survey yielded a noticeable shift in perception within the experimental zone regarding improved indoor relative humidity, although this is at odds with the measured quantitative data. Approximately 27% of respondents in the experimental zone perceived that %*RH* had improved and 65% felt that it had remained the same, with a minority of approximately 4% believing that it had got worse. In the control zones, the majority of respondents reported that relative humidity had remained the same (97%) as shown in figure 5. In accordance with Wargocki et al. (2000) this perceived air quality improvement may yield an improved occupant perception of the indoor air freshness, leading to improved employee productivity levels. A similar trend was noted in regard to temperature, with the experimental zone respondents perceiving improvements in temperature, which is also at odds with the measured data. However, the majority of respondents in all areas perceived that temperature remained the same as shown in figure 6.

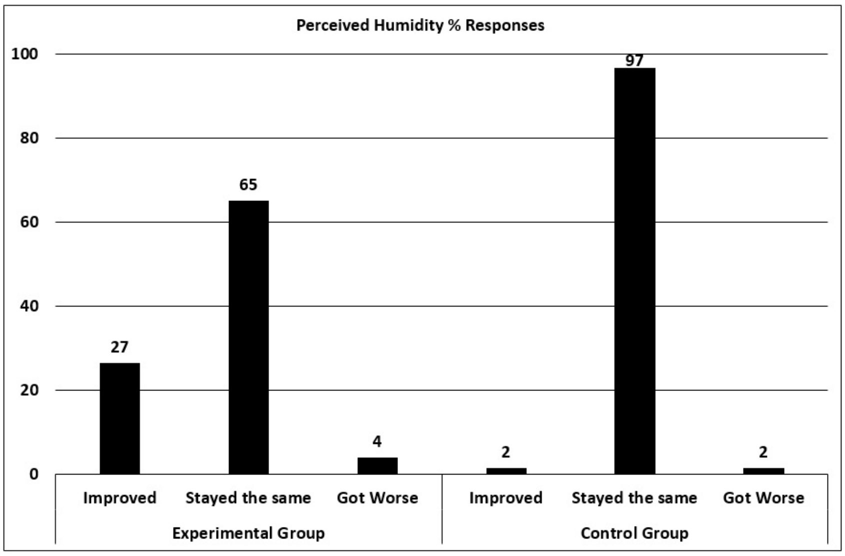

Figure 5: Perceived changes in humidity during the trial

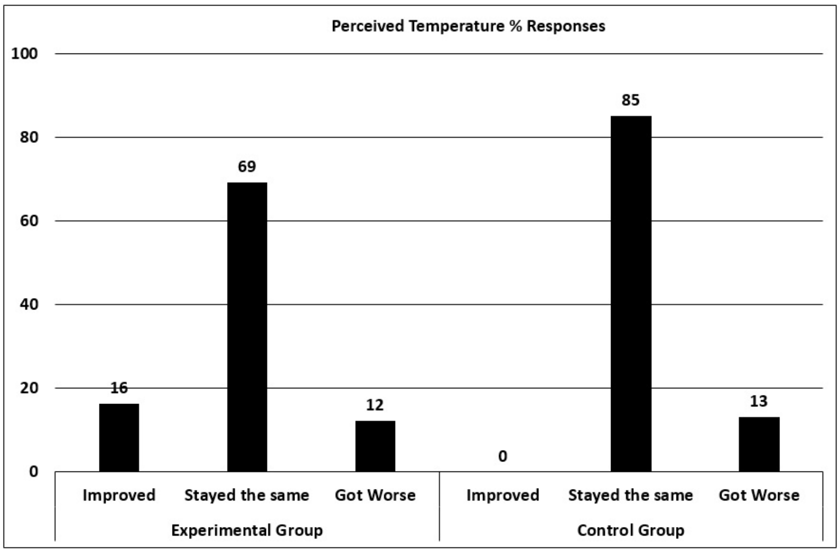

Figure 6: Perceived changes in temperature during the trial

In accordance with research by Costa and James (1995) and Freeman (2008), results suggest an improvement in perceived background noise levels within the experimental area. Although physical measurements of noise levels were not carried out in this research, this may provide an indication of the sound absorption properties of plants in buildings. Of the respondents in the experimental area, 22% perceived an improvement in background noise levels, compared to 0% noting improvement in the control areas as shown in figure 7.

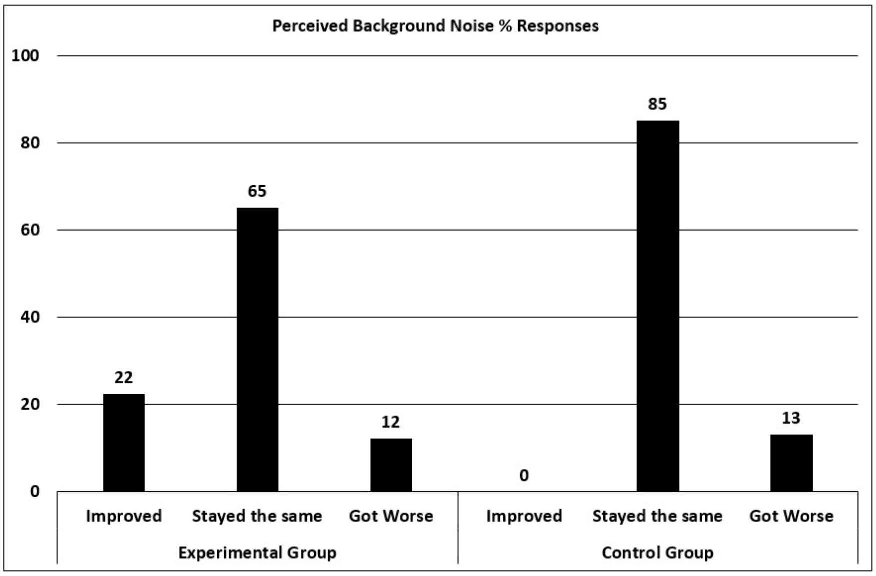

Figure 7: Perceived changes in background noise during the trial

The most significant improvement rate in the experimental area regards office aesthetics as shown in figure 8, with the majority of respondents in the experimental area (45%) perceiving an improvement, although a relatively significant response rate of 20% of respondents in the experimental area also felt that aesthetics got worse, reflecting the subjective nature of office design considerations. This result also supports previous research, which identified a general preference for plants (Smith and Pitt, 2008).

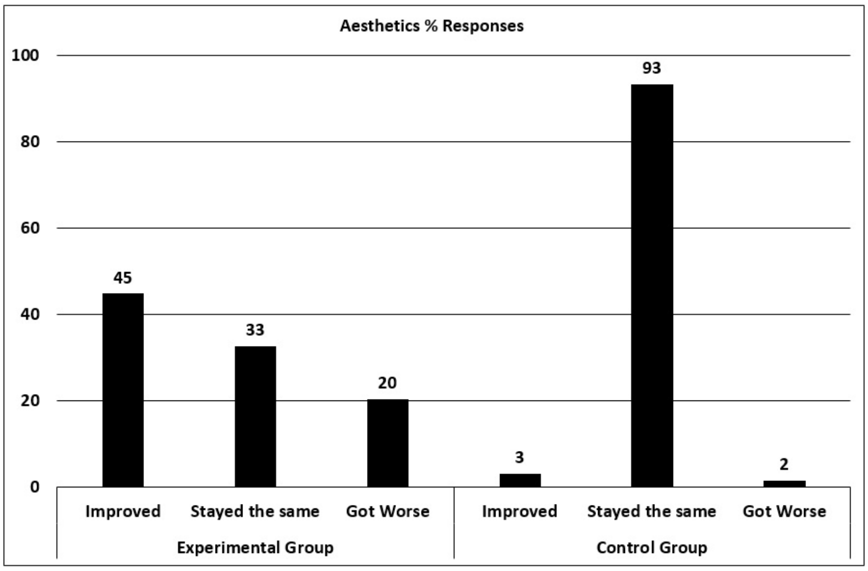

Figure 8: Perceived changes in aesthetics during the trial

Some of the more negative responses regarding plants concerned light levels and personal space, with significant responses from the experimental area suggesting that these had got worse since the beginning of the plant trial, 47% in the case of light and 39% in the case of personal space. This is perhaps unsurprising, given that many of the plants were relatively large, providing shading and potentially reducing natural and artificial light, at the same time as taking up floor and surface space.

Regarding design and layout, the majority of respondents in the experimental area and control areas perceived that this had stayed the same (67% and 93% respectively), perhaps suggesting that the plants were not regarded as a design and layout aspect. However, 27% of respondents in the experimental area perceived that this had got worse, possibly in line with the question on personal space.

The result on privacy perceptions was inconclusive for the experimental area, with the majority (76%) perceiving that it had stayed the same and 12% noting an improvement, which may have been due to the plants. However, 10% considered that privacy had got worse. The reason for this is not clear, although results on this question are possibly dependent on location of the respondents in relation to the positioning of the plants. Within the control group, 92% perceived that it had remained the same, while 7% felt it had got worse. As with the experimental group, it is not clear why privacy may have got worse and we are not aware of any further interventions within the office space.

5. Conclusions

The current study has shown that the use of plants to enhance the indoor air quality is a feasible option which could result in both tangible and intangible benefits. In spite of the fact that the measured relative humidity data for the experimental zone failed to suggest a significant rise in the indoor humidity levels, the water supplied to the plants over the test period, together with the typical indoor plant transpiration rates reported in literature, suggests that the transpiration rates are significant. Therefore, when coupled with an improved control of the indoor air flow, the plants have the potential to supplement the indoor relative humidity, thus improving the building comfort and potentially yielding energy savings where humidification systems are installed.

These results also need to be considered in the context of the potential perceptual or psychological effects of plants uncovered in previous studies and supported in this study. Perceived improvements were noted in regard to perceived indoor relative humidity (%*RH*), temperature, background noise levels and aesthetics. However, perceptions of light levels, personal space and privacy got worse in this study.

Further work will be undertaken on the analysis of the air flow patterns in the building through computational fluid dynamics (CFD) techniques. Funding will also be sought for the installation of plants in all the indoor zones. The evaluation of the potential energy savings through the use of plants as a replacement to traditional humidification systems will also be developed. This will be done through the concurrent analysis of the potential transpiration of plants in relation to the water vapour top-up required during the winter months.

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The Choice of Façade Material
- Values and Beauty

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Abstract

With the need for more environmental friendly buildings in mind, the object of the study is to investigate what factors influence the choice of façade materials in a contemporary Norwegian building project. Later years there has been an increased focus on environmental friendly building. Official politic, legislation and official support of different organisations advocating sustainable building aim at affecting the level of sustainability in the building industry. Finding answers to the research question, the article aims to contribute to the picture of to what extend sustainable values affect the decision makers. In this specific case we have looked at seven public projects. The method used consists of a literature research, seven interviews with the respective client project managers and five of the architects. Additionally a study of the different projects' available project documents, was conducted. In some projects, the choice of façade material was influenced by the general guidelines originating from the government, the user, the client or special building programs. For the projects that were examined methods such as LCC calculations, greenhouse gas accounting and LCA analysis, with the respective tools LCCweb.no, klimagassregnskap.no and SimaPro, were part of the basis for decision-making for facade claddings. For some projects, these analyses and calculations were used only due to documentation requirements, and thus had no major impact on the decision-making. For other projects, they were used to evaluate alternatives on product level. The findings in this investigation shows that sustainability, aesthetics and cost are considered to be the most important factors influencing the choice of façade material. The participation in different sustainability programs do seem to have influenced the evaluation and choice of façade material, both through developed processes and the required use of tools aimed at measuring. The decision makers conclude on a spectre of materials such as different wood solutions and bricks. The explanation for this is partly the projects' different functions, partly how the different project groups execute and evaluate the environmental analysis, and partly the differences in project goals.

Keywords: Sustainable, decision making, façade material

1. Introduction

In the first century BC, Vitruvius wrote about architecture, and is known for the criterions on which to judge good architecture; firmitas, utilitas and venustas – durability, utility and beauty (Vitruvius and Rowland 2007). Vitruvius also wrote about economy and the balancing of cost and common sense in the construction. Resent research has been done to investigate how architects evaluate architecture, and in respect of the façade Vitruvius' criterions are still valuable (Volker 2010). In the later decades, daylight and the use of glass has been considered an important quality, especially in school buildings (Wu and Ng 2003), although recently – at least in Norway – a focus on environmental issues has led to less emphasis on daylight (Houck 2015). The façade is a crucial part of the building design. It not only gives a signal of a building's function and content, but also often, intentionally or unintentionally, reflects a client's values. Functionally the façade works as a climate shield and weather protection. The façade can have a transparent, less transparent and close appearance. Traditionally, the choice of facade material has been linked to parameters like construction, available materials, design and cost efficiency. More recent factors to consider are energy solutions and environmental aspects.

The research question in this article is:
- What factors influence the choice of façade materials in contemporary public Norwegian building project?

The research is limited to look at the choice of façade materials for office buildings and buildings for education within two different public clients; Statsbygg, and Undervisningsbygg. Statsbygg is the Norwegian government's property developer. Undervisningsbygg is the Oslo public building agency for school buildings. Project leaders and architects who have participated in to seven building projects are interviewed about the process and considerations leading to the final choice of façade material. The Norwegian building industry consist of different participants who may have different interests, but who at the same time are dependent on each other. The different participants' experience and competence is mainly developed through the execution of building projects. Parallel governmental financed organisations are working to affect the building industry to develop more sustainable and environmental friendly buildings. Limited to the decisions on façade materials, this paper will look into to what degree such organisations and public programs succeed to play a role when it comes to the decision making in a project. It has been out of the boundaries of this investigation to look at how the different environmental tools have been used. E.g. if the GHG calculations have included production, transportation and embodied CO2 in materials, and operational energy.

2. Theory and framework

2.1 Previous research

Denizou at al have investigated the choice of material for larger urban buildings. The purpose has been to find the mechanisms behind the choice of materials with emphasis on wood. Main findings are that public framework can affect the choice of building materials. The research group recommends to emphasize pilot projects as a tool to achieve more knowledge and acceptance towards the use of wood in future urban building projects (Denizou, Hveem et al. 2007).

In 2012 the Statsbygg, the Norwegian Directorate of Public Construction and Property, ordered a report from Rambøll to investigate what arguments are used to choose other building materials than wood, and to examine when in the building process wood is deselected (Rambøll 2012). Main findings in this research are 1) that requirements related to building materials may be incorporated in public zoning plans, and 2) the participant who influence the most on the choice of material depends on the project procurement arrangements.

A Norwegian research, based on a questionnaire answered by 285 architects, indicate that the architects` intentions to use structural timber in urban buildings is influenced by attitudes towards using structural timber in buildings three to five stories or more. The findings also show that the architects' preference towards the use of structural timer is related to previous experience with the use of structural timber in urban construction (Bysheim and Nyrud 2008).

2.2 Public framework and programs

Currently there exists different initiatives and building programs supporting and promoting more environmental friendly building. Generally one could say that for the investigated projects, all the clients have environmental aspirations. These aspirations are operationalized through the cooperation with the different frame work initiatives.

Framtidens byer – Cities of the future – was founded in year 2008, and is a cooperation between the state, the private sector, and thirteen biggest cities/municipalities in Norway. The goal is to reduce the use of energy, reduce carbon dioxide emissions, improve the city environment and adaption to climate change (Kommunal- og moderniseringsdepartementet 2014).

FutureBuilt is a part of Cities of the future. The vision of the program is to develop high quality sustainable buildings and city areas of the 13 member cities. The program emphasize high quality architecture close to public transport. The National Association of Norwegian Architects is responsible for the managing and operation of the program. The program runs from year 2010 to 2020. The program not only has a set of requirements to be met by the buildings adopted by the program, but also have mandatory requirements to the development and building process itself such as; architecture competitions, greenhouse gas accounting, user participation processes and Building Information Modelling (BIM).

Framtidens Bygg – Buildings of the future, is a also a part of Cities of the future and is available for 10 more cities than the member cities. The target is to participate in pilot projects, and develop competance and experience in sustainable planning, building and rehabilitaiton of buildings. A set of quality requirements are developed and has to be met for buildings adopted by the programe. (Moe and Waage 2014, Kommunal- og moderniseringsdepartementet 2015). Projects adapted by the program are offered consultant help, seminars, planning tools and working methods. The National Association of Norwegian Architects is responsible for the managing and operation of the program.

ZEB (Zero Emission Building) is a Norwegian national research centre on zero emission building. The goal is to eliminate the greenhouse gas emissions caused by buildings and place Norway in the front of innovation and implementation within the field. The main objective is to develop competitive products and solutions for existing and new buildings. The centre encompasses residential, commercial buildings and public buildings. The ZEB centre has 24 public and commercial partners, and it is organized as a joint unit hosted by the Norwegian University of Science and Technology (NTNU) and SINTEF, geographically located in Trondheim (ZEB 2015). ZEB-COM is a term meaning Zero Emission Buildings – Construction, Operation and Materials (Statsbygg 2015).

Enova was established in year 2001 and is owned by the Norwegian state. The objective of the organization is to promote more environmental friendly consumption and generation of energy in Norway. Enova does this through targeted progammes and support schemes. The enterprise is financed via funds allocated from the Energy Fund. The Energy Fund is financed via a small additional charge to electricity bills. Additionally, the Energy Fund has been allocated the proceeds from "The “Green Fund for Climate, Renewable Energy and Energy Efficiency Measures”. The Green Fund’s capital this year is 35 Billion NOK (ENOVA).

It will be beond the limits of this article to go into the accurate definitions of the different terms like passive house, almost zero energy building (nNEB), zero energy building and pluss energy house. But to explain theese terms very short, a building with passive house standard follows the requirements in the Norwegian standard NS3701:2012 - Criteria for passive houses and low energy buildings. School buildings should use less than 75kwh/a. An “almost zero energy building” (nNEB) definition is proposed in a cooperated report as a building using less than 70% energy then the requirements in TEK10 – the Norwegian building regulation, which means 36 kwh/a for school buildings (Rambøll and Arkitektur 2013). A common definition of the term “pluss energy house” is a building where the building through its lifespan (often used 50-80 years) generates more energy than it consumes during its lifespan, the production of building materials and the construction itself included. FutureBuilt defines plus energy house based on the energy use during the operation (SINTEF-Byggforsk 2014).

2.3 Statsbygg and Undervisningsbygg

Statsbygg manages and operates 2,350 buildings, spread across 600 sites in Norway and abroad. Statsbygg yearly operates about 160 construction projects (Statsbygg 2015). According to Statsbygg, this was the first Norwegian organization in its size in the construction industry having a strategy towards sustainable building including reduction of greenhouse gases. Todays strategy focus on redusing the energy consumption in buildings, reduction of greenhouse gases and the limitation of materials containing substances hazardous to the environment . Long term goals are among others, zero energy buildings and reduced environmental footprint. Short term goals are the use of EPD – environmental product declarations for minimum ten products, the limitation of envrionmental hazardous substances in materials and the limitation of materials from not renevable resources (Statsbygg 2014).

Being the Oslo public building agency for school buildings, Undervisningsbygg manages, operates and maintain 1,3 million m2 of building area. Undervisningsbygg manages 750 buildings, and constructs yearly for about 235 million euros (Undervisningsbygg 2014?). According to Undervisningsbygg's strategy document on sustainability 2012-2015, the three main focus areas are energy use, waste and the use of environmental friendly materials (Undervisningsbygg 2012). In the period 2012-2015 Undervisningsbygg plans to use BREEAM in pilot projects, but non of the investigated projects are using BREEAM.

3. Method

The methods used are literature study, case studies, and interviews. Public projects were chosen as case studies, and the two collaborating public building organisations were Statsbygg and Undervisningsbygg. The case study of consists of seven Norwegian public building projects, some finished, and some still in the planning process during the study, see table 1. In depth interviews have been conducted with 12 clients and architects involved in the projects (table 1). An interview guide was developed for the interviews. The first part of the interview aimed at mapping general information about the informer, the organisation and the actual project. The second part of the interview was related to the façade itself; the factors influencing the choice of material, and what participant affecting and deciding the material, and lastly when in the process the choice was made. The interviews were conducted by two persons, one interviewing, the other taking notes. Additionally, the interviews were recorded. The processed texts (in Norwegian) were mailed to the participants for control. Additionally project documents has been examined; Policy documents, Technical documents, reports on LCC, LCA, GHG calculations and the use of EPD (Environmental Product Declarations).

The choice of case studies is the result of a cooperation with Statsbygg (SB) and Undervisningsbygg (UB), and is as followed:

	Function	M2	Client	Status May 2015	Contract type	Project leader/ Architect
1	Police station	3170	SB	Building process	Turnkey	PL1/Arch. not available
2	Research	7475	SB	Planning	Alliance with turnkey	PL2/ARCH2
3	Office, teaching	1250	SB	Planning	Alliance with turnkey	PL3/ARCH 3
4	Office	49700	SB	Planning	Traditional contracting	PL4/ Arch. not available
5	School	11680	UB	Planning	Turnkey	PL5/ARCH5
6	School	9677	UB	Finished	Turnkey	PL6/ARCH6
7	School	9750	UB	Under construction	Turnkey	PL7/ARCH7

Table 1: Investigated projects

Fig.: 1) Vabakkjen (Link Arkitektur), 2) Framsenteret (pka Arkitekter), 3) Campus Evenstad (Ola Roald Arkitektur), 4) Folkehelseinstiuttet (Ratio Arkitekter), 5) Brynsengfaret skole (HRTB Arkitekter), 6) Bjørnsletta skole (L2 Arkitekter), 7) Lillohøyden skole (Planforum Arkitekter)

4. Results

All the investigated projects turned out to have strategic goals concerning sustainability. 5 of the 7 projects were part of Fremtidens Bygg, FutureBuilt or ZEB. In four of the projects, this has resulted in a passive house energy standard requirement. Two of the projects have expressed energy requirements on the level of zero, or close to zero energy use and are considered pilot projects by the client. One project has the goal to be a so called plus energy house.

The majority of the interviewees consider the construction of the outer wall and the façade material as two independent building elements. The interviewees were coherent in their opinion about the process leading to the final façade material. During the conceptual planning, the material was chosen in general terms, e.g. wood or stone. In the detail planning a more specific product was chosen, and then later the exact way of execution, formats and fixing was decided.

All project used the tool LCCweb.no (Life Cicle Cost). Mostly, this executed by the client, but also in some cases by the contractor. In some projects, the LCC calculations played an important role in the decision of façade material. In one project, local building regulations required brick, and therefore an LCC analysis could not be crucial. GAG analysis, using the tool klimagassregnskap.no, were executed in all of the projects, but would not necessarily be crucial. In project 7, a GHG analysis was executed to fulfil the requirements in the contract, but had no practical influence on the choice of materials. The GHG calculation includes material, operational energy use, operational transport, energy use and transport in the building phase. All projects used EPDs as a tool, and applied this on the façade material. The results show, that despite all projects having ambitious sustainability goals, a variety of façade materials such as wood, fiber concrete and bricks were chosen.

The interviews show that the choice of façade material was highly influenced by the environmental ambitions and also the program the project was part of.
PL1: “The project went from passive house standard to plus house standard during the process.”
PL2: “In an early phase of the project, it was decided to reduce the greenhouse gas emissions with 50%. This affected the choice of façade material.”
PL 5: “As a consequence of being a Future Built project, changes may happen.”
PL 6: “Gradually the project became a Future Built project, and therefore a strong focus on sustainability. As a result of this process, the façade material was changed.”
ARCH 6:”For a Future Built project, not only the architectural aspects count in the choice of material, but also the material has to prove to be sustainable.”

Statsbygg, Undervisningsbygg and the respective programs had “sustainability” procedures linked to the different design stages. Mostly the interviewees regarded these systems as valuable, and were satisfied with the systematic and also predictable approach. But also there were critical statements as PL4: “decisions need long processes. You need a parliamentary resolution to continue. This can also be a weakness.”

Some of the interviewees mentioned concerns about the outer wall thickness linked to passive house demands. In most cases the informants consider the choice of façade material as independent from the outer wall construction. The exception in this investigation is the project 3 Campus Evenstad, where the outer wall is constructed in one piece; a cross laminated timber (CLT)/insulation sandwich (80 mm CLT, 310 mm wood fiber insulation, 60 mm CLT).

Table 3 shows the different material choices in the investigated projects. Four of the projects have concluded to use wood as the main façade material. In two projects – both schools, it was decided to use brick, and in one project fiber cement cladding. The interviewees in the two brick projects were the opinion, that despite a high GHG footprint, brick would score well the longer the life span of the LCC calculation. Especially in rough-use environments like schools, brick was considered a good choice. In project two, the client was sceptical to the use of wood due to the rough use of school, but decided to use Accoya and not brick.

Of the four projects where wood was chosen as the main façade material, the involved interviewees meant that wood the main challenge of wood was durability. Of the three school projects in this investigation, only one project has chosen a wooden façade. "It should not be "legal" to use wood in school buildings," one interviewee said, due to the rough use. The four "wood" projects choose different types of products; accoya, Kebony, pine (panels) and CLT. In one project also solar panels were chosen. This was made possible due to funding by Enova. Also the client wanted to test this technology/material and learn from it. Also in project two and six brick was considered seriously. PL 2 said,"a GHG evaluation of brick with a 60 year building life span turned out positive compared to wood. A holistic conclusion was necessary to exclude brick." PL6 said a wide range of materials were assessed, but brick was not possible to choose due to the GHG footprint.

Project	Program	Ambition	EPD	GHG	LCC	Main façade material
1	Framtidens bygg	Passive house and later plus house	Yes	Yes	Yes	Untreated ore pine
2	Framtidens byer	Passive house, Pilot Project	Yes	Yes. Operation, Materials, Transport	Yes	Kebony
3	ZEB-COM	Zero energy, use of timber, pilot project	Yes	Yes. Construction, Materials, Operation	Yes	Cross laminated timber
4	FutureBuilt	Passive house, maybe close to zero	Yes	Yes. GHG reduction 50%	Yes	Fiber concrete
5	FutureBuilt application	Close to zero energy house (nNEB), pilot project.	Yes	Yes.	Yes	Brick, integrated solar panels
6	FutureBuilt	Passive house (first school in Oslo)	Yes	Yes. Operation, Material, Transport	Yes	Accoya
7	.	Passive house	Yes	Yes	Yes	Brick (requirement in the zoning plan)

Table 3: The different projects and their choice of façade material

Factors for choosing façade material

Figure 2 shows how the interviewees have answered on the question on what factors were emphasized when choosing the façade material in the project. The most frequently mentioned factors are sustainability (11), aesthetics (9) and cost (8).

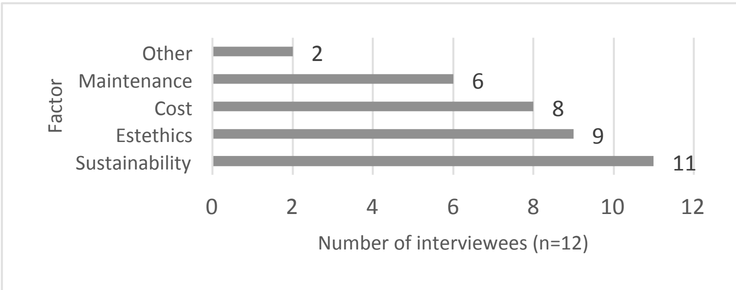

Figure 2: Factors emphasized when choosing façade material

In some projects, the choice of façade material was influenced by the general guidelines originating from the government, the user, the client or special building programs. For the projects that were examined, methods such as EPD analysis, LCC calculations, greenhouse gas accounting and LCA analysis (only project 3) were part of the decision-making for facade claddings. For this purpose the respective tools LCCweb.no, klimagassregnskap.no and SimaPro were used. For some projects, these analyses and calculations were used only due to documentation requirements, and thus had no major impact on the decision-making. For other projects, they were used to evaluate alternatives on product level. In projects with a clear focus on GHG, brick could not be an option according to the interviewees. Also the interviewees were the opinion that in projects with only documentary requirement and not specific measurable goals, there is room for more holistic interpretations and decisions. Also, in some projects LCC analysis are executed on the type of material, but not used to compare the same type of material, but for different products.

5. Discussion

The findings in this investigation shows that sustainability, aesthetics and cost are considered to be the most important factors influencing the choice of façade material. In this research sustainability seem to be a factor as important (or more) than aesthetics. We have to have in mind, that the sustainability goals in each project are measurable, whereas aesthetics are not. However, a possible future research question is to investigate to what degree the conception of beauty is in change. More simple expressed; how can something be beautiful if it is not sustainable? If the architects' or clients' conception of aesthetics change to correspond with sustainable solutions, then there will be no contradictions between the two parameters aesthetics and sustainability.

When the term or factor "sustainability" is broken down into different elements, it becomes clear that the projects have different ambitions. The use of LCC and GAG analysis vary, and also the importance in the decision making. In all of the investigated projects, an EPD analysis of the façade material is executed to determine the final façade material product. The difference in energy ambitions can partly be explained by the difference in building year; Bjørnsletta was the first passive house school in Oslo. Campus Evenstad, if the project reaches its goals, it will be the first ZEB-COM building in Norway. So, even if Bjørnsletta is not defined as a pilot project, and has lower ambitions than Evenstad – which is called a pilot project, they are both "first off" projects in their context. In the Statsbygg report of Rambøll, one conclusion was that the participant who influence the most on the choice of material depends on the project procurement arrangements. However, in this research there are different project procurement arrangements, but all very ambitious. Maybe the question of which participant influence the most is of less interest – as long as there are ambitious and measurable sustainability goals, and a culture or framework on how to work with this aspect.

When analysing what factors influence the choice of materials, it becomes clear, that not only the economical, aesthetical and sustainable (and other) factors play a role, but also the project process itself. A finding is that the process itself affects the decision making. Probably this is the most important tool to develop not only technical goals for a project, but also a culture on how to think, discuss and approach sustainable goals. Although not part of the investigation, it should be reflected on the importance the sustainable framework programs play as facilitator on sustainability. Denizou at al's research showed that public framework can affect the choice of building materials. The findings in this paper supports these findings.

The use and impact of calculations and analyses of EPD, GHG, LCC, and LCA may have a potential for improvement. The findings show, that these factors play very different roles in each project.

6. Conclusions

The findings in this investigation shows that sustainability, aesthetics and cost are considered to be the most important factors influencing the choice of façade material. Also for the architects, sustainability at least as important as aesthetics.

Based on the findings in the seven investigated cases, the participation in different environmental programs do seem to have influenced the evaluation and choice of façade material, both through developed processes and the required use of tools aimed at measuring. Bysheim and Nyrud's findings showing that the architects' preference towards the use of structural timer is related to previous experience with the use of structural timber in urban construction (Bysheim and Nyrud 2008) may also apply on other parts of the building and its solutions. This means, that the framework programs like FutureBuild, ZEB and others not only play an important role for the specific projects, but may also contribute indirectly to improve future projects through former participants.

All investigated projects had environmental ambitions. Still the decision makers conclude on a spectre of materials such as different wood solutions and bricks. An explanation for this is the difference in the projects' requirements and incoherent use of LCC, LCA, EPD and GHG calculations and analyses. Although the different projects even use the same calculation tools, the project processes and goals are still different. Each tool can be used in different ways and the results are in some cases more advisory. In other projects quantitative goals have to be achieved. In one case the requirements in the zoning planning overrule conclusions based on sustainable criteria. Different building functions may also lead to different choices of materials. In this investigation some clients and architects were very sceptical to the use of wood facades for school buildings.

Further research may assess to what degree participants in projects within a public frame work program influence sustainability goals, project processes and decisions in future projects. Have the public frame work influenced the participants' attitude towards sustainable building solutions. Another interesting research question is to what degree the architects' aesthetic judgement and values are influenced by the knowledge of sustainability values and solutions.

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The effect of climate change on the amount of wind driven rain on concrete facades

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Abstract

Private and public buildings built of concrete make up 34% of the whole building stock in Finland, of which almost 40% is now 30-50 years old. The financial and functional impact on Finnish society of this aged building stock is critical because one third of the country's population lives in these apartment blocks. There is a rising national concern on increasing maintenance needs of Finnish building stock. It has been concluded that new conceptual approaches to tackle the problem are acutely needed. The main reasons for facade degradation in the Finnish climate are freeze-thaw weathering of concrete and corrosion of reinforcement induced by carbonation of the surrounding concrete. A common denominator in every mechanism is water in varying forms. It can either work as a passage for harmful substances, e.g. chlorides, cause damage by its phase changes (freeze-thaw) or cause dissolution of substances in concrete. Two recent projects conducted by Finnish Meteorological Institute and Tampere University of Technology, have shown that future climate conditions in Finland are likely to get worse in terms of durability of structures exposed to climate. Precipitation during the winter season is going to increase while the form of precipitation is going to be increasingly water and sleet. At the same time, the conditions for drying are going to get worse. Thus, the deterioration rate of structures will accelerate in the most of Finland if maintenance and protection actions are neglected. To simulate the effect of changing climate conditions, it has been studied how the amount of wind-driven rain (WDR) on facades may change in future climate based on a greenhouse gas scenario. The study was conducted by comparing typical Finnish suburban concrete block build in 1970's in two different locations (coastal area and inland) at current climate and in 2050 and 2100. Based on the study the amount of WDR will increase more in coastal areas than in inland and will be more focused on south and south-west directions. The total increase in WDR will be approx. 15%, while the greatest increase (50%) will be faced by the westward facades in coastal area.

Keywords: Climate change, wind-driven rain, modelling, concrete

1. Introduction

47% of Finland's national property consists of the existing building stock. Thus, the maintenance and protection of the existing building stock are highly important for the welfare of the nation which makes the study of adaptation to climate change of existing building stock significant from the economic and also sustainability point of view. In Finland its significance is emphasized due to buildings' exposure to severe weather conditions.

A significant part of the Finnish building stock is relatively young and homogenous compared to the rest of Europe. A considerable number of envelopes of the precast concrete buildings erected 1960s and '70s have come near the end of the service life largely due to weathering. Thus, it is important to explore the possible climate change scenarios considering their effect on critical outdoor conditions for deterioration of structures, for the repair need of existing building stock and for the timing of repair actions.

Despite the rather young age of the precast building stock, several problems have been encountered in their maintenance and repair. Considering their technical service life, those buildings have in common e.g. highly durable frames but durability problems with facades and balconies exposed to Nordic outdoor climate. Thus, the durability properties of concrete buildings have not been adequate. The structures have deteriorated due to several different mechanisms whose progress depends on many factors related to structures, exposure and materials, which lead to widely varying service lives.

Based on the latest research conducted at Tampere University of Technology (TUT), the durability properties of existing concrete façades and balconies have been found to be poor (Lahdensivu et al. 2010, Lahdensivu 2012, Pakkala et al. 2014). The material properties related to freeze-thaw resistance of concrete and cover depth of reinforcement rarely fulfil the requirements of national building codes. However, despite the insufficient durability properties of concrete, damage that can be seen visually are relative rare.

Visual damage of concrete façades and balconies has a strong correlation with precipitation, wind directions during the rain and freeze-thaw cycles directly after the rain events (Lahdensivu 2012). The increasing amount of precipitation has been shown to have a strong correlation with the rate of the two most important deterioration mechanisms of Finnish outdoor concrete structures: carbonation induced corrosion of reinforcement and freeze-thaw deterioration (Köliö et al. 2014, Pakkala et al. 2014). In this paper the effect of climate change on the amount of wind driven rain on concrete facades is studied to assess the differences of climatic loads at variable locations and façade orientation.

2. Background

2.1 Finnish concrete facades

Since 1970s almost all prefabricated concrete structures in Finland are based on the Concrete Element System (Seppänen & Koivu 1970). That open system defines, for instance, the recommended floor-to-floor height and the types of prefabricated panels used. In principle, the system allows using the prefabricated panels made by all manufacturers in any single multi-storey building.

The concrete panels used in exterior walls of multi-storey residential buildings were, and still are, chiefly prefabricated sandwich-type panels with thermal insulation placed between two concrete layers. Facade panels are made up of two relatively thin reinforced concrete layers connected to each other by steel trusses. The outer layer is generally supported by the inner layer. Sandwich facade panels are connected to the building frame by the inner layer, usually by means of cast concrete joints and reinforcement ties.

2.2 Quality of concrete

The concrete grade used for concrete facade panels and most structural members of balconies has been C30/37 since the late 1980's in Finland based on the guidelines for durability and service life of concrete (Concrete Association of Finland 1989). Earlier the grade was C20/25. The cement used for concrete panels is mostly CEM I (42.5 N) (ordinary Portland cement) because of the good early strength it gives to concrete which allows rapid formwork rotation at the precast panel plant. White cement, CEM I (52.5 R), is also used in facade panels if necessary, but its share of total use is marginal.

The freeze-thaw resistance of the concrete is conducted by air-entrainment of fresh concrete. and it can be determined by testing a protective pore ratio (p_r). In 1976 Concrete Codes started to recommend the protective pore ratio of 0.15 which means that at least 15% of all pores are never filled by capillary water. At the Concrete Code 1989, the protective pore ratio was lifted to reach at least 0.20. Protective pore ratio $p_r < 0.10$ can be considered to make concrete non-freeze-thaw-resistant in Finnish outdoor climate (Lahdensivu 2012).

The success of air-entrainment of concrete used in facades and balconies have been studied by Lahdensivu (2012) from the thin section analysis results of the samples in the BeKo database (buildings built 1960-1995). Based on the study the freeze-thaw resistance differs considerably between various surface types of facades. Pakkala et al. (2014) studied buildings built after the requirement of protective pore ratio of 0.20 has been demanded and presented that only approx. 50% of the precast panels have met the freeze-thaw resistance requirements.

Lahdensivu (2012) presented that visually observable reinforcement corrosion damage existed in 59% of the examined facades. 54% of damage was local and extensive corrosion was found only in 5.7% of the facades. The corrosion damage was almost solely due to carbonation (Lahdensivu 2012).

2.3 Deterioration rate of concrete facades

The deterioration rate and need for repair of existing outdoor concrete structures, especially concrete facades and balconies, have been monitored by systematic condition assessments over 20 years. Lahdensivu (2012) studied in his doctoral thesis the deterioration of prefabricated concrete element buildings at present climate. His studies were based on 947 condition assessment reports made on buildings built 1960 – 1996 (Lahdensivu et al. 2010). He studied the changes on quality requirements, dominating deterioration mechanisms, their progress on present climate based on climate data produced by the Finnish Meteorological Institute (FMI) and effect of a geographical distribution on them. The most essential results were:

- There is a significant lack of quality with concrete structures, also with structures made according to current concrete code,
- The most significant deterioration mechanisms have been carbonation induced corrosion and freeze-thaw weathering,
- The most significant climatic causes for damage have been wind-driven rain and freeze-thaw cycles within few days after the rain events,
- The deterioration rate has been faster in coastal areas than in inland.

Two recent studies by Köliö et al. (2014) and Pakkala et al. (2014) studied rates of carbonation induced corrosion of concrete reinforcement and freeze-thaw weathering of concrete facades, respectively, at the projected future climate. Köliö et al. presented that the increase of precipitation decelerate the carbonation rate and thus the initiation phase of reinforcement corrosion while the increase in CO2 level has a greater opposite impact. On the other hand, the increase of precipitation amount and temperature accelerate the active corrosion phase. Pakkala et al. concluded e.g.:

- Amount of precipitation will increase significantly until the end of the century and relatively more at inland than at coastal areas,
- Amount of freeze-thaw cycles after rain events will decrease significantly after 2050's at southern Finland but remains almost at the same level at inland,
- The amount of precipitation is almost the same at coastal areas and inland but at coastal areas the rate of freeze-thaw weathering is higher because of the annual average wind speed is higher, thus more of the precipitation will shower the vertical surfaces,
- The WDR load is both at present and at future significantly concentrated on south-west, south and south-east orientated facades and its relative increase is greater than the increase of precipitation because of the higher wind speed during the rain,
- Concrete can be durable in the Nordic climate if it has been properly air-entrained.

2.4 Climatic conditions in Finland

Although Finnish climate is relatively steady considering the latitudes, it still varies significantly from the mild and relatively rainy coastal area to the drier inland. However, the

Finnish building stock is mainly concentrated in the few biggest cities and surrounding growth areas. Finland can be divided into four main areas based on climatic differences and concentration of population: the coastal area, southern Finland, inland and Lapland, see figure 1. (Pakkala et al. 2014)

Figure 1: Finland can be divided into four main areas based on climate and concentrations of population. (Pakkala et al. 2014)

2.5 Climate change projections

Climate change as such has been studied worldwide for a long time. In this context, climate change refers to global warming caused by an increase in greenhouse gases, especially carbon dioxide (CO_2). Climate change will affect the geographic and seasonal distribution of precipitation, wind conditions, cloudiness, air humidity and solar radiation. Modelling of future climate is based on alternative scenarios of greenhouse gas and aerosol particle emissions. In the scenarios, different assumptions are made about the future development of population growth, economic development, energy production modes, etc.

The ACCLIM (Jylhä et al. 2009) and FRAME (Vinha et al. 2013) projects have shown that future climate conditions in Finland are likely to get worse in terms of durability of facades and other structures exposed to climate. According to the data of the ACCLIM project, precipitation during the winter season is also going to increase while the form of precipitation is going to be increasingly water and sleet. At the same time, the conditions for drying are going to get worse. Thus, the deterioration rate of structures will accelerate in most of Finland if maintenance and protection actions are neglected. (Lahdensivu 2012)

The FMI examined in the ACCLIM project the different climate models and built models for observing Finnish climatic conditions and adaptation to climate change. In all greenhouse gas emission scenarios, based on three IPCC (2007) scenarios for the evolution of greenhouse gas and aerosol particle emissions, the average temperature rises at a constant rate until 2040. Differences between the scenarios start to emerge only after the middle of the century, see figure 2. (Jylhä et al. 2009)

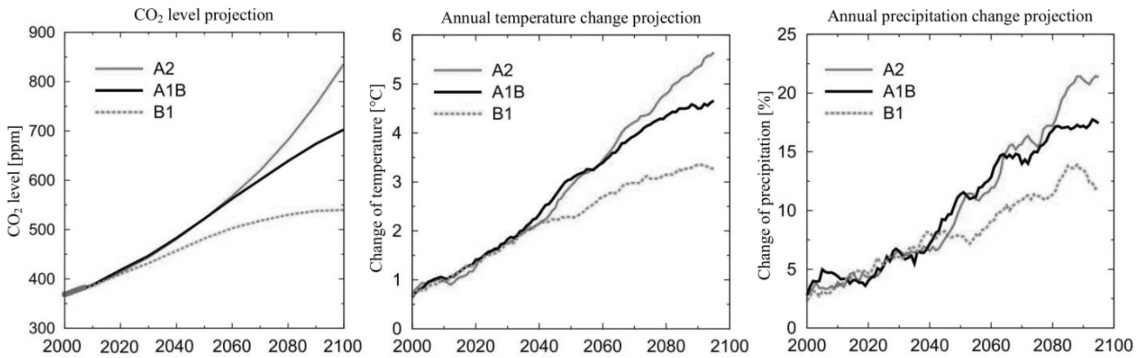

Figure 2: Projections for (a) CO2 level, (b) annual mean temperature and (c) precipitation change in 2000–2100, in relation to the mean of the reference period 1971–2000. The curves depict 11 year running means, averaged over Finland and the responses of 19 global climate models (Ruosteenoja et al. 2013). Projections are given separately for the three greenhouse gas scenarios A2, A1B and B1 (IPCC 2007).

In the REFI-B project (Jylhä et al. 2013) the FMI also forecast the climates of the four regions (coastal area, southern Finland, inland, Lapland) in three periods (2030, 2050 and 2100). The forecasts are based on an average of 19 different models which are all based on greenhouse gas emission scenario A2. The A2 scenario involves a situation where greenhouse gases are assumed to increase significantly − it is a sort of worst-case scenario. The FMI also has other significant greenhouse gas emission scenarios: A1B (quite large emissions) and B1 (small emissions). (Ruosteenoja et al. 2013).

2.6 Modelling of wind-driven rain

Wind-driven rain (WDR) striking building facades has been the focus of several studies in the last decades as mentioned by Blocken & Carmeliet (2004). The moisture load resulting from the WDR depends not only on rainfall intensity and wind speed, but also on raindrop trajectories around buildings. That increases the complexity of the phenomenon greatly.

The standard SFS-EN ISO 15927-3 (2009) presents a factor I_{WA} (Wall annual index) which can be used to estimate amount of precipitation collected by a free-standing driving-rain gauge in flat open country to present the amounts of precipitation that impacts on a real wall. The wall annual index is highly simplified simulation for assessing the WDR against building facades. There are other methods to model the WDR as is mentioned by Blocken and Carmeliet (2004, 2010), e.g. CFD model. It takes into account more precisely the distribution of the WDR in different areas of the facades. Although the wall annual index is simplified method, it gives adequate results for e.g. comparing different locational effects on the amount of wind driven rain on facades. Compared to CFD modelling it underestimates the amount of wind driven rain near the top of the façade but overestimates the amount on the top 2.5 metres with high buildings and low rain intensity. The higher the rain intensity the more it underestimates the amount of wind driven rain. The underestimation increases near the edges of the building. With rain intensities from 10 mm/h to 30 mm/h the wall annual index gives adequately corresponding results with CFD modelling in the vertical middle line with high and low rise vertical buildings and tower buildings. (Blocken et al. 2010).

3. Material and methods

3.1 Research material

Present and future climate projections and their effects on weather conditions critical to concrete degradation have been prepared by the Finnish Meteorological Institute (FMI). The data used in this study are hourly interpolated observations of temperature, wind speed, wind direction and amount of precipitation over 30 years (1980–2009). The future climate projections, based on the A2 scenario, were calculated by FMI to represent hourly data for a similar period in 2050 and 2100. The calculations of this study focus on two locations, the coastal and the southern Finland areas, although both collected and forecast data are also available for other locations.

The locations of the buildings used in this study are set to the same areas as the climate data mentioned above. Imaginary Finnish suburban city blocks, shown in the figure 3, are located at the coastal area and at the southern Finland. The climate observations, both collected and projected, are from Helsinki-Vantaa and Jokioinen. Two types of buildings were studied, both represented typical Finnish multi-storey residential building of 1970's with 2 staircases. The other one was 4- and the other 8-storey.

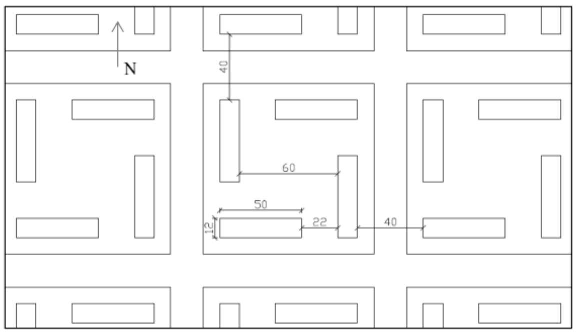

Figure 3: Simplified Finnish suburban street plan with repetitive blocks.

3.2 Modelling of wind-driven rain

The Wall annual index I_{WA} is presented at the standard SFS-EN ISO 15927-3 "Hygrothermal performance of buildings. Calculation and presentation of climatic data." (2009) as follows:

$$I_{WA} = I_A C_R C_T O W \tag{1}$$

, where I_A is the airfield annual index, C_R is a terrain roughness coefficient, C_T is a topography coefficient, O is an obstruction factor and W is a wall factor. The airfield annual index I_A is defined as:

$$I_A = \frac{2}{9} \frac{\sum v r^{\frac{8}{9}} \cos(D-\theta)}{N} \tag{2}$$

where v is hourly mean wind speed [m/s], r is hourly rainfall total [mm], D is hourly mean wind direction from north [°], N is number of years for which data is available and the summation is taken over all hours for which $\cos(D-\theta)$ is positive.

The roughness coefficient depends on the height above the ground and the roughness of the terrain in the direction from which the wind is coming, i.e. is there an open sea, a farm land, a suburban area or an urban area in the upwind direction. The coefficient C_R at height z is calculated as follows:

$$C_R(z) = K_R \ln\left(\frac{z}{z_0}\right) \qquad \text{for } z \geq z_{min} \qquad (3)$$

$$C_R(z) = C_R(z_{min}) \qquad \text{for } z < z_{min} \qquad (4)$$

This study uses only the terrain categories *I* and *III* see table 1.

Table 1: Terrain categories and related parameters. (SFS-ISO 15927-3 2009)

Terrain category	*Description*	K_R	z_0	z_{min}
I	*Rough open sea; lake shore with at least 5 km open water upwind and smooth flat country without obstacles*	*0.17*	*0.01*	*2*
III	*Suburban or industrial areas and permanent forest*	*0.22*	*0.3*	*8*

The topography coefficient takes into account the increase of mean wind speed over isolated hills and escarpments near the building subjected to the study. The research assumes the studied buildings are located at flat surroundings when the topography coefficient $C_T = 1$.

Obstruction factor depends on the horizontal distance to the nearest obstacle which is at least as high as the wall subjected to the study, see table 2. The wall factor is, in the case of flat roof multi-storey building, 0.5 for the top 2.5 m of the wall and 0.2 for remainder.

Table2: Obstruction factor. (SFS-ISO 15927-3 2009)

Distance of obstruction from wall [m]	*4 – 8*	*8 – 15*	*15 – 25*	*25 – 40*	*40 – 60*	*60 – 80*	*80 – 100*	*100 – 120*	*over 120*
Obstruction factor O	*0.2*	*0.3*	*0.4*	*0.5*	*0.6*	*0.7*	*0.8*	*0.9*	*1.0*

4. Results and discussion

Figures 4 and 5 show the amount of the WDR hitting facades facing various directions by using the driving rain index I_A (see eq. 2) for different wind directions in the coastal and southern Finland areas, respectively. The wind directions are given in degrees from north in 10° increments. The figures give the present indices (30 year average, 1980–2009) and projections for future climates in 2050 and 2100. Figure 6 shows wind direction related relative change of the amount of WDR compared to present climate.

Figures 4, 5 and 6 show clearly that south and south-west-facing facades will get significantly more WDR. The same phenomenon has been noted in condition assessment studies where the most deterioration has been observed on south-facing facades and balconies. By the end of the century, wind driven rain will increase approx. 30% in both areas. At inland the increase will be 40% (Pakkala et al. 2014).

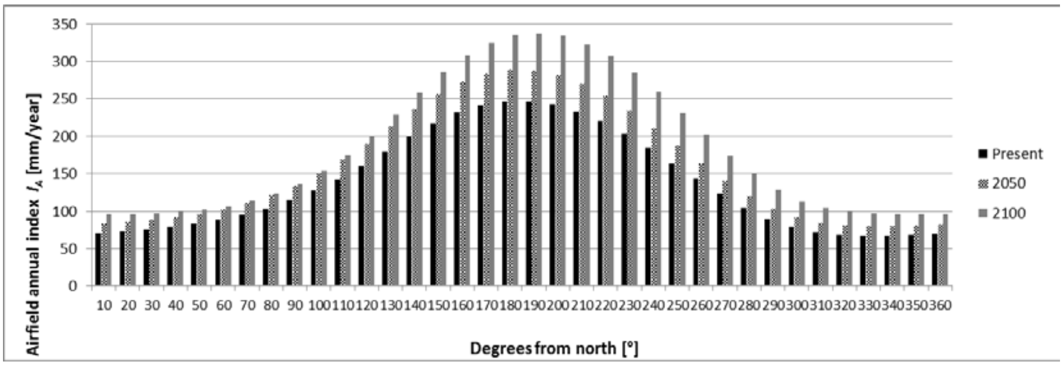

Figure 4: Airfield annual index vs. wind direction of present and future (2050, 2100) climates in the coastal area. (Pakkala et al. 2014)

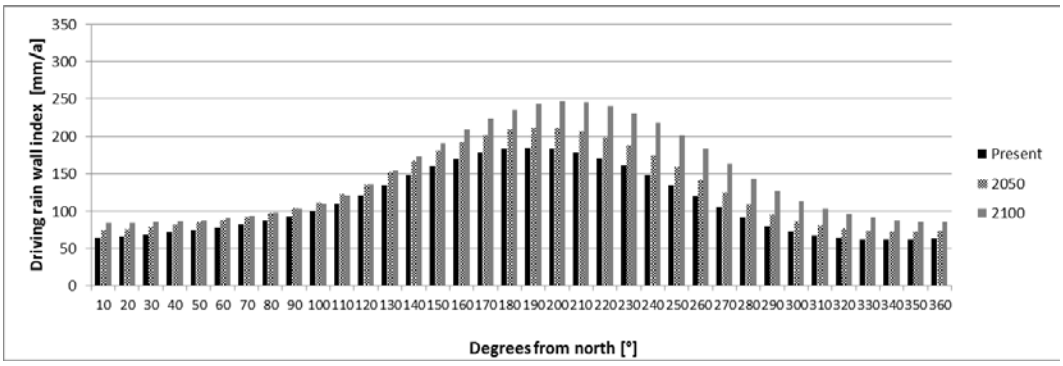

Figure 5: Airfield annual index vs. wind direction of present and future (2050, 2100) southern Finland climates.

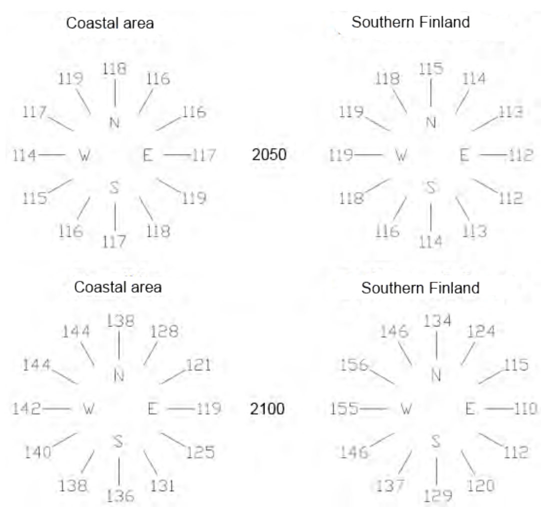

Figure 6: Relative change of the amount of WDR compared to present climate from different wind directions.

The study showed that the height of the building does not have significant impact on the amount of WDR. At the top 2.5 m of 8-storey building an increase at the amount of precipitation compared to 4-storey building is 10% at the coastal area and 20% at southern Finland. At the lower parts of the facades the amount of WDR is in practice the same.

Depending of the façade orientation the amount of WDR is 50 – 90% higher at the coastal area compared to southern Finland, see figures 7 and 8. The highest difference is at the northern facades. The most significant reason for the difference is, as it has been presented before, the higher airfield annual index, i.e. the wind speed during the rain events. Other significant factor is the chosen terrain category. If the terrain category is chosen to be the same with both studied areas, the difference would be 10 – 40%. The south-faced facades can be subjected to 3.5 times higher WDR load than north-faced facades.

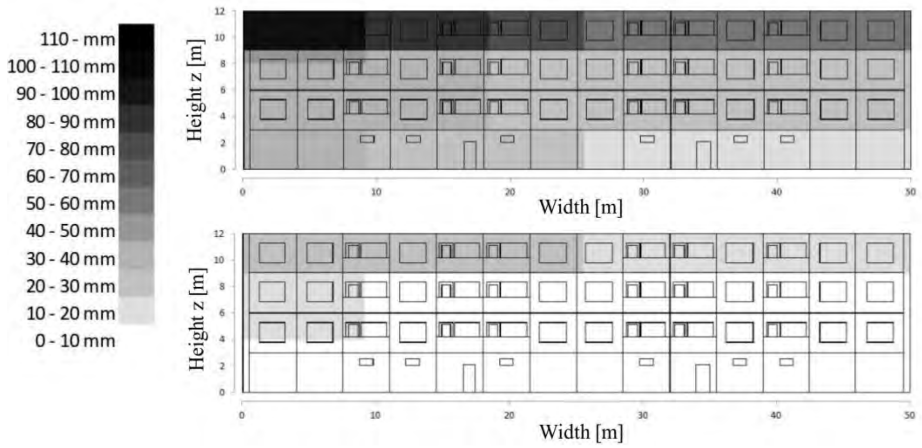

Figure 7: Annual amount WDR on south-faced façades at coastal area (above) and southern Finland (below) at present climate.

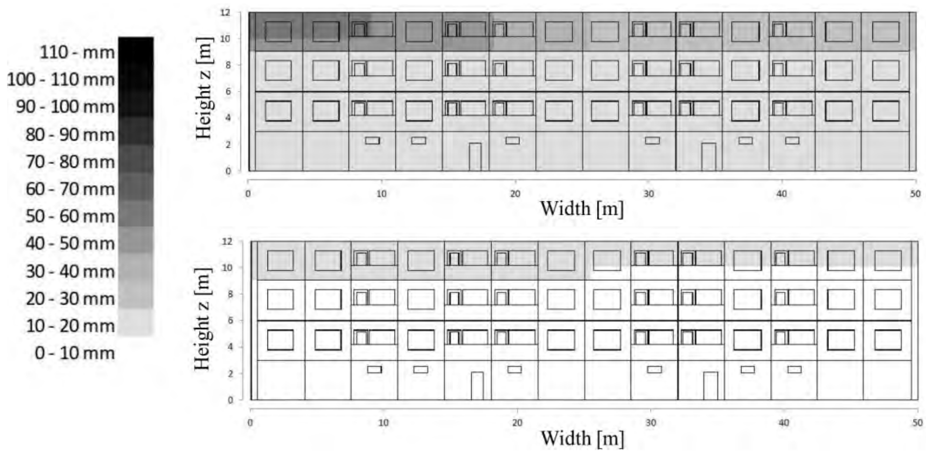

Figure 8: Annual amount WDR on north-faced façades at coastal area (above) and southern Finland (below) at present climate.

5. Conclusions

Precipitation has been shown to have an effect on all of the major deterioration mechanisms of outdoor concrete structures. The future climate conditions in Finland are likely to get worse in terms of durability of structures exposed to climate because precipitation during the winter season is going to increase while the form of precipitation is going to be increasingly water and sleet. At the same time, the conditions for drying are going to get worse. Thus, in this study the changes of the wind-driven rain (WDR) on facades were studied at two different locations. In addition, the effect of façade orientation was studied.

The main results were:

- The amount of WDR is significantly higher at the coastal area than at southern Finland,
- The relative increase of the amount of WDR is higher at the coastal area because of the increasing wind speed during the rain,
- The south-faced facades are exposed to 3.5 times higher WDR load than north-faced facades,
- The top part of the facades are exposed to significantly higher WDR load than the lower parts,
- WDR will be more concentrated on south and south-west directions until the end of the century,
- The most significant factors for high WDR load are the wind speed during the rain event and the openness of the terrain near the studied building.

The method for calculating WDR is simplified, yet it gives adequate results for e.g. comparing different locational effects on the amount of wind driven rain on facades. The main defect of the method is an underestimation of WDR near the edges of the building.

Based on the study it can be concluded that at the future climate it is highly important to take into account the surrounding terrain and locational and microclimatic aspects during planning and with material choices. It should be taken into account that open areas, e.g. at the coastal line, cause significant and increasing WDR load on the facades. In addition, the top part of south and south-west-faced facades should be shielded from rain, e.g. with longer eaves.

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Housing Reconstruction Following the 2012 Nigerian Floods: Was it Built Back Better?

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Abstract

The recently agreed Sendai Framework for Disaster Risk Reduction 2015-2030 calls for reducing the exposure and vulnerability of communities and thus preventing the creation of new disaster risks. It specifically identifies the need to use post-disaster reconstruction to "Build Back Better" and thus emphasizes the strategic importance of housing reconstruction in achieving disaster resilience. In the 2012 flooding in Nigeria, 7.7 million people were affected, 363 fatalities were recorded and approximately 600 000 houses were damaged or destroyed. This disaster greatly worsened an already existing housing deficit thereby placing huge pressure on all levels of government to address the sharp increase in housing demand.

This research assesses the performance of the post-flood housing reconstruction programme in Lokoja, Kogi State, Nigeria. It identifies the efforts made to enable affected communities to achieve improved disaster resilience after the event and compares these to the Build Back Better expectations under the new Sendai Framework.

Qualitative data were collected from stakeholder interviews, project documents and reports and personal observations in the field. The findings indicate that, while some aspects of Build Back Better were implemented in this particular case, others were not and so the reconstruction programme in Lokoja fell short of the Sendai Framework's Build Back Better expectations.

Keywords: Build Back Better, built environment, construction management, housing, post-disaster reconstruction

1. Introduction

The new Sendai Framework for disaster risk reduction 2015-2030 (SFDRR) sets out distinct targets and priorities for action with the intention of reducing disaster losses. The framework focuses on addressing global disaster risk drivers in order *to effectively protect vulnerable persons, communities and countries.* The SFDRR also aims to strengthen community and environmental resilience to disasters (UNISDR 2015) and outlines guiding principles and essential responsibilities for states and institutions. It emphasises the engagement of all-of-society and all state institutions in disaster risk reduction practices (Wahlström 2015).

The SFDRR outlines seven global targets that are expected to be achieved by the end of the next decade (UNISDR 2015). It further identifies four priorities for action to substantially reduce disaster effects and losses over the next 15 years. The priorities for action are:

1. understanding disaster risk;
2. strengthening disaster risk governance;
3. investing in disaster risk reduction;
4. enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.

This study is focused on the fourth of these priorities for action and, specifically, achieving "Build Back Better". The case of a Nigerian housing reconstruction programme following the flooding of 2012 is considered in terms of the "Build Back Better" expectations under the SFDRR in order to determine whether the reconstruction programme measured up to these expectations and, if not, what recommendations can be made for future initiatives.

In section 2, the Build Back Better concept and its elements are described in detail. In section 3, the background to the reconstruction efforts following the 2012 flooding in Nigeria is presented. The methodology for this research is described in section 4 and its findings are presented and discussed in section 5. Section 6 of the paper sets forth conclusions and recommendations.

2. The Build Back Better Concept

The Build Back Better (BBB) concept seems to have originated following Hurricanes Mitch and George in the Americas in 1998 when USAID and its partners agreed to reconstruct affected buildings using techniques and standards to enable the resilience of structures. The measures adopted included: incorporating environmental and geological analysis into designs; encouraging the utilization of effective land-use planning; creating social and economic opportunities for affected communities; and ensuring effective monitoring and coordination by the donors (USAID 1999; Reliefweb 2006). However, BBB gained global attention and adherence during the reconstruction of Aceh, Indonesia, following the Indian Ocean earthquake and tsunami in 2004 (Lyons 2009).

The post-disaster context offers an exceptional opportunity to develop an improved and resilient built environment and BBB advocates the utilisation of this opportunity for the identification of underlying and new disaster risk factors and proposes the systematic incorporation of long-term mitigation measures into reconstruction (Kennedy *et al*. 2008). In addition, BBB emphasises the inclusion of disaster-hit communities in reconstruction processes to create livelihood support and opportunities that facilitate long-term resilience for communities (Lyons 2009).

Several reconstruction guidelines (including FEMA 2000; Clinton 2006) aimed at "Building Back Better" exist but these are not necessarily consistent and this can cause confusion. Consequently, Mannakkara and Wilkinson (2013; 2014) reconceptualised the guidelines to produce a comprehensive framework that considers the physical, social and economic conditions of communities in post-disaster reconstruction and recovery. The authors categorised the themes into three basic elements that represent the BBB concept:

1. Risk reduction;
2. Community recovery; and,
3. Implementation.

These three elements are broken down and further discussed in the following sections.

2.1 Risk Reduction

Risk reduction focuses on minimizing the damage caused by disaster. This includes measures put in place to minimize vulnerability, improve the capacity and resilience of communities (IFRC 2012). Such measures have been classified as structural and non-structural.

Structural Measures: Structural measures involve improved design, establishment and enforcement of building codes and construction guidelines, strengthening of structures exposed to hazards and implementation of effective construction practices (Wamsler 2006; Bosher *et al.* 2007).

Non-structural Measures: Non-structural measures include hazard-based land use planning and vulnerability analyses, discouragement of development on high risk areas, the creation of buffer zones, relocation of settlements to protected zones, public enlightenment campaigns regarding hazards, vulnerability, risk reduction and the development of resilience to disasters (Wamsler 2006; Shaw and Ahmed 2010).

2.2 Community Recovery

Community recovery emphasises the creation of sustainable employment and livelihood support programmes for affected communities (Clinton 2006). It involves measures aimed at the restoration and improvement of social and economic conditions for the affected communities. Community recovery measures are classified into social recovery and economic recovery (Mannakkara and Wilkinson 2014).

Social Recovery: Social recovery refers to the need for disaster victims' physical, psychosocial and cultural well-being to facilitate recovery (Lyons 2009; Mooney *et al.* 2011). Social recovery calls for collaboration between the professionals involved (e.g. psychologists, designers) and the community. Besides attending to mental health challenges, psychological support should be provided to improve communities' adaptive capacity to disasters (Mooney *et al.* 2011).

Economic Recovery: Economic recovery concerns the return of businesses and local economies to stability following a disaster (Chang and Rose 2012). It includes access to subsidized loans and business grants, provision of equipment, seedlings to support farmers, education and skill acquisition programmes to allow affected communities to participate in reconstruction activities and to provide them with the means for sustainable livelihoods (James Lee Witt Associates 2005; NEMA 2013; UN OCHA 2013)

2.3 Implementation

Implementation describes the processes by which risk reduction and community recovery is executed. It involves a number of sub-themes that transmit the BBB concept efficiently. The sub-themes as categorized in Mannakkara and Wilkinson (2013) are stakeholder coordination, legislation and regulation, community consultation and, monitoring and evaluation.

Stakeholder Coordination: Stakeholder coordination deals with the organisation of stakeholders involved in reconstruction projects. The BBB concept recommends the creation of a central body that will effectively coordinate stakeholders involved in reconstruction and recovery (Moe and Pathranarakul 2006).

Legislation and Regulation: BBB recommends supportive laws and regulations that are instituted and enforced in order to reduce disaster risk and to create an enabling environment for managing the reconstruction and recovery processes (Clinton 2006; Le Masurier *et al*. 2006).

Community Consultation: The BBB concept emphasises the involvement of affected communities in reconstruction (James Lee Witt Associates 2005). Community consultation enables reconstruction projects' outcome goals to be better aligned with community needs and thus it facilitates acceptability (ALNAP, 2011).

Monitoring and Evaluation: To ensure successful reconstructed, detailed management plans should be formulated with long-term monitoring schemes to ensure that all the intended risk reduction measures are duly incorporated (Clinton 2006; Moe and Pathranarakul, 2006). Lessons learnt should be documented and adapted in future projects.

3. The 2012 Nigerian floods

The 2012 floods affected 30 of the 36 states in Nigeria and resulted in devastating property losses with about 600,000 houses damaged or destroyed. 363 fatalities were recorded and over 7.7 million people affected (IFRC, 29 Sep 2012; UN OCHA, 15 Nov 2012).

Responding to the disaster, the national government provided relief funds to affected states and to some federal agencies for disaster response, relief and rehabilitation. Non-governmental organisations and corporate bodies also supported the victims with relief materials and financial assistance. Some state governments initiated mass housing schemes to ameliorate the disaster effects on housing and to enable affected communities to recover.

Lokoja, the administrative capital of Kogi State was chosen as an ideal case study area for this research because it was severely affected by the 2012 floods and has since benefited from recent housing reconstruction and community recovery projects. Lokoja is located at the confluence of the rivers Niger and Benue. Community members within Lokoja are largely farmers and are often affected by floods that cause considerable damage to their properties.

In Lokoja, about 1700 houses were affected by the flooding, some of which were reconstructed while others on the flood plain were to be demolished and the affected community relocated (News24 2013). In April 2013, the Kogi State government initiated the construction of 272 housing units for the 2012 flood victims with priority being given to affected property owners.

4. Methodology

Qualitative data were collected from the literature, interviews, project documents and reports and personal observations in the study area. 31 semi-structured interviews were conducted in October and November 2015 with representatives of stakeholders involved in the housing reconstruction and recovery programme.

Representatives of national level agencies and non-governmental organisations as shown in Table 1(a) were interviewed to compile a detailed description of national efforts towards community recovery. At the state level, agencies responsible for managing the government's efforts towards risk reduction, housing reconstruction and community recovery were identified and each of these agencies (described in Table 1(b)) were interviewed to recount their perspectives of the recovery programme. The head of the Farmers Association at the state level also gave details of the disaster effects and efforts made by stakeholders to enable the recovery of affected farmers.

At the project level, supervisory engineers and the contractors involved in the housing reconstruction projects gave an account of the contractor-driven housing production processes. Representatives of owner-driven reconstruction - building-owners who were relocated and affected tenants - also give an account of their participation and efforts.

Representatives of local governments were also interviewed to describe local government's efforts and their inclusiveness in the recovery process. Representatives of the local community, the residents of the new housing scheme, were interviewed to gain an understanding of their involvement and opinions. Descriptions of these local level interviewees are provided in Table 1(c).

Table 1(a): Profile of Interviewees at National Level

Interview Code (C)	*Description*	*No. of Interviews*
C1	*National Emergency Management Agency (NEMA)*	*1*
C2	*Manager, National Inland Waterways (NIWA), Lokoja*	*1*
C3	*Researcher, NASRDA*	*1*
C30	*Representative, The Nigerian Red Cross Society*	*1*
C31	*OXFAM, Nigeria*	*1*

The information received from the interviewees was validated through triangulation. This was done by verifying questions from other interviewees and available project documents and literature. Personal details of the interviewees were kept confidential to encourage the reliability of the information received. Data collected were encoded according to the elements and sub-elements of BBB which were described in section 2 above. The findings and analysis are presented in section 5 as a narrative based on this thematic categorization (Kvale 2007).

Table 1(b): Profile of Interviewees at State Level

Interview Code (C)	*Description*	*No. of Interviews*
C4-C5	*Managers, State Emergency Management Agency (SEMA)*	*2*
C6	*Head, Town Planning and Development Board, Kogi State*	*2*
C7	*Head, Department of Building Control, Kogi State*	*1*
C8	*Manager, Ministry of Land, Housing, Urban Development*	*1*
C9-C10	*Supervisory personnel/Engineers (Post-flood Housing)*	*2*
C11-C12	*Contractors, Post-flood Housing*	*2*
C13	*Manager, Ministry of Environment and Natural resources*	*1*
C17	*Head, Kogi State Farmers Association*	*1*

Table 1(c): Profile of Interviewees at Local Level

Interview Code (C)	*Description*	*No. of Interviews*
C14	*Development officer, Lokoja Local Government*	*1*
C15	*Development officer, Ajaokuta Local Government*	*1*
C16	*Development officer, Kogi Local Government*	*1*
C18	*Community representative, Lokoja Local government*	*1*
C19	*Community representative, Adankolo Local government*	*1*
C20	*Community representative, Koton-karfi Local government*	*1*
C21-23	*Residents, New Housing Estate*	*3*
C24-26	*Owner-built housing reconstruction and rehabilitation*	*3*
C27-29	*Tenants affected by flood (without allocation)*	*2*

5. Findings

Based on the analysed data, the study findings are presented and discussed under each of the three elements of Build Back Better and their corresponding subthemes.

5.1 Disaster Risk Reduction

Structural Measures: According to C7-C10, the government adopted a contractor driven-approach for the construction of new buildings due to the need for quick delivery. C6, C7 and C8 reported that the buildings were designed to the structural standard and took account of the soil conditions and environmental challenges of Lokoja. According to C7, no new building code was established, rather existing codes and construction guidelines were enforced with inspections carried out and approvals issued at prescribed developmental stages for all new development. In addition, quality assurance mechanisms and procedures were established to ensure quality control in reconstruction. C7 identified the quality management procedures established included material quality and specifications checks, multi-department/agency inspections and regular monitoring and supervision.

According to C7, C8 and C9-C10 some contractors who were politically well-connected did not comply with the established quality management standard. C7 emphasised that they were given executive fiat and operated without applying the laid-down quality management procedures with the excuse that they were following a superior order that emphasized quick delivery. Although, beneficiaries had just been allocated their dwellings, wall cracks and damped walls were observed confirming that quality procedures were compromised (Figures 1a and 1b). C9-C10 mentioned that some contractors lacked the capacity to do a good quality job, but were awarded contracts due to their influence.

Figure 1(a) and (b) Figures showing visible defects on newly constructed houses for Post-2012 flood victims in Lokoja, Kogi State, Nigeria.

For owner-driven housing reconstruction, C24 reported that his building was destroyed by the flood but since it was not located within the buffer zone, a new design submitted was approved by the town planning board. C24 mentioned that the reconstruction of the building was often inspected by supervisors from the board to ensure compliance with building guidelines.

The authors observed a lack of drainage channels in the new scheme which exposed the settlement to flood risk due to run-off. However, C13 reported that new drainage channels are being constructed while old ones are being rehabilitated within the Lokoja metropolis to reduce flood risk. In addition, C13 and Tribune (June 26 2015), reported that a shoreline protection and embankment project alongside the river bank is being built to protect some high-risk communities from exposure to flood risk and to serve as a recreational area and park.

Non-structural Measures: A number of non-structural risk reduction measures were undertaken by the government. After the event, risk and multi-hazard vulnerability assessments were carried out and a flood risk map was produced (Aderoju *et al.* 2014). Another study identified the location to site the new housing scheme for relocated victims (Isa *et al.* 2015).

According to C5 and C7, only affected property owners with valid documents were relocated from high risk zones while new developments were barred and buffer zones which were earlier created were now enforced. However, C19, C22 and C23 reported that "we were relocated without provision for basic facilities like schools, hospitals and connecting roads to the town".

C5 reported that National Meteorological Agency and Nigeria Inland Waterways Authority provided early warnings that gave notice of the significant rise in water level to the community through the State Emergency Management Agency (SEMA). All of C4, C5, C13 and C14-C16 mentioned that before, during and after the flooding, SEMA conducted public enlightenment campaigns on vulnerability to flood risk, disaster preparedness and response using all media channels.

5.2 Community Recovery

Social Recovery: C30 reported that assistance was provided by the Nigerian Red Cross Society in the form of relief materials, health, hygiene promotion and, most importantly, the provision of psychosocial support to help traumatized victims work through their experiences. According to C4 and C5 teams of medical experts and psychologists were deployed to various internally displaced persons camps to attend to the medical and psychological needs of the victims.

In terms of housing reconstruction, C21-C23 reported that they were not adequately involved in the housing design and reconstruction process so that the houses provided to them had inadequate numbers and sizes of rooms. It was observed that non-property owners were not given consideration in the allocation of housing. Although, C27-29 mentioned that they were given some money to rent dwellings.

Economic Recovery: According to C22 and C5, grants of NGN50,000 were given to property owners. C14, C15 and C16 emphasised that some money was given to flood victims as relief to ameliorate the effects of property loss. In addition, livelihood support programmes were implemented by NGOs with the distribution of seedlings and fishing nets, while training and capacity building programmes were conducted on risk reduction and disaster resilience (UN OCHA, 01 April 2013).

5.3 Implementation

Stakeholder Coordination: Following the 2012 disaster, a Flood Relief Management Committee, headed by the Deputy Governor's office was set-up to coordinate stakeholders involved in reconstruction and recovery. C7 and C8 reported that the committee coordinated recovery operations, procurement and monitored reconstruction progress and performance. C4 and C5 mentioned that training and capacity development programmes were organised for management personnel to build disaster management capabilities and to enhance the management of the reconstruction and recovery process. However, C18, C19 and C20 mentioned that they were only involved in the distribution of relief items to the locals.

Legislation and Regulation: According to C6, C7 and C8, no new legislation or regulations were established. Rather, existing regulations regarding buffer zones were now enforced. C6 and C7 stated that the enforcement of the existing land use acts and building regulations would ensure that disaster risks are reduced.

Community Consultation: According to C18-C20 they were shown designs of the buildings to be reconstructed and taken to the housing reconstruction site during implementation (News 24 2013). We were given no choice but to accept what the government provided since we were getting it for free. C22 and C23 complained that the new houses are too small.

Monitoring and Evaluation: C6, C7 and C8 stated that lessons learnt from the housing reconstruction projects initiated by government were documented. C8 further mentioned that lessons learnt are applied in an on-going bond-housing project (of 500 units). However, C8 noted that the Post-2012 recovery projects initiated by the government are still in progress.

5.4 Summary of Findings

Disaster Risk Reduction – Structural Measures – BBB *not achieved*: Some measures were taken (embankment construction) but non-conformance with quality management procedures during construction and the lack of drainage channels left the new buildings vulnerable.

Disaster Risk Reduction – Non-structural Measures – BBB *achieved*: Multi-hazard vulnerability analysis, flood-risk mapping and (earlier identified) buffer-zones were enforced. Housing was relocated from high-risk zones.

Community Recovery – Social Recovery – BBB *not achieved*: A lack of involvement of owners in relocation planning, building design and construction processes and a lack of consideration for non-owner residents compromised community recovery.

Community Recovery – Economic Recovery – BBB *achieved*: Several successful measures were taken to enable affected communities to recover economically from the disaster.

Implementation – Stakeholder Coordination – BBB *achieved*: A central committee to coordinate stakeholder involvement was set up by the state government. However, the selection of contractors was influenced by politics and local authorities should have been more involved.

Implementation – Legislation and Regulation – BBB *achieved*: Although no new legislation was passed, existing land-use and building development regulations were enforced.

Implementation – Community Consultation – BBB *not achieved*: Inadequate consultation (especially regarding the relocation site, building design types and the construction process).

Implementation – Monitoring and Evaluation – BBB *not achieved*: A systematic approach to monitoring was initially established but this was negated by the political influence which affected reconstruction implementation. Lessons learnt were documented for future projects.

6. Conclusions

The Sendai Framework for Disaster Risk Reduction 2015-2030 calls for priority action to Build Back Better in reconstruction. Using a comprehensive BBB framework as a guide to evaluate the housing reconstruction programme in Lokoja following the 2012 floods in Nigeria, it is evident that considerable efforts were made by government agencies and other stakeholders and, indeed, some of the elements that comprise BBB were achieved (refer to section 5.4). However, other elements of BBB were not achieved. In particular, the non-conformance of some contractors to the established quality management procedures resulted in some poorly constructed housing units and the lack of drainage channels to mitigate flood risk threatens to undermine the reconstruction and recovery programme unless it is quickly remedied. In addition, the non–participation of the affected community in the design and reconstruction of housing and the lack of consideration of non-owners (affected tenants) in the reconstruction and allocation process indicate that this specific example of a recent housing reconstruction initiative falls short of the BBB expectations under the new SFDRR.

This study has used the SFDRR as a reference framework to measure the performance of the Nigerian post 2012 flooding housing reconstruction programme. By doing so, we can recommend specific improvements in terms of:

- structural measures (building quality improvements),
- social recovery and community consultation (inclusion of all affected community members and greater involvement of the community in the design and reconstruction process)
- monitoring and evaluation (putting in place safeguards to ensure that the reconstruction programme is protected from political influence).

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An Overview of Urban Resilience to Natural Disasters in Brazil

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Abstract

The purpose of this work is to analyse how Brazil is promoting urban resilience to natural disasters. Brazil suffers all kinds of disasters due to its great territorial extension, but curiously the one that impacts the most people - drought - is not the one that causes the most casualties - landslides and flash floods. This work was developed based upon literature review on urban resilience, desk research of all relevant topics and statistical data analysis. The main actions for mitigating these disasters' damage were the mapping of risk areas, training courses and a 24/7 monitoring center. The current Civil Defense protection policy is the first federal law focusing on risk mitigation.

Keywords: urban resilience; natural disasters, civil defense, Brazil.

1. Introduction

In 2010, the population of Brazil was just over 200 million inhabitants, with a urbanization rate of 84,36% (IBGE, 2010). The increase in population density in the cities contributed to disaster events becoming more expressive, since a larger number of people has been affected. Most natural disasters that occur in developing countries are triggered by the ever growing population density in risk areas (Sampaio et al., 2013).

Natural disasters are the consequences of natural phenomena occurrences lasting long enough to produce a negative impact on society and infrastructure (Alcántara-Alaya, 2002). EM-DAT (Emergency Events Database) understands disasters as “situation or event, which overwhelms local capacity, necessitating a request to national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering. Though often caused by nature, disasters can have human origins” (EM-DAT, 2015), plus at least one of the following elements: a) 10 or more casualties; b) 100 or more people affected; c) declaration of state of emergency; or d) request for international assistance.

In Brazil, the main source of disaster data are the emergency situation and state of public calamity decrees, issued by local authorities and recognized by the federal government. The criteria are: disaster intensity, need and availability of resources to be used in order to restore normality (MI, 2007).

Since the establishment of the National Policy for Protection and Civil Defense (*Política Nacional de Proteção e Defesa Civil*, portuguese acronym: PNPDEC), the issue has gained more emphasis due to the understanding by political bodies that disasters can be avoided.

This work was developed based upon literature review on urban resilience, desk research of the National Policy for Protection and Civil Defense and of the Disaster Response and Risk Management Program, and statistical data analysis conducted on official data gathered from the Brasilian Natural Disaster Annual Report, for the year 2012.

2. Urban Resilience

The concept of resilience became known by Holling (1973), who applied it in ecology to study ecosystem dynamics (Janssen et al., 2006). Ecological resilience stands for the ability of a system to keep its functions and controls after being subjected to disturbances (Gunderson, 2000). In an environment - society perspective, when transposing the concept to cities, it is understood that a city is a complex system (social, economical and ecological) that, when struck by external disruptions, is able to return to a previous state of equilibrium or even to improved conditions as a result of adapting and learning from overcoming the event (Adger, 2000; Klein et al.,2003).

According to Lhomme et al. (2013), urban resilience is the ability of a city to recover its functions after suffering a disturbance. Desouza; Flanery (2013) defined urban resilience as the capacity of a city to absorb, adapt and respond to changes. Similarly, UNISDR defines resilience as “the ability of system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions” (UNISDR, 2009). The latter definition was the one adopted in this work because it was understood to be the most complete one.

One of the main characteristic of resilience is the capacity of adaptation that, according to Folke (2006), is the system’s capacity to endure and deal with external changes. This work agrees with Klein et al. (2003, p.38) in their definition of adaptation capacity, which reads as “the capacity to plan, prepare, facilitate and implement adaptation measures” in face of natural disasters.

Jabareen (2013) stresses the gap in the literature to measure and evaluate urban resilience, besides the fact that this is a concept developed on multidisciplinary bases and which comprises multiple aspects, just like cities. Although rich analyses are possible, a focus must be established for the current work; such focus is the urban resilience to natural disasters.

3. Natural Disasters in Brazil

Brazil occupies 47.3 percent of the South American continent and borders all other countries, except Ecuador and Chile. It is bounded by the Atlantic Ocean on the east and has a coastline of 7,491 km. Brazil is currently defined in its constitution as a federal republic, composed of 26 states and the Federal District, where its capital - Brasília - is located. The federative units are divided into five regions: South, Southeast, Center West, North and Northeast (Figure 1).

The South region corresponds to 6,77% of the total territory and has an urbanization rate of 84,36% (IBGE, 2010). The most common natural disasters in this region are pluvial floods, flash floods and landslides associated with intense rain, which occurs more frequently from December to March. Other disasters such as drought, windstorms, tornados and coastal floods also occur in the region.

The Southeast region corresponds to 10,86% of the country’s area and has an urbanization rate of 92,95% (IBGE, 2010). Like in the South region, the most frequent natural disasters are pluvial floods, flash floods and landslides associated with intense rain, also from December to March. Drought events can occur as well.

The Center West region represents 18,87% of the national territory and its urbanization rate is 88,8% (IBGE, 2010). This is the region with the least of natural disaster events, which are mainly pluvial floods, droughts and forest fires.

The North region comprises 45,25% of the national territory and presents an urbanization rate of 73,53% (IBGE, 2010). This region does not present a dry season and has the highest pluviometric annual indexes, making pluvial floods the most frequent natural disaster. Nevertheless, isolated drought periods and forest fires might also occur.

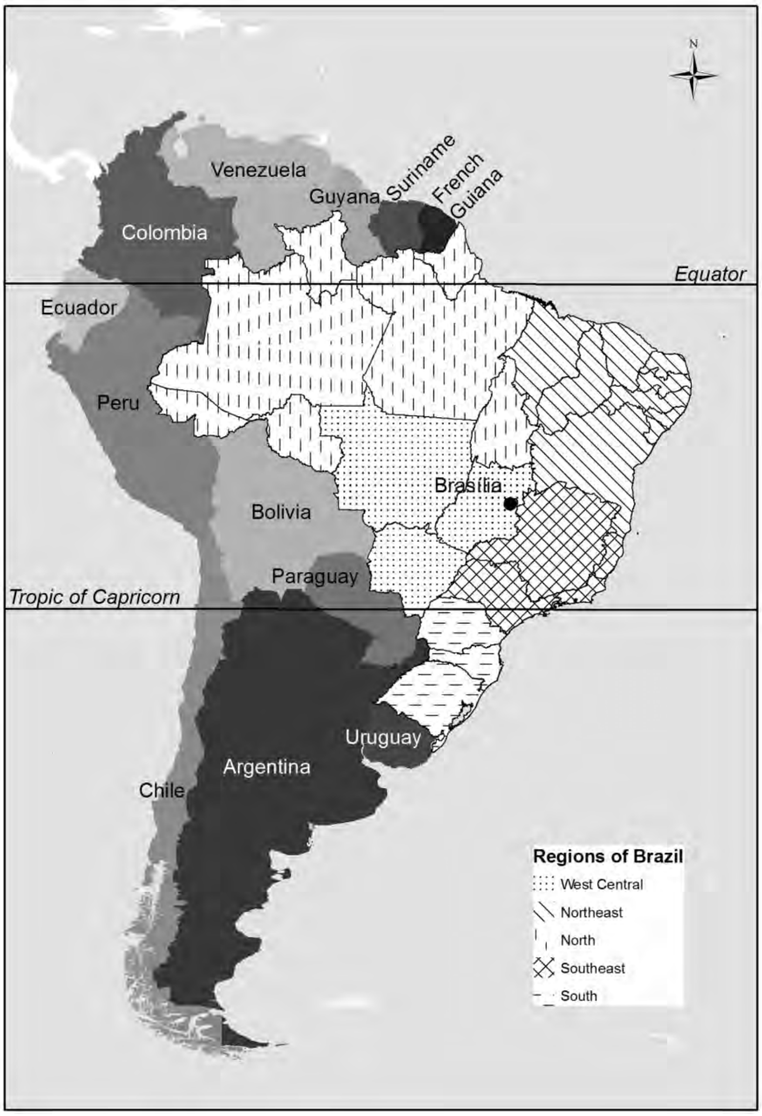
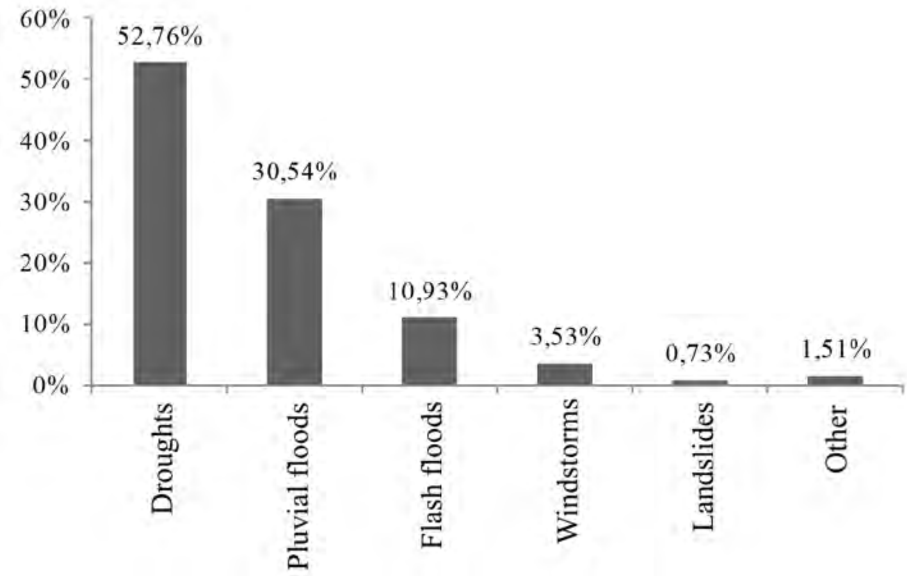


Figure 1 - Brazilian regions and South American countries

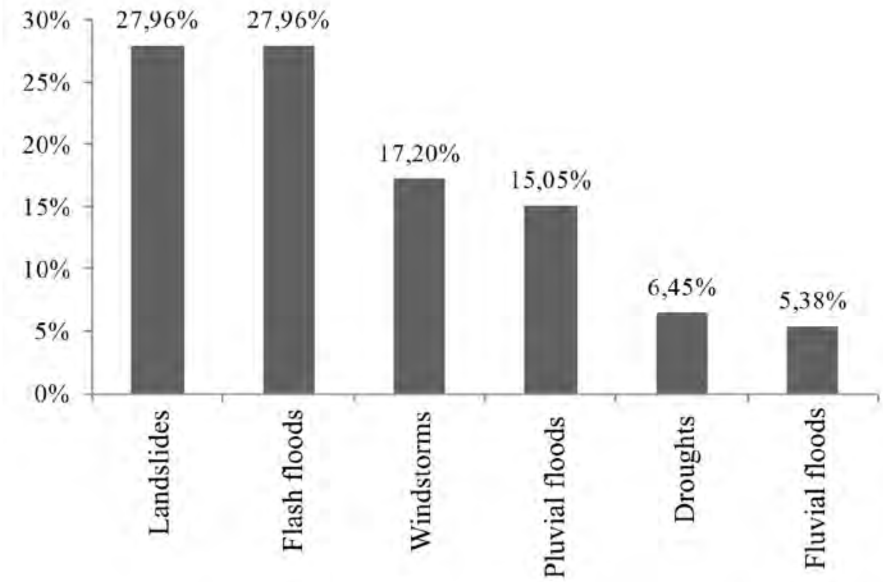
The Northeast region corresponds to 21,25% of the country's territory and has an urbanization rate of 73,13% (IBGE, 2010). This region is home to the greater part of the Brazilian semi-arid climate, which makes drought the most recurrent natural disaster. However, pluvial floods and landslides also occur.

The disasters that affected the Brazilian population in the year 2012 were droughts (52,76%), pluvial floods (30,54%), flash floods (10,93%), windstorms (3,53%), landslides (0,73%) and other (1,51%) according to MI (2012), as shown in Graph 1.

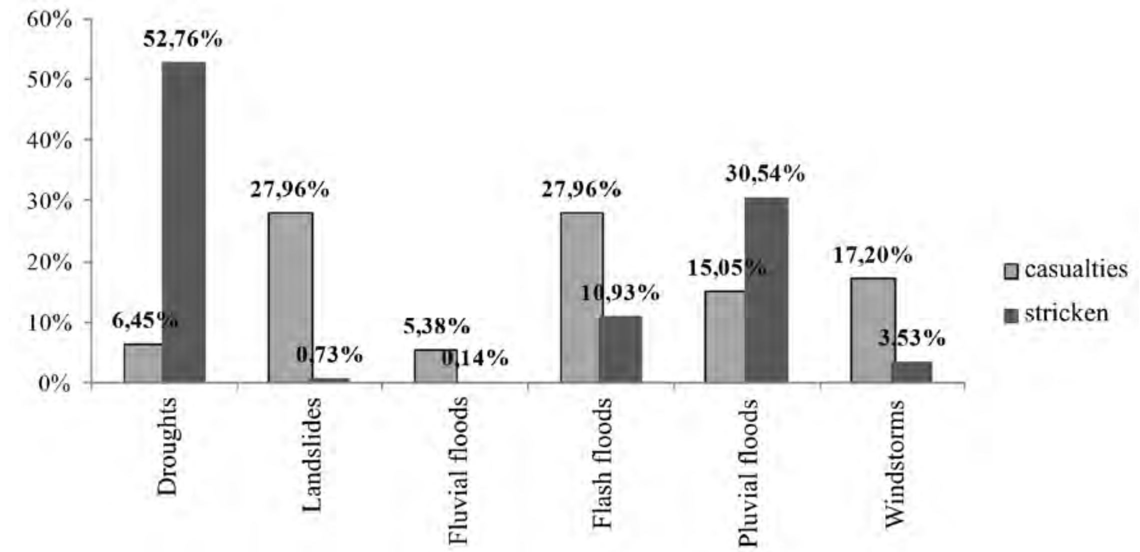


Graph 1 - Distribution of affected people by type of disaster in 2012 (Adapted from the Brazilian Natural Disasters Annual Report, 2012)

Graph 2 shows the percentage of casualties by natural disasters in 2012, as follows: landslides and flash floods (27,96% each), windstorms (17,20%), pluvial floods (15,05%), drought (6,45%) and fluvial floods (5,38%), according to MI (2012).



Graph 2 - Distribution of casualties by type of disaster in 2012 (Adapted from the Brazilian Natural Disasters Annual Report, 2012)



Graph 3 - Comparison of affected people and casualties by type of disaster in 2012 (Adapted from the Brazilian Natural Disasters Annual Report, 2012)

Droughts affect the greatest number of people mainly because they occur more frequently in the Northeast region, which is the poorest region of the country and has 27,83% (IBGE, 2010) of the population.

However, when comparing both graphs side to side, as shown in Graph 3, it is possible to observe that drought, despite affecting the greatest number of people, causes, alongside with fluvial floods, the least number of casualties. The greater share of casualties is caused by landslides and flash floods, since they usually occur in densely occupied areas, especially in the South and Southeast regions - with 14,36 and 42,13% of the population (IBGE, 2010), respectively.

The distribution of natural disasters among the five regions in Brazil, in 2012, was: a) January to May: North region; b) January, March to July and November: Northeast region; c) January to March: Center West region; and d) throughout the entire year in the South and Southeast regions (MI, 2012).

4. Civil Defense

In Brazil, Civil Defense is the institution responsible for planning actions and managing risk concerning natural disasters and technical incidents. The Protection and Civil Defense National System is present in all three government spheres: Federal, State and Municipal. Each level has its own duties and responsibilities and their work is coordinated by the National Civil Defense.

Historically, the Brazilian civil defense has always acted in a reactive manner, i.e. taking measures only after a disaster event. According to Valencio (2010, p.752) the institution had become dedicated to “mainly deal with standard procedures in the disaster response phase, related to scenario coordination and fulfillment of damage evaluation bureaucratic requirements”. Two major disasters that took place in 2010 and 2011 exemplify this attitude.

In 2010, the states of Alagoas and Pernambuco, both in the Northeast region, suffered from massive pluvial floods due to strong storms. According to the World Bank report, the indirect and direct costs amount to R$ 1.89 billion in Alagoas state and R$ 1.4 billion in Pernambuco state (World Bank, 2012).

Frota et al. (2010) stress that, in spite of these disasters, the National Civil Defense has still maintained a reactive attitude, with little to no effort being made towards organizing and conditioning State and Municipal Civil Defenses to avoid or mitigate new disasters.

In 2011, the mountainous region of Rio de Janeiro state, in the Southeast region, was hit by several pluvial floods and landslides, also an outcome of severe rainstorms. The losses were estimated at R$ 4.78 billion (World Bank, 2012).

Although landslides are expected in Rio de Janeiro state during summer, preventive countermeasures were far from sufficient, if existent at all. Dourado, Arraes and Silva (2013) classify the State Civil Defense as highly qualified to perform search and rescue operations in landslide events, but poorly developed when preventing such events is concerned.

“The main issue identified in this period is the lack of prevention programs, which is enhanced by political stimuli to the occupation of risk areas and the deficiency in integrated action between state organs and local authorities” (translated from Dourado et al., 2013, p.51).

5. The National Policy for Protection and Civil Defense (PNPDEC) and it Initial Progress

The federal law that provides guidelines to Civil Defense actions is the National Policy for Protection and Civil Defense (PNPDEC), which entered into force in 2012. This policy is composed of prevention, mitigation, preparation, response and restoring actions; with emphasis on the adoption of preventive measures to minimize the effect of disasters, the stimulus for the development of resilient cities and the inclusion of risk mitigation in urban planning.

Partnerships have been established with research and technology institutions and academia, who provided technical and scientific support to natural disaster management, such as the National Center for Monitoring and Disaster Warning (port. acronym: CEMADEN); the Disaster Research and Study Center of Santa Catarina Federal University (port. acronym: CEPED-UFSC); besides other traditional public companies that helped with mapping services, the Brazilian Geological Service (port. acronym: CPRM) and the Technological Research Institute (port. acronym: IPT).

Since the establishment of the PNPDEC policy, a national register of the municipalities that are most susceptible to natural disasters has been made, and for each of these locations two documents are prepared: a chart mapping susceptibility to gravitational mass movements and floods and a geotechnical aptitude to urbanization chart. These two maps aim to provide the Civil Defense and local, state and national authorities with information to assist in adequate urban expansion planning, by pinpointing areas that are fit and unfit to urbanization. Thus, avoiding the increase in risk areas in those cities. (Sampaio et al., 2013)

CEPED-UFSC created a series of capacitating courses in risk management for public administrators and Civil Defense employees, with both theoretical and practical classes. CEMADEN is a 24/7 meteorological, hydrologic and geologic monitoring center.

6. Discussion

According to Marengo (2007), global climate models predict possible changes that would cause intense climate events, such as heat and cold waves, severe storms, floods and droughts. These events would be of particular concern to big cities like São Paulo and Rio de Janeiro, both in the Southeast region.

Though climate change is a global concern, its local effects - such as floods and heat waves - can be most damaging to urban centers, given their elevated carbon dioxide emissions and great concentration of people, economical activities and infrastructures (Romero-Lankao and Dodman, 2011).

The concept of resilience relates directly to the ability of recovering from a disaster in an efficient manner, which can only be done through preventive planning and adaptation. It is necessary to know what disasters might be faced and to create mechanisms that allow lessons learnt to be passed on, which is not about turning a city immune to disasters, but mitigating risks and damages alike.

The first steps of the National Policy for Protection and Civil Defense focus on building the knowledge required to face disasters, and are restricted to preparing technical instruments, training public administrators and Civil Defense employees and 24/7 monitoring. It is still necessary to intensify and amplify the range of actions, mainly concerning raising awareness, improvement of the city infrastructure and fairer urban policies. "[...] a well structured institutional and administrative framework is a prerequisite for a city's sound resilience initiatives" (Malalgoda et al., 2013, p.80).

7. Conclusions

The concept of resilience serves as a guide to measure what to aim to reduce the risk of disasters. Rather than as an end in itself, it is a primordial analysis category in all discussions involving cities and natural disasters.

Data from 2012 showed that a significant share of casualties resulting from disasters occurred in big cities, which can be aggravated by eventual extreme climate events.

So far, the Brazilian Civil Defense was used to act only after disasters, in the response phase. Changing culture is a very slow process, so the current policy, which strongly focuses on preventive actions to resist natural disasters, is a very important first step that must be continued, improved and reinforced in order to create a future risk management culture.

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Understanding the impacts of climate change on cultural heritage buildings: a case of York, UK

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Abstract

Cultural heritage is not only an important part of a country's identity but also a key driver of tourism (which can play an important role in a nation's economic and social resilience). However worldwide heritage buildings are gradually becoming more vulnerable, due to natural decay and deterioration, effects of climate change, and human-induced impacts, such as poor or ineffective maintenance. An increased number of extreme weather events, many of which are associated with the impacts of climate change, are posing significant problems in managing and conserving cultural heritage around the globe. Being exposed to a number of natural hazards and having a great cultural heritage, York (UK) presents a case study that provides the basis for the exploration of the strategies required for the improved disaster risk management of vulnerable heritage buildings. Through the engagement with practitioners responsible for the management of a range of heritage sites, this paper identifies the challenges faced when considering climate change adaptation measures. It argues that improved climate change adaptation and enhanced hazard mitigation strategies, involving a broad range of suitably trained stakeholders, are extremely important considerations when it comes to the assessment, maintenance and conservation of cultural heritage.

Keywords: cultural heritage buildings, climate change, mitigation, adaptation, case study

1. Introduction

Heritage sites are crucial assets for local communities and national states on both social and economic levels (Choi et al., 2010). Despite having stood strong for, in some cases, thousands of years, they remain under constant threat from natural hazards and human-induced threats. While close attention is paid to the protection of human life and livelihood as well as economic infrastructure, the protection of cultural heritage can be somewhat overlooked and under prioritised. A key factor indicating the need to increase the resilience of heritage sites to the impacts of climate change is the particular fragility of their historic fabric (Throsby, 2012), and thus their vulnerability to the effects of climate change and impacts of natural hazards.

Cultural heritage is exposed to a number of risks that can be divided into natural hazards (such as earthquakes and volcanoes), and those related to climate change (such as increased precipitation, flooding, droughts and heat waves). In addition, human-induced threats, which are essentially social and economic in nature and range from increased urbanisation, mass tourism and traffic congestion to industrial air pollution and increasing energy demand, can compound the problem (Jigyasu, 2006). All the risks associated with natural hazards, impacts of climate change, and human-induced threats, put significant pressures on cities and possible conservation efforts of historic urban environments. The increasing vulnerability of heritage sites and their assets is not merely due to increased exposure to hazards and extreme weather events. With increasing urbanisation, many urban heritage sites are now becoming engulfed by dense urban areas with huge concentrations of people and restricted access for emergency vehicles and personnel. Transformation processes in historic settlements are also breaking traditional urban boundaries, disturbing delicate ecological relationships and exposing these settlements to increased disasters and climate-related risks. Furthermore, cities have special climates which, due to complex characteristics, can be very difficult to predict: streets and buildings alter wind patterns and solar radiation, resulting in temperature and humidity changes as well as precipitation and pollutant concentrations.

The increasing pressures on heritage sites' environment, carrying capacity and socio-economic developments are likely to reach a critical point in the near future and require urgent action (UNISDR, 2015). As a consequence of the ever changing environmental and economic climates, heritage sites may currently be exposed to a greater risk from various threats than ever before in history (Croft, 2013). Heritage sites are critical to any community, and the importance of their conservation cannot be understated. Post disaster damage and potential destruction of heritage sites can cause catastrophic emotional damage to communities and residents, the avoidance of such occurring should be viewed with the utmost importance (Spennemann and Graham, 2007). Heritage sites are not merely important on a sentimental level: the economic and social benefits of their conservation have to be considered. They provide communities with character and substance, but the economic value of these sites and the revenue and tourism they bring to communities should also be noted (Choi et al., 2010).

In using York as a case study, this paper will explore current approaches to climate change mitigation and adaptation measures for cultural heritage and discuss the challenges and gaps in these strategies.

2. Types of climate change adaptation and mitigation measures for cultural heritage buildings

Whilst a great range of disaster risk reduction measures exist, not all of them are appropriate for cultural heritage due to their potential negative impacts on their values. However a number of structural and non-structural measures can be utilised if used appropriately taking into account the specific heritage values.

Non-structural activities such as education and training are the most appropriate in the context of cultural heritage. A number of training programmes have been set up that focus on heritage specific engineering techniques: they are designed to train stakeholders in heritage engineering and to equip them with the skills required to continually maintain cultural heritage sites, and sufficiently protect sites from natural hazards and human-induced threats. Hazard mapping is also becoming increasingly popular. For instance in the UK, English Heritage have recently began working with the Environment Agency to map hazards and potential threats around the UK, and is reflected in the UK National Heritage Protection Plan (Davis, 2002). Non-structural adaptation measures for cultural heritage sites also include financial management, visitation practices, and policies.

Structural adaptations are sometimes inevitable; however, they should be avoided where possible due to the risk of altering the fabric of a heritage site. For instance, Jigyasu (2006) highlights that some post-earthquake reconstruction measures in Marathwada region of India led to the destruction of significant components of cultural heritage rather than to protecting them. In the UK heritage sites are not permitted to perform key structural changes or introduce major structural measures. However, structural adaptations can be applied to sites by professional construction stakeholders (Davis, 2002) – this however is not often performed as it requires extra funding. It is also important to bear in mind that structural measures applied within the surrounding landscape might also reduce or increase the probability and the extent of the hazards' impact (Perry, 2015). These measures are to an extent supported by a number of international, regional and national frameworks described in the next section.

2.1 Legal framework and governance for the protection of cultural heritage from climate-induced hazards

In 1954 the first convention designed to draw attention to heritage protection was put in place - the Hague convention for the Protection of Cultural Property in the Event of Armed Conflict (UNESCO, 1954). It outlined that the protection of world heritage and culture from human-induced threats, such as armed conflict, should be a priority on both a national and international level, and further underlined that these sites require safeguarding and treating with the utmost respect. This followed by the establishment of the ICOMOS principles and charters of heritage conservation, which over years have not only extended the scope of cultural heritage beyond select monuments but also conservation approaches beyond mere preservation to management of change.

More recently, the Sendai Framework for Action (SFA) (UNISDR, 2015) marks significant progress with respect to the former policy document on disaster risk reduction (DRR), the Hyogo Framework for Action. Culture is now explicitly recognised as a key dimension of DRR and the need to protect and draw upon the various benefits of heritage as an asset for resilience is more clearly highlighted (Dean and Boccardi, 2015).

The UNESCO World Heritage Committee has recommended that State Parties include risk preparedness as an element in their World Heritage site management plans and training strategies (Paragraph 118 Operational Guidelines). This was extended in 2011 to all cultural heritage sites by highlighting risk management within the Historic Urban Landscape approach that emphasised the necessity of legal compliance and effective integration into national or regional legislation (UNESCO, 2011). In order to ensure the effectiveness it emphasises the particular importance of raising awareness and communicating the benefits of a formalised risk management approach in order to increase political will and to increase the resilience and the safeguarding of the historic cities to the primary and secondary hazards and threats. The risk management system has to consider the costs associated with the impact of disaster and climate change effects on human settlements, economic and social activities, environment, cultural heritage and historical urban properties, and consequentially the benefits of introducing a system for mitigation of risks.

The EU and Member States have also reacted to the challenges posed by climate change and other threats with activities in several fields. Among the most important actions is the setting of a consistent and supportive legal framework for targeting these challenges. The global legal outline shows a complex system where EU has a general legislative competence in the field of environmental management; some specific matters regulated by binding acts, such as Water and Flood directives (Directive 2007/60/EC); a general international system of soft law aimed to improve the resilience of communities, where international bodies and organisations, mainly represented by UNESCO for cultural heritage and UNISDR for disaster reduction, have an important role. Climate change is seen by many governments as a risk multiplier that has influenced shifts in policy that covers natural hazards, thus requiring not only improvements in emergency management, but also in prevention and preparedness (Werrel and Femia, 2015). Accordingly, a number of adaptation and mitigation programmes and strategies have been introduced in the last decade, however the extent to which these initiatives encompass cultural heritage is negligible. With reference to culture, the EU supports cooperation between Member States to conserve and safeguard European cultural heritage and the adoption of incentive measures through special culture programmes and dedicated budget lines, but expressly excludes any harmonisation of laws and regulations of the Member States (art.167 TFEU).

However, recently, following the “Europe 2020 Strategy for a Smart and Sustainable Growth”, new EU cultural policies and related funding programmes have considered that special attention should be given to cultural heritage threatened by natural hazards and human induced threats and to propose dedicated plans. Specifically, the European Work Plan for Culture 2015-2018, expressly mentions as a goal to be pursued, a study on risk assessment and prevention to safeguard cultural heritage against natural risks (*OJ 23.12.2014 – C463*).

In the UK, the sole driving force behind the protection, prioritisation and allocation of funding to heritage sites throughout England is centred in the National Heritage Protection Plan (the Plan) introduced in April 2011. The plan consists of two key elements: first, it establishes a framework for determining heritage prioritisation throughout the UK, highlighting which sites require most urgent protection; this will help to increase collaboration of sites and aim to eradicate duplication of works, with the hope of outlining areas which have been overlooked or dismissed. Second, it proposes that action plans would be put in place to address the needs of the aforementioned prioritised sites in the form of resources and funding (English Heritage, 2013). The framework set up throughout this plan consists of four key areas:

- *Foresight:* Identifies potential threats and issues from economic, environmental and historical perspectives; assesses awareness of relevant parties; and gains perspective on issues from within these parties and organisations.
- *Threat:* assesses the risk of all potential natural hazards and human induced threat, and their impact on a site; and establishes strategic action. One of its particular focuses is flooding.
- *Understating:* identifies site-related information in order to understand its vulnerabilities; and prioritises the significance of the sites and the issues they are facing.
- *Response:* sets out response measures including protective, managerial and help and advice oriented measures.

3. Methodology

York has been chosen as a case study city for this paper (it is introduced in the next section). The case study method is deemed appropriate as it allowed focusing on understanding of dynamics presented within a single setting and answering *whether* and *how* questions (Yin, 1994; Eisenhardt, 1989). Whilst a case study cannot offer generalisation, its conclusions can be applied to the development of new theories and concepts, and the revision of existing ones.

An extensive web and literature research was initially conducted to identify any secondary literature. Four site visits from April to June 2015 were then conducted as it helps to obtain valuable insight (Lofland and Lofland, 1995) when discussing the projects and to understand the environment and the context in which the project is taking place. Finally eight semi-structured interviews with a number of key stakeholders involved in the management of the heritage sites were conducted; this was deemed important because the stakeholders' perspective on the process of the project implementation could provide valuable information on existing measures as well as the challenges faced by the heritage sites in the context of climate change. The interviews covered the following aspects: main threats faced by heritage sites, risk assessment and risk mitigation measures, funding, and impact of policies. The interviews were recorded, transcribed and thematically analysed. Thematic analysis was chosen due to the complexity of the dataset and the need for a flexible analytical process to provide a structure (Howitt and Cramer, 2011).

3.1 York case study

York is a historic walled city with a population of 200,000 at the confluence of the rivers Ouse and Foss in North Yorkshire, England, and is the traditional county town of Yorkshire. The city has a rich heritage and has provided the backdrop to major political events in England throughout much of its two millennia of existence. The city offers a wealth of historic attractions, of which York Minster is the most prominent, and a variety of cultural and sporting activities making it a popular tourist destination for millions. The city was founded by the Romans as Eboracum in 71 AD. It became the capital of the Roman province of Britannia Inferior, and later of the kingdoms of Northumbria and Jorvik. In the Middle Ages, York grew as a major wool trading centre and became the capital of the northern ecclesiastical province of the Church of England. Consequently the historic building stock in York is widely variable and noticeable periods of growth can be observed through analysis of historic maps of the city: it ranges from Roman style to the medieval timber framed structures, and there is also a strong Georgian architectural influence (Stephenson and D'Ayala, 2014).

York therefore has a large variety of cultural heritage sites, many of which are prone to climate-induced hazards, and in particular flooding (Hutton and March, 2002). A number of actions are taken by the City of York (and its York Prepared team) in order to reduce the impacts of flooding, as a large number of heritage and historic sites requires protection and prioritisation to avoid suffering permanent damage as a consequence of the ever-changing environmental climate. Although York has suffered historically at the hands of flooding since the early thirteenth century (Radley and Simms, 1971), studies have been carried out which outline that flooding has become significantly worse in York over the past century (Archer, 1999; Macdonald et al., 2003; Macdonald and Black, 2010); notably this occurred between the 1940s and 50s (Farrant, 1953), until significant flooding in the 1980s and 2000s.

4. Discussion: Living with floods or surviving floods?

As described in previous section, York and its heritage sites are regularly affected by flooding. Current flood mitigation measures deployed in York include a floodwall and the Foss Barrier. These mitigation measures however do not fully protect the heritage related built environment of the city. The York local authorities treat flooding as a natural process and thus emphasise that it is impossible to fully prevent such events and therefor the focus should be on risk management (City of York Council, 2015).

The majority of York's environmental issues have historically come in the form of flooding, usually as a direct result of the River Ouse bursting its banks after periods of heavy rainfall. The continued worsening of flooding in the York region has to some extent been related to the land usage of areas north (upstream of the Rover Ouse) of York; the removal of sufficient vegetation is seen as a key factor in increasing run off and thus causing increased flooding in York (Sansom, 1996); this could be exacerbated in the future by the effects of climate change (English Heritage, 2008). According to the analysis of epigraphic flood markings (inscribed markings) (Macdonald, 2007) inside the basement of the old Merchant Venturers' Hall in central York, the city had been built up over the original flood plain during the centuries. Although the ground level in York has been raised, there was no change in base river level during the historical period. Examination of historic and contemporary maps indicates that no significant changes to the channel form through York appear to have occurred in the past 250 years (Macdonald and Black, 2010).

4.1 Main challenges

Although relatively resistant to flood damage, historic-building materials can all suffer some degradation and may need appropriate treatment. The degradation is often triggered by a combination of flooding and weathering, which affect materials of the site structures. These materials include stone, solid brick and mortar walls, timber frames, wattle-and-daub panels, timber boarding and panelling, earthen walls and floors, lime-plaster walls and ceilings and many decorative finishes (English Heritage, 2008). Organic materials such as timbers swell and distort when wet and suffer fungal and insect infestations if left damp for too long; if dried too quickly and at temperatures that are too high, organic materials can shrink and split, or twist if they are restrained in panels (Historic England 2015). Inorganic porous materials do not generally suffer directly from biological attack. Significant damage can occur when inherent salt and water (frost) crystals carried through the substrate are released through inappropriate drying or very cold conditions; in addition to severe water damage, water contaminants and sediment concentration significantly increase during a flood period (Longfield and Macklin, 1999), which can result in heritage and historical sites suffering from erosion and contamination, as well as generic water damage.

As already mentioned in Section 2, physical damage requires structural interventions that would enhance protection, however the interviews have demonstrated that there are a number of flaws that make the existing protection system not as effective as it could be, despite the UK having a system in place that inspects heritage sites (as described in Section 2.1). The following challenges have been highlighted by the interviewees:

- *Ineffective communication*: There is a very little contact between English Heritage and the owners and managers of the heritage sites. This impacts the ability of the latter to identify possible hazards and address them in a timely manner. Whilst most of the site owners and managers are aware of the hazards based on their experience, they are not prepared to deal with other potential hazards. The communication with local authorities exists however it is mainly aimed at the emergency response. In addition, in the event of flooding local authorities team heritage building similar to any other building assets affected by flooding.

- *Lack of formal stakeholders' engagement*: Whilst some collaboration exists, it is often informal and depends on personal relationships, as there is no specific contact for heritage site protection.

- *Lack of competencies*: local stakeholders are mainly responsible for the identification of the damages and risks; they however are not appropriately trained to conduct such exercises. This leads to the rather *reactive nature* of strategies adopted by the site owners and managers. Whilst the inspections take place every five years, it is not sufficient for the levels of pre-emptive decision-making that are typically required for effective DRR.

- L*ack of funding for pre-emptive measures*; instead the funding can only be received once the site has been damaged (and the damage may be irreversible).

5. Conclusions

This paper has discussed that despite an increasing number of frameworks for addressing climate-induced hazards for heritage sites, there is still a need for change in the way these frameworks are implemented locally. The lack of practical enforcement results in sites remaining unprotected and exposed.

The remarkable robustness of many historical structures in York has already demonstrated their resilience and ability to adapt to changing environment, however with the increase in extreme weather events, there is a need to support and enhance such resilience.

This is the case not only in York but internationally. Although Sendai Framework on DRR establishes the recognition of culture as a key dimension of DRR, there is still a challenge of implementing the policies, which would build the capacities and set up institutional mechanisms at different levels and ensure that culture is given its due recognition.

Despite a large range of policies and tools, the actions aimed at the mitigation of climate change impacts for cultural heritage are dispersed. It is necessary to provide appropriate tools to proactively act in minimising (or indeed preventing) the impacts of climate change as well as in the case emergencies caused as a result of climate- induced hazards. In addition, there is a need for sharing knowledge and actions with stakeholders, through either close interaction with environmental and construction professionals, and through training and guidance at site level. It is also important to incorporate climate adaptation strategies and develop risk management plans for cultural heritage as a part of a larger pro-active planning and development strategies and risk mitigation plans, rather than in isolation. Risk management of cultural heritage sites should be seen as one of the important components of the urban space, with the impacts of new spaces on heritage spaces being considered. The most important aspect of ensuring the effective implementation of the prevention and mitigation measures to heritage sites is through empowering and engaging communities and encouraging full participation in the preservation of what is notably their cultural and heritage sites. It is often the case that local stakeholders are those who are most passionate in maintaining the cultural fabric of sites, and the most enthusiastic about site preservation.

The main question however remains: How can site managers and custodians be supported in finding adequate responses to increase the resilience of heritage from natural hazards and climate change related risks? There is a need for an integrated multi-sectorial disaster risk management framework that would address this issue focussing on pro-active strategies and formal multi-stakeholders' engagement.

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Heat Stress in the U.S. Construction Industry

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Abstract

Construction workers perform demanding physical tasks and can be exposed to excessive heat and environmental conditions resulting in heat related illness and injury. Few research studies have examined the heat related illness and injury issues in the construction sector, particularly in the United States. Our literature review revealed that most heat stress research in the construction sector occurred in Australia, Hong Kong, India, United Arab Emirates, Japan, and China. The US Occupational Safety and Health Administration Fatality and Catastrophe Investigation Summaries database was search for a five-year period (2009-2013) for heat related cases in the construction sector. The research detailed in this paper summarizes the fifty-eight OSHA fatality and inspection reports during that period and describes the risk factors associated with heat stress among construction workers. Best practices and strategies to mitigate exposure are discussed, and a path forward for future research is offered. The U.S. does not regulate heat specifically but uses the General Duty Clause for heat related enforcement.

Keywords: Heat stress, safety, health, construction

1. Introduction

Construction work requires workers to be exposed to the elements, and in the summer months that includes heat. Heat stress fatalities are a concern as observed from the OSHA fatality index (OSHA 2015a) where 30 fatalities were observed in 5 years in construction alone.

The purposes of this paper are threefold. Firstly, we will evaluate the extent and severity of the problem of construction fatalities related to heat, through OSHA reports, identify and describe the risk factors associated with heat exposure among construction workers. The paper will identify the best practices and strategies to mitigate exposure, and try to determine a path for future research in order to find the extent of heat protection measures practiced in the US, how much contractors understand what measures they need to take in order to protect their workers from heat.

2. Background

Heat stress occurs when the body is unable to lose heat after continuous physical labour. This causes body temperature to rise and the heart rate to increase. There are several ailments that arise on construction sites that are related to this excess heat. These are heat stroke, heat exhaustion, heat cramps, fainting (heat syncope), and heat rash (Lopez 1996; McKinnon et al. 2005).

Heat stroke, is the most serious of the ailments, and it is caused by the inability of the body to control its internal temperature, thus the body stops sweating, and excess heat is not dissipated. Signs of heat stroke include: mental confusion, delirium, loss of consciousness, convulsions, and even coma, body temperature of 106^{o}F and higher, and skin that is hot and dry. Heat exhaustion is the result of excessive loss of fluids through perspiration, caused by failure to drink adequate water and/or intake of salt. Workers suffering from heat exhaustion, are weak, and fatigued, and experience nausea and headaches, while at the same time they have clammy skin, and slightly elevated temperature (Lopez 1996). Fainting occurs to workers not acclimated to hot environments, in particular when they are just standing still in the heat. It is suggested that fainting victims lie down for a short time, away from direct heat. It is also suggested that in order to eliminate the chance of fainting workers should be moving around instead of standing still. Lastly, heat rash occurs in hot and humid areas, when sweat is not easily evaporated (Lopez 1996; McKinnon et al. 2005).

Construction workers perform demanding physical tasks and can be exposed to excessive heat and environmental conditions resulting in heat related illness and injury. As reported by McKinnon et al. (2005) from data provided by the Bureau of Labour Statistics, 40% of deaths in 2002 related to heat strain occurred in the construction industry. Few research studies have examined the heat related illness and injury issues in the construction sector, particularly in the United States. The literature review revealed that most heat stress research in the construction sector occurred in Australia, Hong Kong, India, United Arab Emirates, and China (McDonald et al. 2008; Chan et al. 2012; Farshad et al. 2014; Rowlinson et al. 2015; Jia et al. 2016; Li et al. 2016).

Some research in the US has produced industry suggestions and regulations, examples of which include informational pamphlets and material from National Institute of Occupational Safety and Health (NIOSH) that provide information for preventing heat stress, identifying the symptoms, and guidelines for acclimatization (NIOSH 2014). The Occupational Safety and Health Administration (OSHA) similarly has information and pamphlets available its website, but in addition regulations for heat stress prevention recommendations and employer obligations to preventing and protecting workers from heat stress (OSHA 2015c). It is clear to say that guidelines and recommendations are available to US contractors to implement in order to reduce the incidences relating to heat stress (fatalities and injuries) in the US, and yet these incidences occur and they seem to be happening in specific regions of the country, and more likely to small contractors.

3. Methodology and Collected Information

Fatality and Catastrophe Investigation Summaries are developed after the US Occupational Safety and Health Administration conducts an inspection in response to a fatality or catastrophe. These summaries and inspection details provide a description of the incident and are available online at https://www.osha.gov/pls/imis/accidentsearch.html. On August 9, 2015, a search was performed to build a database of construction heat-related fatalities and catastrophes. The search was limited to a five-year period from January 1, 2009 through December 31, 2013. OSHA's database for 2014 was incomplete. The cases are catalogued using keywords, and the ones used for this search were: heat exhaustion, heat stroke, and heat. The search was only limited to construction related industries, and that was achieved using OSHA's Standard Industrial Classification Codes for Construction. These are: Major Groups 15 (Building Construction General Contractors and Operative Builders), 16 (Heavy Construction Other than Building Construction Contractors), and 17 (Construction Special Trade Contractors). Some of the case summaries were duplicated and these cross-referenced in order to remove these duplicates (OSHA 2015a). Sixty-five cases matched the search criteria, and after reviewing each case seven were eliminated. The eliminated cases dealt with electrical burns, HVAC equipment, and were not related to heat exposure. This left 58 cases in the five-year period that met the criteria for heat related fatalities and catastrophes in the construction section (OSHA 2015a).

The cases listed in the OSHA (2015a) directory are mapped by state in Figure 1. As observed the majority of the cases took pace in southern states (California, Arizona, Texas, Louisiana, Georgia, South Carolina, North Carolina, and Arkansas), where temperatures are expected to be higher. Yet, there were incidences in northern states as well. One incidence took place in Wisconsin, a northern states, and that happened in May of 2010. This suggests that although the majority of the cases would happen in the south, contractors should be aware that even in northern states, cases involving heat stress can take place. Thirty (52%) of the cases involved a fatality, while the rest (48%) were non-fatal. Nine of these cases (16%) took place concrete work, eight (14%) in specialty trade work, while seven (12%) of these were in roofing, siding, and sheet metal work, and another seven (12%) in highway and street construction.

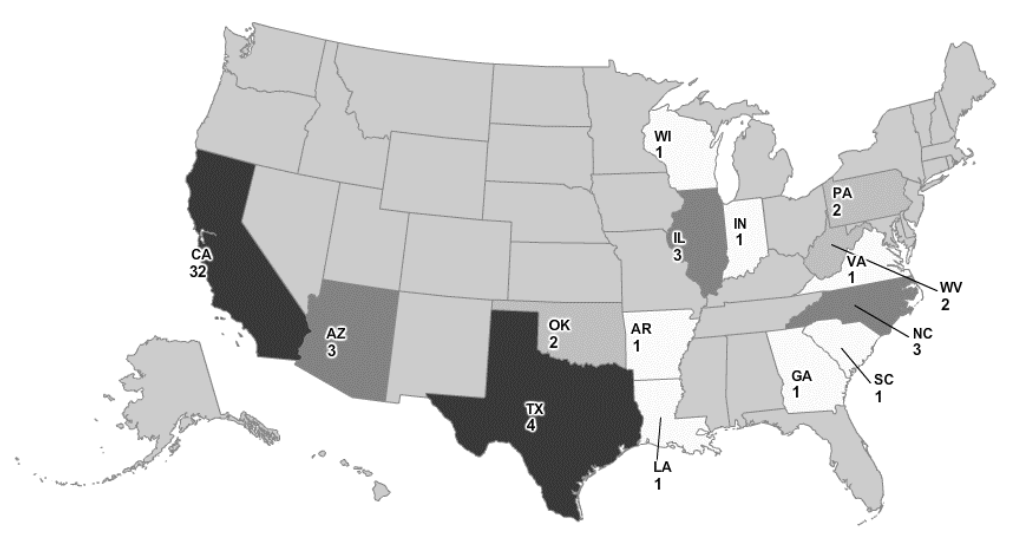

Figure 1: Heat stress case studies by state (OSHA 2015a)

As observed in Table 1, over half of the cases that experienced an incident involving heat stress took place in contracts under $50,000, while that percentage for contracts under $1,000,000 was 79%. This suggests that the majority of the incidences took place in contracts undertaken by small contractors.

Table 2 shows the heat stress incidences according to the month they took place. As expected, the majority of the incidences took place in the summer months (June, July, and August) with a percentage of 74%. It is clear though that incidences resulting in heat stress do not only occur in the summer. As observed there was one case in February, albeit that incident took place in California.

Table 1: Project costs with heat stress incidents (OSHA 2015a)

Project Cost	***Number of Cases***	***Percentage***
Under $50,000	*31*	*53%*
$50,000 to $250,000	*5*	*9%*
$250,000 to $500,000	*4*	*7%*
$500,000 to $1,000,000	*6*	*10%*
$1,000,000 to $5,000,000	*9*	*16%*
$5,000,000 to $20,000,000	*2*	*3%*

$20,000,000 and over	*1*	*2%*
Total	***58***	***100%***

Table 2: Month of heat stress incidence occurrence (OSHA 2015a)

Month of Incident	***Number of Cases***	***Percentage***
February	*1*	*2%*
May	*7*	*12%*
June	*15*	*26%*
July	*21*	*36%*
August	*7*	*12%*
September	*6*	*10%*
October	*1*	*2%*
Total	***58***	***100%***

4. US Heat Stress Regulations

The U.S. does not have specific regulations for occupational exposure to heat. According to the General Duty Clause of the Occupational Health and Safety Act (OSHA), Section 5(a)(1), it is up to the employers to provide their employees with a workplace that is "free from recognizable hazards" that might cause harm to the workers. This is a legal obligation from the part of the employer (OSHA 2015c). Under these regulations and obligations employers are required to provide all PPE, record any injuries and illnesses, provide potable water, first aid, and training. When a worker is experiencing heat stress and seeks medical attention the employer is required to report the incident. If the worker though merely rests and drinks water, without needing first aid or hospitalization, the n the employer does not require to report the incident. As a result, many instances of heat stress remain under reported. Furthermore, the penalties to the employer for allowing heat stress fatalities to take place are not severe, and of low monetary significance.

As a case study to highlight the regulatory and practice implications within the US construction industry, this fatality is provided. An employee on his first day of his new job was installing formwork for curbs. The temperature was 97 Fahrenheit with humidity of 74%. The heat index reached 130 degrees Fahrenheit according to the OSHA citation report number 313632184. OSHA found the new employee was not acclimatized and employees were not trained to recognize heat related illness. US OSHA does not have a specific heat stress standard in for nay industrial sector. To cite employers for violations involving heat stress, OSHA uses the General Duty Clause. The General Duty Cause requires that "each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees"(OSHA 2015b). In this case the citation for the fatality totalled a mere $3,500. The average monetary penalty for the 30 heat related fatalities in this dataset initially assigned by OSHA was $7,542.50. However, many penalties are negotiated lower. The 30 fatalities were as well for a final average fine of $5,643 per fatality. This is hardly a monetary deterrent for companies to understand and heat stress in the construction sector. The largest fine was $27,435, but most are a few thousand dollars with one as low as $300.

Awareness of heat related illness is seen as a key to prevention (Lopez 1996). In the US, many construction companies use OSHA's voluntary 10 and 30 hour training programs for enhanced training of their workforce. The 10-hour class is intended for entry level workers, while the 30-hour class is more appropriate for supervisors or workers with some safety responsibility. However, neither class requires any information about heat stress, nor is it mentioned in the list of electives. Including heat stress in this training would benefit workers and increase awareness in the industry, however small contractors do not require this training of their workers.

5. Heat stress prevention recommendations

Rowlinson and Jia (2015) proposed a methodology for developing tools for determining optimized work-rest regimens and work paces by applying the predicted heat strain (PHS) model to anchor heat stress management guidelines. They propose the development of regional guidelines developed by the presented protocol and the continual update of these guidelines can be compared to provide a global picture of occupational heat stress and advance knowledge of the effect global climate change on work-related stress.

More heat prevention recommendation come from McKinnon et al. (2005) where the authors suggest early recognition of the symptoms and prevention is key in limiting the progression of heat related issues to a more serious phase. They suggest that workers should use personal protection equipment (PPE) that allow for ventilation of the body, implementing engineering controls to remove workers from direct sunlight and heat, provide plenty of drinking water, acclimate the workers to extreme temperatures, and administer educational programs for workers to recognize heat stress symptoms.

Heat stress prevention measures have been successfully implemented in other parts of the world. One particular example comes from the Arabian Gulf, where McDonald et al. (2008) describe measures taken in Qatar in order to decrease the heat-stress-related medical treatments. Incidents were seen to be reduced from a value of 0.164 incidents per 200,000 workhours to 0.012 in a period of 3 years. This was achieved by applying engineering controls, for heat reduction in rest areas and by applying administrative controls in work areas. Such measures included umbrellas, insulated water bottles, evaporative bandanas, acclimatization of the workers, employee rotation, buddy system, work-rest period guidelines, and water consumption guidelines.

It seems that the communication of the hazards associated with heat exposure on the construction job site, in conjunction with administrative controls, is the best method to prevent heat stress incidences. Such a plan, similar to the one described by McDonald et al. (2008), is described in a conference paper by Chesson (2012). The author there describes successful measures that promote a comprehensive approach both for heat management and sun protection for workers employed at an oil field on Barrow Island in Australia. Such measures included engineering controls (reflective shields, mechanical ventilation, tents, etc.), administrative controls (tool-box meetings, work-rest schedules, self-pacing, education, etc.), and PPE (cool vests and bandanas, personal cooling equipment, loose fitting light coloured clothing, etc.)

6. Discussion

Some of these ailments discussed in this paper can be treated with basic first aid in order to eliminate the possibility of death. Heat stroke requires the prompts removal of the worker to a cool area, and at the same time attempt to cool them down by soaking their clothes in water, and vigorously fanning them, while waiting for medical help to arrive. First aid for heat exhaustion includes the removal of the worker from direct heat to a cool place for rest, and injection of electrolyte solution, while more severe cases would need medical treatment (Lopez 1996).

It is important though to prevent heat stress from happening, rather than dealing with its aftereffects. Lopez (1996) suggests the following: install ventilation and cooling fans; incorporate equipment that require less physical labour such as pneumatic tools; provide drinking water to all workers; acclimate workers to heat through gradual exposure; incorporate loose fitting clothing; educate workers on symptoms and treatment of heat stress.

In a study performed by Kenney (1985) showed that medical screening could be used to predict the performance of workers under heat stress conditions. These conditions were achieved my providing workers with a vapour barrier rubber suit that inhibited the dissipation of sweat, while pedalling on a stationary bike. Healthier workers were able to perform better in the physical test, and, and the author concluded that to increase worker’s performance, it would be advisable to acclimate them in these adverse environments (Kenney 1985). The author continued by suggesting annual exams take place to evaluate the capability of workers to perform their tasks in extreme heat conditions.

Heat stress can be caught early by incorporating wearable devises and sensors that sound alarms when certain health parameters; such as heart rate and body temperature, exceed normal conditions. An example of an early study is described by Cohen et al. (1988) where employees wearing personal monitors that measured physiological strain and were able to monitor themselves and takes breaks as suggested. A more recent study (Gatti et al. 2013) looked at a modern monitor that measured heart rate and breathing rate under simulated construction activities, and the authors concluded that with advances in technology, it is possible to monitor workers’ condition instantaneously.

Rowlinson et al. (2014) report that climatic heat stress is determined by six key factors. They are (1) air temperature, (2) humidity, (3) radiant heat, and (4) wind speed indicating the environment, (5) metabolic heat generated by physical activities, and (6) “clothing effect” that moderates the heat exchange between the body and the environment. Rowlinson et al. (2014) suggest that by making use of existing heat stress indices and heat stress management processes, heat stress risk on construction sites can be managed in three ways: (1) control of environmental heat stress exposure through use of an action-triggering threshold system, (2) control of continuous work time (CWT, referred by maximum allowable exposure duration) with mandatory work-rest regimens, and (3) enabling self-paced working through empowerment of employees.

7. Conclusions

Heat stress in US construction sites occurs in the southern states, but some of the northern states have had heat related incidences. In addition the majority of the cases took place in contracts that are below 1 million in value, suggesting that the majority of the incidences probably happen to projects undertaken by smaller contractors.

Administrative and engineering controls have been proven from research in other countries to reduce the number of incidences, and it seems that a good regiment of such measures would make a significant improvement to the US construction heat related incidence rates. What is still unknown is the identification of the best measures that need to be implemented that would be cost effective for small scale contractors who do not have the capability and flexibility to provide an array of prevention techniques. Further research is required to identify current US practices, with emphasis in practices employed by small contractors, and identify the effectiveness of such measures.

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Part II: Constructing Commitment and acknowledging human experiences

What does 'common sense' really mean in health and safety?

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Abstract

Extensive literature search has revealed that construction workers refer to the use of 'common sense' in site safety. This was also discovered in a recently completed PhD project where workers openly discussed a common sense approach to health and safety on site. The use of this term can be problematic. Different workers labelled different behaviours under this generic term. Also, some used it to refer to positive experiences and application of knowledge based on experience. Others employed the term negatively, or dismissively: "*It's just common sense*…" General use of the term puts emphasis on 'basic knowledge' required for attaining minimal or satisfactory achievement of a given task or activity. This is in conflict with some workers' interpretation of skilled and experience based action. In academic language ideas in this field are more substantially and in depth explored under 'communities of practice' and 'local knowledge'. These concepts offer an avenue for analysis not tied to specific wording employed by respondents but interpreting broader sets of data particularly for this study (i.e. observation material and text around specific extracts of text). This paper presents findings from five micro construction firms regarding the concept of common sense and site safety. Practical constraints, such as a researcher's stage of development and skill in qualitative analysis, potentially hinder the development of argumentation. The interpretative school of thought accepts researchers' influence on the processes; and we add depth and nuanced understanding to this discussion via practical examples of such issues. Interpretation of the data collected through ethnographic case studies indicates although workers interpret common sense differently, although it is essentially a means of working safely. However, common sense safety techniques tend to fall outside strict site rules which are often bureaucratic.

Keywords: common sense, communities of practice, interpretative research, site safety

1. Introduction

The notion of incorporating a 'common sense' approach to construction site safety is a fairly new concept. This concept has gradually gained momentum in the academic realm (see Ludhra, 2015; Oswald *et al*, 2015; Aboagye-Nimo *et al*, 2013) and in some policy making reports (see Lord Young of Graffham, 2010; Davis, 2009). Literature on common sense safety tends to considered common sense in a positive light, to mean '*the ability to behave in a sensible way and make practical decisions*' (Ludhra, 2015: 3). An individual's ability to behave in a sensible manner with regard to safety can be interpreted differently depending on context. Thus common sense can be studied as a practice-context related subject.

This paper seeks to generate an understanding of the meanings construction site workers attribute to the idea of common sense in construction site safety. The overall aim of this paper is to explore what workers of micro construction firms mean by the term common sense. As mentioned in the previous paragraph, the study considers the term in relation to settings of the participants of the study. In order to understand the contextual conditions that influence the way in which individuals may employ 'common sense'. The next section explores literature on communities of practice and situated knowledge.

2. Communities of practice in construction

The focus of this study is on the micro construction firm as a 'community'. Communities of practice are semi-formal, self-governing networks of people who share a common interest in a specific aspect of practice (Bartholomew 2008: 146). Another way of describing communities of practice is an activity system about which participants share understandings concerning what they are doing and what that means in their lives and for their lives and for their community (Edwards and Mercer, 2013). Thus, workers operating in such a community are united in both action and in the meaning that action has, both for themselves, and for the larger collective (Lave and Wenger 1991: 98). This paper investigates the common knowledge that is shared by micro construction firms in the form of local knowledge and common sense in relation to site safety.

Workers produce safe working practices and hence safe working environments by engineering heterogeneous elements including knowledge, materials, relations and communication within a community of practice (Gherardi *et al* 1998: 204). Such knowledge is known to exist outside formal organisation structures although recognized and empowered by the organisation (Bartholomew, 2008: 148-149). This type of safety practice and use of informal knowledge in construction is relatable to coalminers' 'pit sense' (Kamoche and Maguire, 2011). Pit sense is described as a tacit and situated form of knowledge constituted by tunnellers as a way to navigate and assess risk (ibid: 725). Similarly, the construction industry uses tacit and local knowledge extensively as it is important in raising performance at an organisational level (Addis 2014: 1245). This type knowledge which is often referred to as common sense due to its inexplicable nature is very instrumental in accident prevention and site safety (Aboagye-Nimo *et al*, 2015). Particularly, it helps workers to be able to choose between different physical approaches when confronted with risks (Forsythe 2014: 242).

2.1 Common sense and local knowledge

Previous studies into the use of common sense in construction site safety have defined common sense as the practical knowledge and judgement developed by workers after gaining years of experience on site (see Oswald *et al*, 2015; Aboagye-Nimo *et al*, 2013). Practical knowledge and judgement on site requires complex interaction of explicit and tacit knowledge gained through training, experience, guidance by leaders, experiential learning in new situations and from experts and experienced workers who have preceded us (Gherardi and Nicolini 2002: 192). People without extensive local knowledge may stand right next to danger and not notice it (Baart 2009: 953). Local knowledge is knowledge specific to a particular situation (Sole and Edmondson, 2002). It can be described as the knowledge that people in a given community have developed over time, and continue to develop (Tutt *et al*, 2013). Thus it can be argued that this type of knowledge is context-related. A lack of this local knowledge can result in unsafe conditions for workers and their colleagues (Koch, 2013). In terms of common sense and local knowledge, what is 'reasonable' in terms of safety must be shared knowledge i.e. workers must agree on it. In relation to the knowledge-sharing process on construction sites, there are four different influences namely; openness, motivation, trust and pressure of time (Fong 2007: 208).

Using this common sense and local knowledge may occasionally fall outside the scope of official safety procedures as implied by Lord Young of Graffham (2010) and confirmed by Oswald *et al* (2015). This will thus create some misunderstanding between workers using this type of knowledge (micro construction firm workers) and those implementing official safety procedures (e.g. principal contractors). Unfortunately, when misunderstandings occur between principal contractor and subcontractor, it can lead to the subcontractor can be put on a 'blacklist' (Taylor, 2013).

The key themes will be investigated through fieldwork. Explanation of the research methods adopted for the empirical investigation follows.

3. Research methodology

This research seeks to understand the subjective view of construction site workers in relation to common sense safety. For this reason, an interpretation of the views expressed by these workers is imperative; thus the philosophy of interpretivism is adopted. Since common sense can be argued to exist differently amongst different communities of practice (see section 2), the concept of common sense was stretched to cover phrases presenting similarities in meaning. These included phrases such as '*automatically knowing*', '*general knowledge*' and '*obvious knowledge*'. Great care was taken through methodological rigour and robustness to ensure that this did not result in 'concept misformation' (see Campbell *et al*, 1984). Some of the factors taken into consideration was the possibility of the researcher misinterpreting the data collected as they were still in the process of carrying out a PhD research project. This was minimalized by the inclusion of research supervisors of a variety of expertise including a linguistics expert.

Numerous researchers that have sought to understand practices of groups and teams operating on construction sites encourage the use of in-depth qualitative methods (see Fellows and Liu, 2015; Tutt *et al*, 2013). In order for a researcher to understand a context and appreciate a group's shared values and beliefs, it is important that the researcher gains insight into what, how and why their patterns of behaviour occur (Fellows and Liu 2015: 24). A researcher can thus become very effective at gaining such insight by immersing their self in the group being studied i.e. becoming part of it (Pink *et al*, 2010). Epistemologically, an ethnographic approach is one of the most effective methods by which a researcher can explore value structures and beliefs that influence the group behaviours especially during the construction phase of a project (Fellows and Liu, 2015). In this paper, the definition adopted for an ethnography is:

'*an iterative-inductive research (that evolves in design through the study), drawing on a family of methods, involving direct and sustained contact with human agents, within the context of their daily lives (and cultures), watching what happens, listening to what is said, asking questions, and producing a richly written account that respects the irreducibility of human experience, that acknowledges the role of theory as well as the researcher's own role and that views humans as part object/part subject.*' (adapted from O'Reilly, 2012: 3; Pink *et al*, 2010: 648).

Non-participant observations, semi-structured interviews and conversations were incorporated under the umbrella of the ethnography. Five micro construction firms operating on different sites were studied in this research (see table 1). They all operate in the East Midlands region of the United Kingdom (UK). In order to build trust between researcher and participants, gatekeepers were used to establish the contact. This was followed by an honest disclosure of the aim and nature of the study. These steps were crucial to the study because small and micro construction firms are known as 'hard-to-reach' due to their secluded nature in relation to their interaction with outsiders (Willbourn, 2009).

Analysis of the data was conducted starting with a thorough thematic coding of the information (transcribed interview data and field notes from observations) using QSR NVivo. Using this computer assisted approach helped in the better organisation of the collected data. In addition, patterns were able to be drawn from the data, especially inferences that could not be drawn from analysing interview data and observation data separately.

4. Findings and analysis

Participants from all the five sites (i.e. the five micro firms) were working at different stages of their various projects. Site activities included electrical wiring, plumbing works, brick laying, screeding, excavations, laying foundation, landscaping and roofing works. Ages of the participants and their years of experience in the construction industry also varied vastly amongst the research participants. The least experienced participant had been on site for only one year and the most experienced site worker had worked for 40 years. This ensured a good variation in workers' views particularly when discussing a topic as contextual as common sense. Table 1 below presents an overview of the five case studies.

Table 1: Profile of case studies

Details / *Case study*	*Type of work*	*Nature of the project/ work*	*Number of participants*
Case study 1	*General builders*	*Refurbishment of existing structure*	*5*
Case study 2	*Ground workers*	*Preparation for new builds*	*3*
Case study 3	*Ground workers and general builders*	*New building*	*3*
Case study 4	*General builders*	*Preparation and laying foundation for new housing community*	*3*
Case study 5	*General builders*	*Completing new building*	*4*

The owners of the micro firms were John (14 years' experience), Derek (20 years' experience), Scott (13 years' site experience), Tony (13 years' site experience) and Tom (12 years' site experience) respectively.

4.1 Initial impressions of common sense and site safety

One consistent finding from both observations and interviews was the fact that none of the newer employees (less than two years' of site experience) associated any of their safety practices to common sense or local knowledge. On the other hand, participants that had extensive experience in the industry seemed to attribute a significant amount of their safety practices to common sense and their extensive site experience. For instance, Andy (Case study 5) who had about 38 years of experience on site stated;

"*Safety is common sense, isn't it?"*

To him, common sense and safety are not mutually exclusive entities. He holds both concepts collectively. Tony shared a comparable view. He believed *"general health and safety"* could not flourish without common sense. Ludhra (2015) agrees with the points raised above as it was found that common sense is relevant in safety practices.

Another point that came across from most participants was how 'dynamic' common sense safety was. Andy clarified that "*common sense [safety]*" varied from site to site. He believed that common sense is demonstrated or used differently as a response to project and site conditions. Thus one needs to depend on their local or situational knowledge when implementing the common sense approach. Rick, having over 32 years of construction site experience also mentioned that common sense depends on what a worker was doing, citing scaffold use as an example. Thus there was a general view that common sense is indeed dependent on the situation at hand. In other words, common sense is not a planned approach to safety but more of a responsive technique. The workers highlighted how important it was to have context-related knowledge on risk management. This is in line with findings from Tutt *et al* (2013) and Baart (2009) that safety knowledge can be very specific to precise situations and thus outsiders or less experienced individuals would not comprehend the level of risk or dangers prevailing.

In trying to explain what he understood by the concept of common sense safety, Tom used a past situation to illustrate how his experience and local knowledge had saved him from a potential accident. He was asked to carry out an unsafe activity; *"…to jump into a trench without ladders"*. His response to that request was *"no"*, stating that "*normal people don't do that*". He thus insinuates that there are some basic standards of safety that the average workers must have. His common sense and local knowledge about working in such conditions or situations enabled him to analyse the situation at hand and subsequently decide it was not safe and hence he would not go through with the task.

In trying to improve the understanding of the meaning of common sense in safety from the participants' perspectives, the next sections look at different ways that common sense was found to implemented on site.

4.2 Common sense as a positive safety approach

Some workers believed common sense was a good way to approach safety. Even going to the lengths of likening good safety practices to common sense. As mentioned in the previous section, Andy rhetorically asked 'whether common sense was not safety'. Although he likened implied common sense and safety were one entity, he clarified that further training was always needed for all workers. It is worth noting that he did not assume a complacent stance or imply that workers knew it all and hence did not need further development. This corroborates findings from Reynolds *et al* (2008) as they identified that good workers admit that further safety training is always important as it helps improve upon safety awareness and helps workers to stay focused. Through observation, it was also witnessed that Andy was very communicative with his colleagues. Although Tom did not point to common sense directly, he and Andy both agreed that the best was to help workers practice safely was to continuously tell them what is safe.

Common sense as a term may be used casually by the participants when discussing safety but when one analyses the data from interviews and observations in its entirety, it is obvious that outsiders may have a different view of what the workers 'really' mean. Rick added that he had been on many different sites since he began his construction career and as such had seen a variety of risks. In reference to how common sense was applied to ensure safety, he described how and when he believed people on site should apply common sense:

"*it depends on what you're doing. You may be on a scaffold, make sure there's no hand rails missing. Yeah, you got easy access, safe access? If you're working on excavations, are they fenced off so you can't fall down? If there's traffic is it, is it all fenced off so that you can get around?*"

Although he attributes the above scenarios to common sense (which some claim to be basic knowledge) it may be difficult for new and less experienced workers to also identify these with such ease. A less experienced worker may assume missing handrails are part of the design and hence continue to work on it. Also, a worker new to excavations may not know the depth at which the digging may lead to serious dangers. In examining Rick's statement, it can be gathered that he is not proposing a laid-back attitude for safety. On the contrary, he is proposing that workers question or double check whatever activity they undertake. Managing knowledge in many situations including safety matters in the construction industry is difficult because site activities are fluid and dynamic (Dainty *et al,* 2007) and for this reason, Rick's idea of constantly reassessing situations is an effective way of maintaining site safety.

Tony discussed that using common sense and experience, he is able to manage and supervise his workers. It was through this knowledge that he is able to decide what "*PPE [personal protective equipment] to provide for all the workers [for their various tasks]*". He believed that as a leader, it was his duty to double-check and reassess situations and help come up with effective solutions that newer workers may not be able to comprehend. He added that even though there are stricter rules for health and safety in recent times, there can be different ways of carrying out a task safely and sometimes the common sense approach will be safer than the officially written procedures. A typical example of such a situation was described as workers being forced (by official site policies) to wear gloves for every task even though it may reduce their firm grip on certain tools hence causing 'riskier' situations for the workers and their workmates. Forsythe (2014) explains that experienced workers possess experiential and local knowledge that will enable them to choose a safe technique when faced with different situations. For his leadership style, Tony adopted an open communication system where workers can freely debate the safest approaches in working. This is because other workers may have a better common sense approach to a particular situation than others. The open discussion technique was also encouraged by John and Derek. On one occasion, Derek was observed having a serious dialogue with one of his newer workers. The topic of discussion was whether an area they were working could be considered as an enclosed area. This discussion was joined by all the other workers and was resolved agreeably. Derek's side of the argument won the most support from the colleagues on this particular issue. This further demonstrates the openness described by leaders. In comparing the construction industry to coalminers' pit sense, older and more experienced workers believe it is their responsibility to protect the younger workers not as a requirement of their job but as personal protective and altruistic role.

John states that he knows all his workers are '*bright'* and as such he can leave them to use their own discretion when working safely. He further adds that he still makes it a point to walk around site and have direct discussions with them in order to know that their discretionary ability is being utilized in a beneficial manner. This is also in line with Andy's response whereby he believes further training and teaching need to be conducted continuously as it helps in the formation and sharpening of ideas. Going beyond the formal risk assessment activities, John adds the following:

"*I'm a big believer in there's never just one way of doing something. Risks do differ*".

In such situations, he firmly believes that one's common sense and experience would be invaluable as far as identifying effective solutions for the prevailing risks. This is in line with his practice of encouraging other workers to voice out their opinions with regard to safe practices. In relation to allowing new workers to use their own discretion, workers from Case study 2 were observed discussing that it was only appropriate when the worker is known to work safely. One of them added that "*you only get to know each other when you've worked with them for some time*". This idea of getting to know one's colleagues was linked to trust because workers believed that one person's mistake or unsafe practice could easily lead to further safety problems for other site operatives. Andy's quote clarified this narrative precisely as he stated the following: "*I mean if you can't trust those you're working with, then you can't trust anyone*". Trust is one of the main indicators of effective knowledge-sharing on site (Fong, 2007). Even though common sense is meant to be an individual's basic knowledge on safety (therefore differing from one person to another); site workers feel they have to be able to evaluate and trust exactly how much safety knowledge their colleagues have.

To summarize, by using common sense in a positive manner workers are able to question situations that they believe could lead to dangerous outcomes. More importantly, people are able to use this common sense more effectively if they have gained a wealth of experience on site. Also, an important part of using common sense safely is by knowing that one's colleagues have a good understanding of safety and thus can be allowed to work to make decisions on their own. This section has presented a positive aspect of common sense and safety. The next section offers empirical findings of workers that did not perceive this concept in same light.

4.3 Using the notion of common sense to avoid bureaucracy

Out of all the five sites visited, workers from Case study 3 showed the least regard for official safety practices. This was also reflected in their responses concerning common sense safety. In trying to dismiss discussions about site safety, George (from Case study 3 with 8 years' of experience) casually responded by saying "*As you can see, it's all up and down. It's just common sense*". George associated health and safety to official site policies and regulations. This response was quite the opposite of what workers from the other four cases had been presenting. On the contrary, the other sites' participants had clarified how they believed workers needed to question situations and be open about how they perceived risks. Scott also revealed that he believes that safety should be about general knowledge and for that reason, it should be left to the workers on site. He stated that the bureaucrats sitting in site offices did not really know what was happening 'on the ground'. It is clear that his problem is not working safely but instead he had a problem with bureaucratic arrangements put in place by those in managerial positions. He states:

"*[They should] Leave it to us really. [We] know what we're doing anyway*".

He believes the individuals that set the site rules and regulations should appreciate workers have enough safety knowledge (i.e. common sense) when dealing with practices. Considering he is the owner of this small company, he could be in the position to encourage communication between his team and the openness and further discussion of the best safety methods. He based his feelings on situations he had encountered from previous projects whereby they had worked as subcontractors. Kamoche and Maguire (2011) found that managers in the coalmining industry may turn a blind eye to workers using pit sense. In other words, they know the practices may not be official but they understand that it is a safety technique that the experienced workers are adopting. Unfortunately, Scott and his team had not experienced this kind of attitude on construction sites.

In trying to further clarify his views on how feels about bureaucratic safety rules, Scott stated that: "*Obviously we've all got basic general knowledge of health and safety so we all know what's safe and what's not safe…*". Scott has strong views about what he believes the people higher up in the management chain ought to be doing but has failed to engage with them. This may be out of fear of his company being blacklisted. In one of the discussions observed during a lunch break in Case study 5, workers of the small company openly discussed the potential ramifications of pointing out impractical sections found in official rules and regulations. One worker described is as "commercial suicide" because he believed it was an act of killing one's own business opportunities; another indication of being placed on a blacklist. According to Taylor (2013), many prominent principal contractors in the UK were guilty of using this blacklist to exclude many firms from their projects.

Some of Scott's comments indicated that he was more concerned about finishing works than working safety, for example, "*[People] probably want to get their work done fast obviously because you need to get the work done as fast as possible*". To him, completing tasks was a necessary trade-off if safety was to be sacrificed. This was also associated with project manager and principal contractors having bureaucratic safety rules that slowed down productivity and still demanded workers to finish activities in an unattainable timeframe. When asked about working with teams (i.e. as fellow subcontractors), he insisted that his preference was to have site managers and other subcontractors out of their way. This could be resultant of the pressures of having to deliver projects in timeframes so tight that they would rather carry on with their work and not get distracted. Workers from this group were using the term common sense in two ways; the first was common sense as a safety approach i.e. a similar view to what others had expressed on other sites and second, was using the concept to avoid having to confront safety bureaucratic rules and regulations. With regard to the second point, coalminers trying to use their informal and local safety knowledge (pit sense) were forced to increase or maintain productivity in the face of increased bureaucratic measures increased in their industry (Kamoche and Maguire, 2010).

Steve was the most experienced worker in Case study 3 with 28 years of site experience. Although he shared some similar views to his colleagues', he showed some contrasting views as well. He believed bureaucracy was getting in the way of carrying out practical work. He expressed unhappiness at how bureaucratic health and safety issues in the construction industry had become. Specifically, he talked about how safety rules and procedures have become prescriptive: "*[People should] use common sense. They're too much by the book instead of common sense. You can't always do jobs like you can on paper*". This comment was in reference to risks being more practical and dynamic and hence standardizing safety approaches was not the way forward. This view was shared by all the other groups. Fong (2007) highlights one of the major factors to affect knowledge-sharing on site to be pressure of time. As indicated by Scott, he and his team would rather get on with their work, thus the pressure of time is clearly preventing the possibility of knowledge sharing that could have happened between their team and others.

4.3.1 The odd one out

Steve (the most experienced participant from Case study 3) shared some positive safety views with respect to the use of common sense and safety. Steve had assumed the role of safety representative of their team i.e. he was in charge of discussing safety matters with principal contractors and other teams on the site. He was observed telling George and Scott what was supposed to be done regarding certain safety issues. Considering Steve's views and behaviours in the context of findings from his colleagues, it can be interpreted that he acts as the 'moral compass' of their group. Alternatively, it can argued that he has more experience of working with different contractors and hence is more experienced in 'playing the game' of job satisfaction. His colleagues do not exhibit the same amount of restraint when having to deal with those they observed to be in rule-making positions. It may be possible that Steve is the one that has kept their company in business for so long as he has prevented the other team members from committing commercial suicide by using a different form of common sense i.e. knowing when and how to satisfy project requirements especially when dealing with safety matters. With the many hoops and hurdles that workers have to jump through on site, participants from Oswald *et al* (2015: 533) were quoted as stating that they '*couldn't finish their jobs without breaking rules*'.

5. Conclusions

Findings from five micro construction firms operating in the East Midlands of the UK have been presented in this paper. The methodological strengths of this study lied with the philosophical underpinnings. For the ontological aspect of this study, common sense was approached to be a subjective concept i.e. different people would interpret it differently. For this reason, it was crucial that the researcher got very close to participants being studied. Through multiple ethnographic case studies, the chosen micro firms were closely studied to gain understanding of how site workers perceive and use common sense safety.

Unless teams and individuals in decision-making positions accept the need for including the common sense and local knowledge approach in site safety, workers will feel pressured by what they consider to be overbearing bureaucratic measures. Unfortunately, if these conditions continue to prevail, workers of small and micro construction firms may be forced further underground. As mentioned earlier (see Willbourn, 2009) they are already known to be the hard to reach groups especially on safety matters. Workers may also carry out practices that may be prohibited even though they may be safer. Additionally, under the time pressures coupled with excessive site rules, workers may also end up cutting corners creating more unsafe environments an opposite of what the rules were supposed to accomplish. Common sense is not a laissez-faire attitude towards safety. In some instances, it challenges workers to double-check situations that would have not been critically evaluated under the bureaucratic safety measures. Workers may be afraid to discuss their views of using this informal type of safety approach with major contractors out of fear of being blacklisted. When construction common sense safety is compared to pit sense used by coalminers, it is evident that more can be done in the industry to accommodate this invaluable approach to safety as it is based upon experience and vital local knowledge.

This study was part of a larger PhD research project and future studies have been recommended to look into the safety practices of other micro construction firms in other regions of the country. Following the anticipated success of this next phase, the study can be extended to cover projects outside the UK.

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An Ethics Reasoning Approach To Health And Safety In Construction

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Abstract

The legal, business and moral cases for health and safety are promoted as the rationale for companies adopting good health and safety practices in construction. The legal and business cases are limited by compliance to laws that are extant and subject to change and to an equating of business success with profitability, thus subjecting safety investment to successful returns on investment. The moral case has strength in that it is derived from fundamental moral principles concerning what is good, a perspective on health and safety that has longevity. Despite strong and improving legislation in many jurisdictions, commissioned research demonstrating the positive nature of the business case and the good intentions of the industry and its professional advisors, health and safety in construction has not achieved a prevention culture and fatal accidents, serious injuries and illness continue to occur. Focussing on the moral case and how it relates to both compliance with legal duties and maintenance of good business practices, a project was initiated to explore the of foundations workplace ethics and to determine whether these foundations and the practice of ethical decision making was understood by all stakeholders and supported by the key decision makers. Research in the field of educational psychology and moral development indicated that conventional moral reasoning, exercised by a majority of adults, was based on compliance with legal requirements and prohibitions and on adherence to social group norms. Utilising a critical theory methodology to analyse workplace culture on construction sites a new perspective on the complexity of interrelationships on-site was developed that uncovered a range of reasoning processes behind health and safety decisions. An understanding of ethics reasoning addresses the limitations of conventional moral reasoning and underpins a new approach developed by the authors to health and safety education and autonomy in decision making. This paper describes the authors' module on ethics reasoning, developed for construction professionals and which is incorporated into two undergraduate degree programmes.

Keywords: Construction ethics, health and safety, safety decision making

1.Background

1.1.Regulatory measures and improvement

The history of the development of health and safety legislation in the United Kingdom (UK) often parallels the history of significant safety failures (HSE 2014b) which mirrors similar developments internationally, e.g. the Seveso directives in Europe following on from the 1971 Seveso disaster. The legislative approach to OSH proved effective with accidents and accident rates consistently falling since the 1970s (HSC 2003b). Davies and Jones (2005) examining the efficacy of the regulatory approach found a general downward trend in over 3-day injury rates for men and women and downward trend in major injuries until 2000, with an upward trend since. When correlated with the business cycle, it was noted that a 1% increase in the GDP above trend was associated with a 1.4% increase in the rate major accidents suggesting to Davies and Jones (2005) that accident rates increased with the hiring of new workers and with increased worker effort (as in overtime working). Schlagbauer and Heck (2014) have found that increased worker effort leads to an increase in accidents when workers have insufficient rest/recovery time which leads to tiredness and exhaustion, and thus to reduced concentration and physical capacity, and thus to accidents. The ISSA (2010) found an increase in psychosocial risk and ill-health as a consequence of the post 2008 economic downturn and Goh et al. (2015) estimated that there are 120,000 excess deaths per annum in the USA attributable to workplace stressors and how work is managed.

Between 1995 - 2015 the rate of fatal injuries to workers in Great Britain (GB) declined from 1.2 to 0.46 deaths per 100,000, though the Health and Safety Executive (HSE) acknowledge that that the trend since 2008 is less clear, (HSE 2015b). The decline in the rate of injuries has fallen from 2.9 to 0.5 per 100,000 between 1974 - 2014 and the fall in (reported) non-fatal injuries was from 336,701 to 77,310. Half of this reduction is due to changing employment patterns and occupations, (HSE 2014c). The increase in work-related stress and related conditions have been increasing since the 1990s and this may be as much due to an increasing awareness of the conditions as to actual increases due to increased psychosocial risk in the post-2008 period. The sharpest decrease in the fatality rate occurred after the introduction of the 1974 Health and Safety at Work Act and subsequent regulations until 1997, with the rate then reasonably level until 2008 when it dropped again over the two year period 2009/2010 and has again remained level since, (HSE 2014d).

As construction accounts for 5% of the British workforce but 31% of all fatal injuries and 10% of reported major injuries, it is therefore the highest risk industry in the UK (HSE 2014a, 2014e).

1.2.Alternative models for achieving Prevention

In parallel with the statutes a number of theories on occupational safety and health (OSH) and models of good practice were developed, most notably Risk Assessment and Risk Management, which are now internationally recognised approaches to OSH. Other theories, concerned with the failure of regulatory compliance to achieve a prevention culture, examined problems associated with management practice, worker behaviour (Geller 1998, 2000, Cooper 2000, 2010) and the contradictions between the demands of production and profits and workers' need for employment (McAleenan 2015). Behaviour Based Safety, the outworking of the works of Cooper (2000, 2010) and Geller (1998, 2000) have become internationally recognised and adopted by statutory safety bodies (HSA 2013, Fleming and Lardner 2002) and large corporations (Cooper 2015). In parallel with these developments, the International Social Security Association (ISSA) was advocating the reintegration of OSH competencies into vocational and professional education, (ISSA 2003).

The authors, had developed and were implementing Operation Analysis and Control, a holistic model which promoted a dynamic approach to the management of work activities that focuses on the elimination or control of hazards from the outset of project and activity planning,(McAleenan and McAleenan 2001, 2002).

The development of OAC commenced from the analysis of the limitation of the language of Risk Management and of the safety discourse. The central concept was control and what was necessary to the process of control of work activities on construction sites. The analysis went to the core of human awareness, understanding and perceptions of work and the management of work activities. The result was the negation of risk based approaches to work and project outcomes and its replacement by an approach that respected and utilised the competence of workers who are fully au fait with the requirements of the task, are, with the right resources, capable of achieving them and are in control of their own activities including the safety component.

1.3.Ethical failings in construction

The process of developing OAC entailed, amongst other things, an examination of a number of concepts associated with the moral case for OSH and in particular the assumptions underpinning the discourse of safety leadership and its impact on agency.

Corporate Social Responsibility (CSR), a central ethical and moral issue in the industry, is expected to be a driver for social and environmental sustainability while meeting the requirements of shareholders. Yet within the construction industry, the reputation for unethical practices is regarded as a major contributor to reduced quality and poor safety practices (Hamza et al. 2007 and 2010, Olufemi and Oyedeli 2014, CIOB 2013, Ameh and Odusani 2010), that contributes to accidents and the endangerment of human life (Zhou and Wu 2013). Additionally, the CIOB (2013) found that 49% of respondents believe that corruption is present and that 50% do not believe that the industry is doing enough to counteract it.

In the field of educational psychology and moral development, Kohlberg (1971) and Eckensberger (2007) stated that conventional moral reasoning, exercised by a majority of adults, is based on compliance with legal requirements and prohibitions, and on adherence to social group norms. Focussing on the moral case and how it relates to both compliance with legal duties and maintenance of good business practices, the authors initiated a project to explore the foundations of workplace ethics and to determine whether these foundations and the practice of ethical decision making was understood by all stakeholders and supported by the key decision makers.

Utilising a critical theory methodology to analyse workplace culture on construction sites a new perspective on the complexity of interrelationships on-site was developed that uncovered a range of reasoning processes behind health and safety decisions. An understanding of ethics reasoning addresses the limitations of conventional moral reasoning and underpins the case for a new approach to health and safety training and autonomy in decision making. The aim of this paper is to elucidate the case for an ethics reasoning approach to professional education and describe a project by the authors that led to the development of a module on ethics reasoning which has been incorporated into two undergraduate programmes.

2.Ethics, morals and reasoning

2.1.Definition of ethics and morals

It is useful at this point to clarify a distinction between the terms “ethics” and “morals” as both are often conflated, (Chismar 2004). Ethics is an internal process whereby the individual strives to attain authenticity as a human being, (Žižek 2012) and as such it is a function of Man as a social Being. Morals, specifically moral behaviour, is a function of agency and ethics reasoning and is directed outwards towards others, a manifestation of care for others, (Žižek 2012).

The project recognised the range of moral philosophies that exist and the fact that they sometimes do not sit comfortably with each other despite them being fundamentally concerned with doing good or doing no harm to others. Why this should be so informed the objective of the project; to determine the function and universality of ethics and how moral behaviour is decided, as well as the methodology for exploring this objective. The strength and stability of the moral case for OSH that elevates it above both the business and legal cases required an exploration of the fundamental level in order to explain and supplant the above described unethical behaviours with a rational ethic that permits of objectively and universally “good” moral behaviour.

2.2.Problems with agency in the real world

It can be difficult to reconcile the notion of Agency with real world situations. The competent worker, expected to make work-related decisions based on age, experience and level of skill (Dalton Vs Frendo, Irish Supreme Court 1977, in Garavan 1997), none-the-less finds him/herself engaged in work where what to do, when to do it, with what resources and even how to do it is often subject to the decisions of managers and supervisors who convey this information to the worker.

In unsafe situations, the legal right and duty not to undertake unsafe work is often also a fiction, known and understood by all but left unstated as this would negate its function as a “legal fiction”. This reflects Hegel’s (in Russell 1996) refection of Kant’s notion of autonomy where-in the moral agent assumes responsibility for translating abstract injunctions into concrete moral obligations (Žižek 2012). For Hegel (1817) autonomy and the freedom to act stems not simply from following one’s own will, but from there being real world structures that correspond to the structures of the will, i.e., a rational State that respects the freedom of the individual.

In the concrete reality there are many structures within which the moral agent exists but which are less appreciative of moral autonomy or tolerant of agency. The workplace culture described by Schein (2013), springs from the values and beliefs of its leaders is, with its hierarchical structures and heteronomous decision making, reflective of unequal social relations where-in decision making is bounded by production targets and operational necessities. Safety (vision) statements such as “Stop Work” or “Safety First” are bounded by the subliminal messages inherent in Geertz’s (1973) alternative Thick description of workplace culture, which permeates a workplace and can contradict the overt messages that his Thin description describes as being an aspect of a superficial awareness of culture.

A deontological model of site safety has safety rules jostle for position amongst statutory duties, commercial contracts, contracts of employment and professional codes of conduct, creating disharmony and confusion. This model is the outworking of Kohlberg (1971) and Eckensberger’s (2007) “conventional moral reasoning”, a reasoning based on group interests and adherence to societal norms and laws where loyalty to the group or the influences of laws with the greatest sanctions are dominant. Yet construction professionals Codes of Ethics/Conduct conflict with this deontology, advocating a post conventional reasoning based on universal rights and exhorting the professional to exercise their judgments in the interests of wider society (IEA 2015).

OSH is not the sole consideration of professional ethical decision making, but when contextualised with the Universal Declaration of Human Rights (United Nations 1947) the professional has a duty to understand the human rights of the worker and to fully appreciate and implement this obligation to workers, the employer and the client.

2.3.Moral necessity

The moral injunction to do no harm to others is embodied in health and safety laws. Morality derives from culture and embodies those mechanisms that make culture a system of uniquely human controls (Geertz 1973). It is how Man relates to the world and others in it, and from it materialises his self-realisation (Freire 1973), his self-actualisation (Maslow 1943). It is also inherently human, arising from Man’s awareness of himself as a species distinct from other species and within which he recognises others, and himself in others (Fromm 1961). This is the root of empathy in which is found the form of morality that echoes the symmetry between Self and Other (Žižek 2012). The process of ethical development and moral maturing is the process of humanisation (Freire 1973) and defines the practical relationships with others. In its mature form the symmetry of moral action acts to the benefit of all.

The awareness of ourselves and others of necessity entails an awareness of both that which is beneficial and that which is detrimental in human relationships; we either harm or we help, and this is codified in the Golden Rule of Moral Reciprocity, “treat others as we would want others to treat us”. This stands in contrast to the “zero level rule”, “do not do to me what you do not want me to do to you”, (Žižek’s 2012). With the publication of the Seoul Declaration (ILO 2008) a new series of paradigms were prescribed which shifted the focus from accident prevention, the “zero level rule”, to the creation of workplace cultures that actively contribute to the welfare and wellbeing of workers; the Golden Rule entering into health and safety practice.

In exploring Hegel’s dialectic, Žižek (2012) distinguishes ethics as care for the self, a striving towards authentic being. This concept of ethics parallels Freire’s (1973) concept of humanisation and is at the core of the human ontological project. Human behaviour is the synthesis of internal ethics and external morality and as such the moral case for health and safety stems from necessity, being, as it is, inherent in the relations that exist between people. Thus the ethical failures in the construction industry and the resultant harms are not simply detrimental to workers and organisations but are the antithesis of humanisation and social progress.

2.4.Ethics Reasoning approach to OSH

Codes of conduct and codes of ethics are integral to professionalism. The Engineering Council (EC, 2013) advocates that the professional bodies place a personal obligation on their members to act in accordance with the Royal Academy of Engineering (RAE, 2011) and EC standards and principles. The Joint Board of Moderators (JBM, 2009) has more specific guidelines for teaching ethics and the professionalism expected of students on construction degree courses in the UK.

A number of problems have been identified with the teaching of ethics. Warnick (2010) suggests that the dissatisfaction felt by some professionals in regard to current work ethics impacts negatively on quality, while Strahlendorf (2005 citing Logan 2001) lists economic pressures, differing national and cultural standards and the lack of legal standards as some of the reasons for unethical behaviours. Herkert (2000) suggests that the focus of engineering ethics on individual and micro-ethics is to the detriment of work on social or macro-ethics concerned with collective social responsibility which would have a bearing on Corporate Social Responsibility and the OECD (2004) principles of consideration of all stakeholders. Guenther (2000) argues for the need of professionals to have the ability to reason out ethic issues in any situation rather than be constrained by specific rules that may be in different professional codes. This is echoed by Strahlendorf (2005) who makes the case for professionals being able to question those codes and reason out appropriate ethical approaches to moral behaviour.

Ethics Reasoning is on the curricula of a number of universities (e.g. Univ. of Texas 2015 and Leeds Univ. 2015). Whitbeck (2011) has also conducted work on ethics reasoning in engineering and the RAE (2011) guidance contains case studies to facilitate reasoning skills.

This project commenced with the work of Piaget (1932) who pioneered the work on cognitive development and moral reasoning in children and this was substantially developed and tested widely by Kohlberg (1971) and Eckensberger (2007). Their findings of an invariant development of moral judgement are classified in three categories; pre-conventional, conventional and post-conventional (Table 1).

Table 1: Kohlberg's levels of moral reasoning

Level of moral development	*Stage of reasoning*	*approx ages*
Pre-conventional, "do's and don't's"	*Stage 1. Right is obedience to power and avoidance of punishment.*	*< 11*
	Stage2. Right is taking responsibility and leaving other to be responsible for themselves.	
Conventional	*Stage 3. Right is being considerate: "uphold the values of other adolescents and adults"' rules of society.*	*adolescence and adulthood*
	Stage 4. Right is being good, with the values and norms of family and society at large.	
Post-Conventional	*Stage 5. Right is finding inner "universal rights" balance between self-rights and societal rules - a social contract.*	*after 20*
	Stage 6. Right is based on a higher order of applying of applying principles to all human-kind; being non-judgemental and respecting all human life.	
	adapted from Kohlberg,1986	

Using these levels and stages as a foundation, the authors developed an industry specific undergraduate module within the Quantity Surveying degree course that included a problem solving component. As the semester progressed, students were presented with hypothetical and real-world scenarios of increasing complexity that included the use of case studies relating to contract acquisition, construction quality and ODH on construction projects. The students were asked to suggest individual and group solutions to the problems identified and to provide a rational explanation for their choices, which were then subject to challenge in open forum discussion.

These exercises were integrated with teaching and study on various theories of ethics, in particular utilitarianism, deontology and virtue ethics, and in the context of international and national codes relating to Human Rights and OSH obligations. The expectation was that the first year students who undertook this module would initially demonstrate stages 3-4 ethics reasoning and be moving towards stages 4-5 reasoning by the end of the module and with appropriate reinforcement, be demonstrably stage 5 by their graduation year. This would accord w with the general findings in Piaget (1932) and Kohlberg's (1971) work.

In the first iteration of the module the outcomes showed a higher than expected pre-conventional reasoning, however by the second semester, a number of students were demonstrating reasoning at one level higher, close to Kohlberg's (1971) prediction that 50% of students would reason at one level higher after twelve weeks. This is likely to have been due to the students having a period to time in which the module and learning was assimilated into their thinking.

The second iteration of the module introduced the moral philosophy and theories of ethics described above, and this cohort of students demonstrated more conventional stage 3 reasoning with some demonstrating stage 4. The stage 3 reasoning emerged strongly with problems with high construction and OSH context and with which the students were less familiar. This stage 3 reasoning was related to their perception of loyalty to their (fictional) future employer and acceptance of the authority of managers. However in more generalised problems where their awareness of the law was broader, stage 4 social conformity reasoning was more in evidence.

The module has evolved over 4 years and now comprises the following elements:

- Ethical problem solving exercises to develop skills
- Introduction to the prevalent theories of ethics
- Case studies, to be analysed on the basis of the various theories
- Stages of Ethics Reasoning
- Contextualisation, construction and international protocols and codes
- Agency and resolving conflicts

The project demonstrated that the context within which skills development occurs needs to be one that is familiar to students to allow them to exercise personal judgement rather than defer to an existing deontology. As such it is appropriate that the ethics reasoning skills development takes place continuously throughout their under-graduate studies, for example through regularly presenting case studies in other modules that allow the students to evaluate and address the moral issues in them. This will further allow for greater assimilation as there will be period between teaching/study when the ideas and skills can imbed. A new under-graduate Safety Engineering and Disaster Management degree course, co-developed by one of the authors, recognises this and has integrated ethics reasoning throughout the course with a clear focus on developing and demonstrating stage 5 reasoning and critical analytical thinking into Prevention through Design by their graduation year.

3.Conclusions

Ethics and moral behaviour are at the core of Man's relationships with others and with himself, and construction is the epitome of these relationships, contributing to Man's wellbeing, satisfying basic needs and meeting the higher emotional and intellectual needs of self-actualisation. They are at the heart of construction professionalism and transcends simple adherence to codes or compliance with statutes. Ethics Reasoning recognises these deontologies as milestones on the road to a mature ethic based on equality and respect for all humanity, and a morality that acts in the interests of and advances the wellbeing of all.

An Ethics Reasoning approach to the industry and, specifically, to OSH recognises that professional and vocational workers have the capacity within their competences to be aware of and act on the universal principles of social justice and human rights. This approach further recognises and takes account of the various ethical philosophies found in national cultures and through the reasoning process contextualises these perspectives with the fundamental principles of moral behaviour, i.e., the Golden Rule.

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Regulatory Factors Contributing to Building Collapse in South Africa: A Case Study

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Abstract

This paper presents the causes of building collapse linked to non-compliance to relevant regulations. A case study research that was conducted on the Tongaat mall building collapse in South Africa forms the basis for the highlighted factors. Through data collection that entails content analysis of official inquiry into the collapse and subsequent semi-structured face-to-face interviews of construction workers who took part in the ill-fated project, major regulatory failures were identified. Salient findings show that the regulatory functions on the building project were compromised, and the inability to ensure that the project fulfils all compliance requirements significantly enhances the existence of a work environment that led to two fatalities and twenty-nine injuries. This study corroborates findings that have highlighted implementation as the weak link in H&S practice in terms of construction regulations in South Africa. In other words, the benefits of adequate policies on paper can only emerge through proper applications on construction sites.

Keywords: Accident, Construction, Health and Safety, Regulation, South Africa

1. Introduction

The collapse of the Tongaat mall building that was under construction in November 2013 is a justification for optimum construction management practice in South Africa. The practice illustrated in the analysed reports shown in Emuze et al. (2015) is indicative of several deviations from acceptable H&S practice. The triggers for the collapse, a beam and two columns occurred due to poor supervision of construction work. This paper is a follow-up on the work presented in the 2015 CIB W099 conference held at Belfast, Northern Ireland. In the paper presented in Belfast, Emuze et al. (2015) used content analysis as a method to provide possible reasons for the accident that resulted in 2 fatalities and 29 injuries. Emuze et al. (2015) note that poor construction work, poor supervision of work, and non-compliance to H&S regulations constitute the major contributing factors that led to the Tongaat mall building collapse. These contributing factors were also reported when buildings collapsed in Malaysia (Aini et al., 2005) and the United States of America (USA) (Levy & Salvadori, 2002). However, this particular paper reports on the lived experiences of the participants in the ill-fated project. Base on the findings of the official inquiry into the accident, it was determined that the research would benefit from further exploration of the experience of project actors through face-to-face interviews that tend to yield rich data (Ritchie et al., 2014).

This approach is concerned with understanding particular situations, rather than generalizing findings. The method used is primarily for in-depth analyses of interviews, recorded observations and documented communication (Thomas, 2011). Thus, face-to-face interviews that were preceded by content analysis presented in Emuze et al. (2015) were used to collect the responses to the research questions. The research question that forms the nexus of this paper is "*how did regulatory factors contribute to the collapse of the Tongaat mall in South Africa*". The objective of this paper is to provide the answer to this question by presenting the implications of building collapse from the perspective of regulations in the next section. Thereafter, the methodology section concisely indicates the procedure that was followed to obtain additional primary data in the study. The methodology then leads to the results and a discussion on the implications of regulatory failures in construction accident causation. The conclusions tied the insights from the accident together. It is important to focus on accidents linked to collapse in construction as it seems to be an ending tragedy in South Africa where another major collapse occurred in October 2015 as shown in Figure 1 (http://www.news24.com/Multimedia/South-Africa/PICS-Deadly-Joburg-bridge-collapse-20151015#). A pictorial view of the Tongaat mall collapse shown in Emuze et al. (2015) speaks to the need to stop the circle of building collapse in South Africa.

Figure 1: Collapse of a bridge under construction in Johannesburg (Source: News24: online)

2. Synopsis of the Tongaat Mall Building Collapse

The regulatory failures experienced on the Tongaat mall collapse involve multiple parties to the project. Based on the analysed inquiry documents in Emuze et al. (2015), the notable failures pertain to structural design, quality of construction work and supervision and non-compliance to the requirements of construction regulations (Table 1). This paper focuses on the regulation aspects of the failures observed in the accidents. The developer / client of the project failed to comply with official orders to stop the project. For instance, the developer ignored court orders to stop construction six days prior to the collapse of the slab that led to fatalities. Before the court order, the host municipality had been expending efforts to stop construction for a range of contraventions. A major contravention is the refusal to heed the instruction not to proceed with construction work on site. The municipality reports that it did not grant 'permit to build' to the developer of the mall. This attitude to regulations by the developer, which is hereafter referred to as the client, impacts on construction H&S (Smallwood, 2008). As shown in this accident, it could contribute to injuries and fatalities. This is particularly crucial when compliance is not open to negotiation. As shown in the findings of this building collapse, the client may have averted the loss of lives if compliance was observed. The compliance issue is not new in South Africa. In a 2009 report by the construction industry development board (CIDB), the Department of Labour (DoL) flagged non-compliance in most of the construction sites that were visited by its inspectors. The client is not alone in terms of regulatory failure. The engineer and the contractor appear to follow the footsteps of the client in this regard. From the analysed documents, the engineer may be found wanting concerning full compliance to section 9 of the South Africa construction regulations, which states that "*the designer of a structure shall inform the contractor in writing of any known or anticipated dangers or hazards relating to the construction work, and make available all relevant information required for the safe execution of the work upon being designed or when the design is subsequently altered*". Compliance or non-compliance to this clause influences the triggers of the collapse, which is a slab that was supported by beams and columns that cracked.

Table 1: A summary of causal factors of the Tongaat mall collapse

Failure (s)	*Description*
Construction work / supervision	Slab sagged before collapse
Construction work / supervision	Scaffold / formwork / false work removed too soon
Construction work / supervision	Weak concrete used for construction on site
Construction work / supervision	Severe lapses in construction work and supervision
Construction work / supervision	Reasons for construction failure - beams
Structural design	Reasons for construction failure - design
Structural design / construction work	Steel bars are missing in the elements - slabs, beams, etc.
Construction work / supervision	Lack of H&S audit on project site
Regulatory control	Mall plans rejects / failed approval four times
Regulatory control	Demolition of the site was never approved
Regulatory control	Developers was consistently fined for failures
Regulatory control	Workers instructed to keep working despite official notice

Source: Emuze et al. (2015)

The link between design and accidents as well as the outcomes of accidents in the form of injuries and fatalities has been highlighted in the work of Cooke and Lingard (2011). For instance, the Australian study examined 258 construction fatalities and note that 40% were linked to the design of the work place. The compliance gaps were also notable when the workings of the general contractor (GC) on the project are x-rayed. This is not unconnected to the lack of relevant qualification by the general foreman (GF) of the GC. Qualification is relevant to knowledge of the regulatory environment. Given that the analysed inquiry document shows an unconcealed disregard to section 5 of the construction regulations, it is very likely that the GF do know the regulations, which is not an excuse in law. In particular, the section says that a principal contractor should "stop any contractor from executing construction work which is not in accordance with the principal contractor's and/or contractor's H&S plan for the site or which poses a threat to the health and safety of persons". The interpretation of this clause and its compliance is important and it requires the GF, assuming he is in the know, to take steps to mitigate possible failures on the project site.

These narratives from the analysed document provide impetus for the collection of data from the participants of the collapsed building project. The next section presents a concise version of the methodology utilised in the research.

3. Methodology

Similar building collapse studies at the construction stage in which fatalities and injuries were recorded have used a case study research design to interpret the events (Aini et al., 2005). The case study approach was also used for this study in order to gain analytical comprehension of the events (Thomas, 2011). Primary data collection in the study comprises context analysis (Emuze, 2015) and face-to-face interviews, which forms the basis for the findings presented in this paper. Before the commencement of the interviews, the official inquiry documents of the DoL were analysed to identify issues dominating the media coverage of the Tongaat mall accident. The media coverage refers to online and printed news materials that were evaluated in terms of text (words) and images that have been recorded without the interference of the researchers. Online materials were accessed through the press releases of the DoL in South Africa, and the printed materials were sourced from newspapers. The analysis of content was linked to the role of actors in the collapsed building.

The analysis utilised the textual data to elicit meaning, gain understanding, and develop empirical knowledge on the collapsed mall (Corbin and Strauss, 2008). After the content analysis that produce the discussion in section 2 of this paper, on site visits were made to the location of the accident several times to schedule interview appointments with participants of the project. The findings of the analysed document provide the basis for the compilation of the interview protocol, which was made up of 33 questions that interrogated the issues uncovered in the analysed documents. However, the questions related to regulations constitute the focus of this paper. These questions include:

- How did you experience on-site inspection of the Tongaat Mall project?
- What is your perception on the enforcement of compliance with Construction Regulations (2003) by the local authority / municipality during the Tongaat Mall design phase?
- What is your perception on compliance enforcement on the Tongaat Mall project?

Figure 2 shows that the developer did not adhere to the tenets and principles of the construction regulations of South Africa as amended in 2014. This assumption stems from the fact that construction of the mall continued unchanged although plans were unapproved by the municipal authority. On site visits and documents show that the construction is taking place close to a rail track where authorization for construction was not given at the time of the accident. In brief, the regulatory questions emerge from Figure 2. These questions were posed to the interviewees in the study. The interviews focused on the project participants that were directly involved with the construction of Tongaat mall so as to access information on actual events from primary sources. Although the client and GC of the collapsed building declined to be interviewed, members of the inquiry (including H&S specialists, community liaisons officer, and local municipality building inspectors, and subcontractors) talked to the research team off the record. The interaction with the members of the inquiry paved the way for the contact made with some workers on the project. Thus, actual interviews were conducted with nine construction workers that were active on the project at the time of the accident. The interviewees were all male workers.

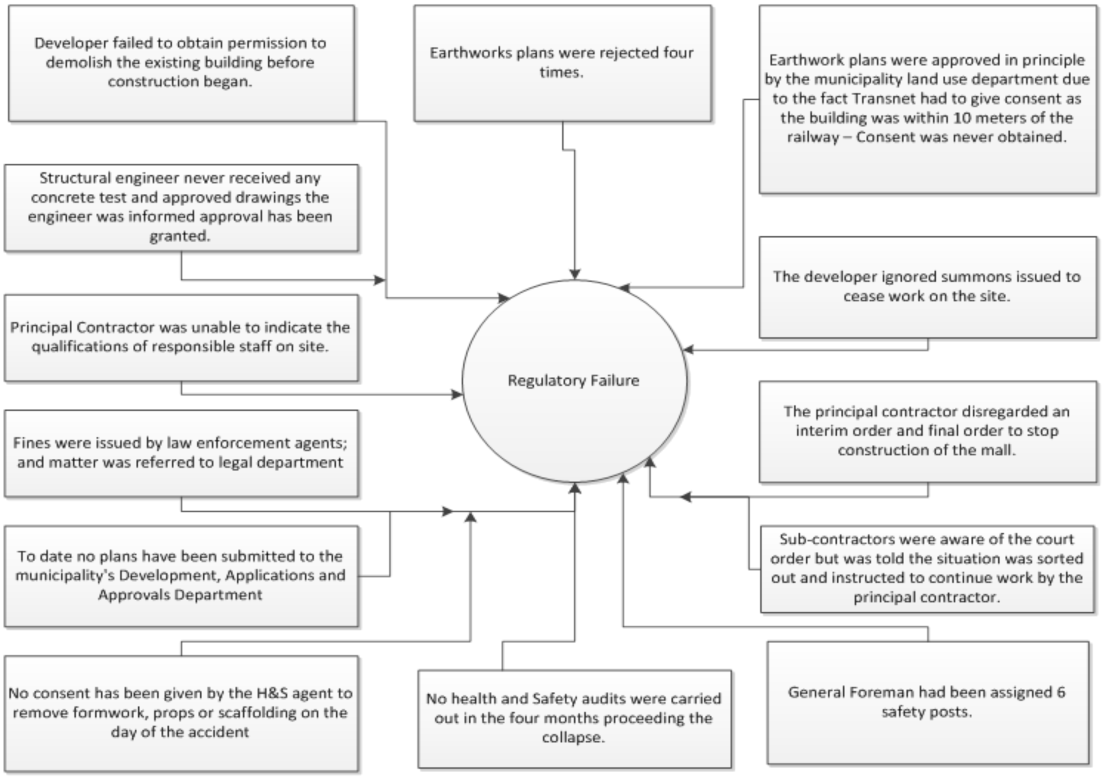

Figure 2 is a summary of the regulatory failures extracted from document analysis

4. Results

When the background information of the interviewees were analysed, it was apparent that the general workers perceive that the GF for the contractor is their employer, who assign them to various tasks on the project, although all of them see themselves as concrete workers. The interviewees confirm that they have extensive experience in the industry, though they are not specialized in a particular trade, although they work mostly on concrete work. More important to this paper is the revelation that these workers appears to have a superficial knowledge of the South African construction regulations as they were unable to engage in conversations that shows extensive understanding of either regulations or legislation related to construction.

The interviewees also report that there was high employee turnover on the project and often, workers were assigned to tasks that are beyond their capacity to accomplish. When asked why a worker would undertake a task that he is not qualified to accomplish, the interviewees point to issues surrounding job security. That is, if a worker does not agree to undertake an assigned task, he may be out of the site within a short time. Given that the unemployment rate in South Africa is estimated to be 25.1% in 2014 (Central Intelligence Agency (CIA), 2015), these workers were not willing to risk secured employee by objecting to instructions from the GF.

In particular, the responses of the workers to the aforementioned regulatory open ended questions presented in section 3 are illustrated in Figure 2. These questions investigated the involvement of the local governmental authority in the Tongaat mall project in terms of on-site inspections and the enforcement of relevant regulations.

Figure 3: Interviewee perceptions of regulatory environment in Tongaat project

It also assesses the enforcement of the regulations by the municipal authority where the project is located. The analysis of the data indicates that the interviewees were not really aware of inspections performed on the site. This suggests that either the interviewees were not notified when such persons arrived on site or that they did not recognized such persons on the site. The lack of clear responses to the municipal question signified that the local authority had limited presence on the site. The responses to the third question mean that the interviewees perceive a significant lack of leadership in terms of enforcing regulations on the project. For example, the interviewees could not identify the responsible personnel that represented the municipality on the project in terms of regular visits to the site.

Furthermore, the interviewees say that would decline ever working on a site where personal protective equipment (PPE) is not accessible contrary to legislation. They will also be hesitant to work on a site where the required supervision and where construction regulations are lacking.

The interviewees also note that the high rate of production was forced on them to the detriment of quality workmanship. They cited the fact that walls were constructed too fast without the necessary reinforcement or bracing whereas formwork and props were also removed too soon. The removal of formwork from a column triggered the collapse of the building on the 13th of November, 2013. The interviewees recognize that the procedures were incorrect, and when they attempt to object, they will be reprimanded. The interviewees pointed out that work is scare and that they are in dire need of employment so much so that this placed them in a position where compliance to the directives given to them must be obeyed without a challenge. In brief, most of the interviewees were unhappy about the lack of PPE on site. They were also saddened about the fact that their H&S and wellbeing were compromised on the project.

The analysed data show that the rate of unemployment among the interviewees was high and that they needed the remuneration – hence their inability to challenge poor work processes. The interviewees again reiterated that if they did not comply with the directives given to them their employment would be terminated. Some of the interviewees indicated that they do not want to be associated with the construction of the mall to guard their own safety and wellbeing. As shown in Table 2, a cross analysis of the content analysis and interview findings establish the fact that the accident occurred on a site where clear deviations from construction regulations and the requirement of the H&S Act of 1993 of South Africa existed side-by-side.

Table 2: A summarised cross analysis of regulatory factors of the Tongaat mall collapse

Content analysis + Interview findings
Lack of inspection by regulatory bodies and professional team
Construction procedures were questionable in order to meet deadlines and to avoid penalties.
Formwork was removed to soon
Control and regulation of concrete mixing questionable
Construction flaws were rectified in dubious ways
Construction workers had little or no knowledge of the Construction Regulations
Supervisors were substandard and lacked leadership
Lack of inspection by regulatory bodies and professional team
Appointed safety officer was unknown to construction workers
Inadequate induction / work training

Source: Authors

5. Discussion

This aspect of the research confirms the regulatory contributors to the Tongaat mall building collapse accident. Given that incident investigations are normally used for origins of failure in a system (Manuele, 2014), it is vital to understand various contributory factors to the Tongaat mall accident. The Tongaat mall collapse could be seen from a multifactorial aspect of incident causation. The study that began in 2014 and was first reported in Emuze et al. (2015) shows that there was an initiating event, which was followed by many contributing factors that evolved in sequence. Such sequence could be likened to the illustrations of the loss causation model (LCM) of Bird and Germain (1985). This model recognises that management should prevent and control accidents. It would appear that for management to prevent accidents, the first step would be to adhere to all the requirements in a regulatory environment. Causal factors in accidents may start from decisions made by management when policies, standards, procedures, provision of resources and accountability system are constrained (Manuele, 2014). Again, the observation by Manuele (2014) resonates with the events of the Tongaat mall accident. In specific terms, the striking of formwork when it is rather too early is evident of inadequate accountability system in which the GC through the actions of the GF continued to work sub optimally on the project. Flagrant disregard of even a stop order from the municipality is evidence of the use of a GF that do not appreciate the definition of an accident, which is aptly defined as "… unexpected event or occurrence that results in an unwanted and undesirable outcome… (Hollnagel, 2004: 5)".

Researchers have recognised the importance of the client in the management of H&S, especially their influence on contractors (Smallwood, 2008; Suraji et al, 2001). To emphasise the crucial role of clients in H&S management, Suraji et al. (2001) argue that construction accidents are caused by inappropriate responses to certain constraints in the environment. They observed, for example, that the client responses are the actions or failure to act in response to constraints that emerge during the development of a project. According to them, these include reducing the project budget, adding new project criteria, changing project objectives and accelerating the design or construction efforts of the project. These perceptions are reinforced by clients who abdicate their roles and put on H&S responsibilities on contractors. In the case of the Tongaat mall accident, the client appear to be in haste to complete the project so much so that the permit to build was not obtained and the H&S component of the project was subservient to time and cost considerations. The client appears to be fixed on occupation date / opening day of the mall.

In a socio-technical system (such as in construction) where the relations between human and machines are intertwined, compliance to regulations should be the minimum in terms of good H&S practice. The system shapes the technical and social conditions of work in a way that both the system's outputs and the needs of workers are accommodated (Manuele, 2014). Regulation is a key part of the system in construction and when accidents eventuate, abnormal outputs are within the system. The lack of control in managing loss is always due to deficiencies in management programmes, standards identified and the degree of compliance with such standards (Amyotte, and Oehmen, 2002). Whereas, high-level governmental and regulatory factors tended to be similar for accidents that occur in socio-technical systems, the physical and human factors differ across different projects (Woo and Vicente, 2003). Thus the risk posed in an environment where compliance to regulations and the legislation is either low or limited can be high. This is the case in South Africa as attested by the CIDB (2009). For example, this particular accident killed 2 people and injured 29 while another recent bridge collapse in October 2015 also recorded fatalities and injuries (Figure 1). A lack of effective mechanisms to implement legislation and regulations for improved H&S performance in a developing country such as South Africa is a major issue (Alkilani et al., 2013).

This next step of the study is to make use of the context analysis and interview data in the compilation of graphic representations of the events / causal flow of the accident. With the use of causal trees, event trees, and causal-effect charts, this step would entail the management of the complex flow of recorded events so as to create an overview of complex happenings in the Tongaat mall accident. Such representation would focus on the propagation of the effects of undesirable actions inherent in technical faults and human errors through the project system of Tongaat mall building construction (Svedung and Rasmussen, 2002).

6. Conclusions

The narrative in this paper shows that regulatory failures were rampant in the collapsed building in South Africa. Some of these failures provide fertile grounds for the propagation of multiple causal accident factors. A socio-technical accident causation model that highlights the influence of organisational culture of both clients and GC involved in Tongaat mall project is needed to show all the shortcomings that were in existence when H&S policies, standards, procedures and accountability took the back seat in the ill-fated project. The model would relate to inadequacies in controls, especially from the regulatory environment, which appears to allow construction to continue on the site despite several stop orders from the concerned authorities. In relation to this paper, the answer to the question posed in section one is that regulatory factors significantly contributed to the collapse of the building in terms of clear disregard for important sections of construction regulations, and H&S legislation in South Africa. Evidence of deviations can be seen in Table 2 and the interview findings. This realisation unfortunately confirms the long held perceptions that while South African construction is not lacking in legislation, compliance is a major hurdle to be scaled in the industry.

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Construction Permit to Work Requirement in South Africa: Closing Commencement Gaps

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Abstract

The Construction Regulations enacted in 2003 realised a range of roles and practices that have impacted the status of health and safety (H&S) in South Africa. In 2014, the regulations were revised with the introduction of new sections that are aimed at reinforcing the regulatory environment. One of such section is the 'permit to work' requirement, which inter-alia, seeks to stop the award of work to non H&S complaint contractors. To assess implementation readiness, a sequential mixed method study was conducted in 2015. The collected survey and interview data shows that there are practice gaps that would lead to the inability of clients to obtain the work permits as envisaged by the revised regulations. The multi prong implications for clients, designers, and contractors means procurement delays will occur in the interim and such events would impact on project planning. The delays may occur due to capacity constrains at the Department of Labour (DoL) who is mandated by law to issue the permit. More important is the need for the DoL in South Africa to remove all implementation road blocks so that the permit to work system that is met to engender injury and accident free construction work environment would be successful.

Keywords: Construction, Health and Safety, Regulation, South Africa

1. Introduction

The implementation of optimum H&S practice is a prerequisite for a reduction in injuries and accidents in the construction industry (Hallowell, 2010). Among other various interventions, legislation and regulations are used to promote good H&S practice in the construction industry. The use of legislation is relevant in an industry in which non-compliance is prevalent due to its structure. In terms of structure, the construction industry in South Africa is dominated by a large number of small and medium size (SME) contractors (Emuze and Smallwood, 2011). These SMEs are unable imbibe the zero-accident culture (Othman, 2012). The expansion of the zero-accident or zero-harm culture in the industry has increased the need to know, and implement, relevant H&S regulations in the industry (Wilkins, 2011). Price Water House Coopers (PwC) (2013) reports that while there have been insinuations that fatalities are linked to the high price environment – chasing profits causes accidents that result in injuries and fatalities – the reality is that improving H&S is a profit motivation (Smallwood, 2004). Most construction workers employed by SMEs and even large contractors in South Africa are either semi-skilled or unskilled with little education and this poses a great challenge in managing H&S since risks to H&S increases with a low level of awareness and lack of training (Lingard and Rowlinson, 2005). In an attempt to promote workers' compliance to H&S regulations in the industry, the need to convey the implications of dangerous conditions and effects of non-compliances through appropriate training and education cannot be over emphasised (Wilkins, 2011).

Windapo and Oladapo (2012) note that construction H&S has long been the focus of attention of many industry stakeholders in South Africa. PwC (2013) reports that leading construction companies, the government and unions are showing increased concern with respect to H&S, which is essential if the industry is to remain progressive. The poor H&S performance in South African construction is therefore motivating stakeholders (Agumba and Haupt, 2011) and the government is not left behind in this motivation in terms of interventions. One of such intervention is the enactment of Construction Regulations. However, there is a gap in the implementation of the Construction Regulations that was promulgated in 2003. The gap is apparent as clients lack consistent and uniform standards of compliance with H&S because they often appoint contractors without verifying their H&S compliance capability. According to Windapo and Oladapo (2012), contractors perceive regulations as an additional burden, which they have to conform with and which gives rise to unnecessary costs. In an attempt to avoid these perceived additional costs, contractors tend not to comply fully with H&S regulations. For instance, contractors are not compelled by the client to notify the DoL before commencing with projects where required. This reported action of contractors is the basis for the overall study, which is done in partial fulfilment of the requirement for an MSc qualification.

One of the research questions of the study that forms the tie for this paper is "*How should public sector client implement the newly introduced construction works permit in South Africa*? The objective of this question is to determine the public sector's readiness in terms of the fulfilment of section 3 of Construction Regulations (2014), which states that a client who intends to have construction work carried out, must at least 30 days before that work is carried out apply to the provincial director for a construction work permit to perform work which exceeds 180 days, or will involve more than 1800 person days of construction work or works contract is of a value equal to or exceeding thirteen million rand or CIDB (Construction Industry Development Board) grading level 6 (Republic of South Africa (RSA), 2014). The Construction Regulations of South Africa is applicable to all persons involved in construction work and its application impact directly on construction H&S. This paper start with a synopsis of the newly introduced permit to work requirement of the regulations and its implications for construction projects in the next section. Thereafter, the methodology section concisely indicates the procedure that was used in the research. The methodology discourse leads to the findings and a discussion, which informs the conclusions of the paper.

2. Scope of Construction Regulations (2014): A Synopsis

Construction regulations (2014), which was promulgated on the 7th of February 2014 (RSA, 2014) apply to all persons involved in construction work – section 2(1) of the regulations. At the launch of the regulations, the South African labour minister states that:

"*For any legislation to be effective it must be enforced and our inspectors will not tolerate non-compliance. These regulations should serve as a deterrent to all those who have not yet grasped the value add of creating and maintaining healthy and safe workplaces. As we are well aware, construction workers build our roads, houses and workplaces and repair and maintain our nation's physical infrastructure. This work includes many hazardous tasks and conditions such as work at height, excavations, noise, dust, power tools and equipment, confined spaces and electricity. Therefore worker involvement is a key factor in improving safety performance on a construction site. Organised labour, as well as employers, must ensure that H&S of workers on construction sites is not compromised. We cannot be callous with the lives of workers. We must always remember that behind the statistics of people who are killed in our industry, there are real human beings, children who lose parents, wives or husbands who lose their loved ones who are in most cases breadwinners. This industry should not be thought of as a killer industry but rather take its place as a major player in our economy" (SACPCMP, 2014)*".

As shown in Table 1, the regulations were issued in terms of the Occupational Health and Safety Act 85 of 1993 (RSA, 1993). Among other clauses, section 3 of the regulations introduced a new requirement to the construction industry in South Africa. The permit to work requirement place compliance obligations on stakeholders – clients, contractors, DoL and construction H&S professionals. The section states that a client must ensure that the principal contractor keeps a copy of the construction work permit contemplated in sub regulation (1) in the Occupational H&S file for inspection by an inspector, the client, the clients authorized agent, or an employee. Obtaining the permit and keeping it for inspection are grey areas for the implementation that began in August 2015.

In order for the public sector to fulfil the requirements of Construction Regulations (2014), there is need for it to accommodate regulatory changes and make the necessary improvements that will afford required compliance. Section 5(5) of Construction Regulations (2014) states that where a construction work permit is required as contemplated in regulation 3(1), the client must appoint a competent agent to assist him in undertaking the measures he needs to take to comply with the requirements and duties imposed upon him by or under Construction Regulations (2014) provisions and the Occupational Health and Safety Act (OHSA) 85 of 1993, and that the duties which are to be carried out by the agent must be done with integrity. This requirement brings up a range of issues. One is the competency and capacity of DoL to accommodate the permit to work applications; and two, is the available of competent construction H&S professionals that can be appointed by the client in order to fulfil the purpose of the regulations. These two issues are significant in South African construction that suffers from many incidents of injuries and accidents (CIDB, 2009) and chronic non-compliance cases on construction site as evident in major accidents (Emuze et al., 2015).

Table 1: A summarised application scope of construction regulations 2014

CONSTRUCTION REGULATIONS 2014
OCCUPATIONAL HEALTH AND SAFETY ACT, 85 of 1993
Scope of application
2. (1) These Regulations are applicable to all persons involved in construction work. (2) Regulations 3 and 5 are not applicable where the construction work carried out is in relation to a single storey dwelling for a client who intends to reside in such dwelling upon completion thereof.
3. Application for construction work permit.
3. (1) a client who intends to have construction work carried out, must at least 30 days before that work is to be carried out apply to the provincial director in writing for a construction work permit to perform construction work if the intended construction work will: (a) exceed 180 days; (b) will involve more than 1800 person days of construction work; or (c) the works contract is of a value equal to or exceeding thirteen million rand or Construction Industry Development Board (CIDB) grading level 6. (2) An application contemplated in sub-regulation (1) must be done in a form similar to Annexure 1. (3) The provincial director must issue a construction work permit in writing to perform construction work contemplated in sub-regulation (1) within 30 days of receiving the construction work permit application and must assign a site specific number for each construction site. (4) A site specific number contemplated in sub-regulation (3) must be conspicuously displayed at the main entrance to the site for which that number is assigned. (5) A construction work permit contemplated in this regulation may be granted only if: a) the fully completed documents contemplated in regulation 5(1)(a) and b) proof in writing has been submitted—
(i) that the client complies with regulation 5(5) (ii) with regard to the registration and good standing of the principal contractor as contemplated in regulation 5(1)(j); and (iii) that regulation 5(1)(c), (d), (e), (f), (g) and (h) has been complied with. (6) A client must ensure that the principal contractor keeps a copy of the construction work permit contemplated in sub-regulation (1) in the H&S file for inspection by an inspector, the client, the client's authorised agent, or an employee. (7) No construction work contemplated in sub-regulation (1) may be commenced or carried out before the construction work permit and number contemplated in sub-regulation (3) have been issued and assigned. (8) A site specific number contemplated in sub-regulation (3) is not transferrable.

Source: RSA (2014)

3. Methodology

In this research, the implications of the Construction Regulations (2014) for the public sector was explored as past research and present anecdotal evidences show that the DoL and by extension, construction clients, may not be able to cope with the requirements of the implementation of the permit to work system. The study began with a review of the regulations and associated literature to get a sense of the direction and intent of the new clauses. Thereafter, the findings of the literature were used to compile a semi-structure questionnaire distributed among general contractors (GCs) in a metropolitan area in South Africa. The questionnaires were administered on construction sites so that the targeted sample was reached. The questionnaire was distributed to a sample of 28 GCs actively registered with the CIDB in grades 6-9. The grade of the contractors is in conformance with section 3 of Construction Regulations (2014). The questionnaire consisted of ten questions each, with several sub questions. The questionnaire referred to the implications of the regulations for the Department of Public Works (DPW) procurement system. The survey yields 79% response as only 22 questionnaires were validly completed and processed. Primary data collection in the study thus comprises survey research and face-to-face interviews, which forms the basis for the findings presented in this paper (Creswell and Plano Clark, 2011).

Before the commencement of the interviews, the survey data were analysed to identify the main perceptions of the respondents. The data also influenced the collection of the textual data in that the interview protocol focus on getting the opinions from the regulatory authority and other construction professions, especially in relation to the permit to work requirement. The interview field work began by identifying built environment professionals that have managed construction projects on behalf of the DPW in the province, director of procurement in DPW, chief director infrastructure in DPW, and an official of DoL in the province. A letter, which explained the purpose of the interviews, was delivered by hand to some of the participants, while emails were sent to participants whom upon being called on the phone asked for the letters to be emailed. Face-to-face interviews were successfully secured with eight out of nine potential interviewees. Interviews were conducted between the month of March and April 2015. Semi-structured face-to-face open ended interviews were conducted by taking notes while audio recording of the interviews was in progress. In brief, purposive sampling was deemed useful for the study because it is important to collect the perceptions of people in construction with requisite work experience and contact with DPW procurement system.

4. Results

When the survey respondents were asked to indicate the number of years that they have been involved in construction, all of them have been working in the industry for more than six years and three of them even have more than 20 years construction industry experience. As shown in the tables in this section, the respondents were asked to rate their perceptions on a five point Likert scale, which range from 1 (strongly disagree) to 5 (strongly agree). An 'unsure' option was provided on the scale to cater for questions in which the respondents were either not able to comprehend or provide an answer. The computation of the responses was done with descriptive statistics, which produce the percentage responses for each sub question and the associated mean scores (MS). The statements in the tables have been ranked based on the MSs and where there is a tie, the standard deviation score was used to break it (Salkind, 2015).

In Table 2, it can be observed that when asked whether Construction Regulations should promote compliance to H&S in the industry, majority of the respondents were generally in agreement. The ranking suggests a significant agreement with the perception that the regulations should promote compliance to H&S in the industry. The statement is relative to the need for everyone involved in construction to be familiar with the regulations. However, the respondents concur that compliance with Construction Regulations (2014) requires specific competences because it has realised a number of revisions that differentiates it from Construction Regulations (2003). One of such revisions is the permit to work requirement that is enforced by the DoL. To this end, the respondents suggest that sensitisation of stakeholders is required in the industry as most of them are not familiar with the revisions in Construction Regulations (2014).

Table 2: Contractors' perception of Construction Regulations of South Africa

Statement	*MS*	*Rank*
Construction Regulations should promote compliance to H&S in the industry	4.63	1
Industry role players are relatively familiar with construction regulations 2003	4.17	2
Compliance with construction regulations 2014 requires specific competences	3.89	3
Construction regulation 2014 realised notable revisions and requirements	3.77	4
Industry role players are relatively familiar with construction regulations 2003	3.75	5
Permit to work system to be enforced by DoL in August 2015 is based on construction regulation 2014	3.63	6
Industry role players are relatively familiar with construction regulations 2014	2.93	7

Source: Authors

In Table 3, the respondents strongly indicate that delayed project initiation has economic and social impacts on the community. This perceived delay could be made worse if the view that the DoL has not engaged project actors on the modus operandi for the implementation of the permit to work system is a reality. The table confirms the media perception that the permit to work requirement could delay project initiation and planning because of the required documentation and the capacity of DPW to function properly in this context. Another reason for this perception could be the paucity in the number of construction H&S professionals that can be engaged for the implementation of the system. It is also notable that awareness related to the permit to work system enforced by the DoL in August 2015 is deemed to be low as opposed to high by the contractors that took part in the survey. On the average, the respondents were also of the opinion that clients' deliverables are vulnerable to the requirements of the permit to work system.

Table 3: Contractors' perception of permit to work requirement

Statement	*MS*	*Rank*
Delayed project initiation has economic and social impacts on the community	4.50	1
DoL has engaged project actors on the implementation of the permit to work system	3.62	2
Permit to work could delay project initiation and planning	3.55	3
Awareness relative to the permit to work system to be enforced by DoL in August 2015 is high	2.94	4
Clients deliverables are vulnerable to the requirements of the permit to work system	2.33	5

Source: Authors

The survey findings become clearer with the interviews that were conducted with the DoL and other professionals that would be directly involved in the implementation of the permit to work system. When asked to indicate whether they are aware of the permit to work system that came into effect in August 2015, six out of eight interviewees responded in the affirmative. The six interviewees indicated that they are aware of the permit to work system, although how it will be implemented is not clear to most of them. One of the interviewee claim total ignorance about the regulations, and another interview is uncertain about the time of its application.

In addition, the interviewees were requested to indicate if they are familiar with Construction Regulations (2014) in terms of key points of departure from Construction Regulations (2003). The question was used to determine whether the interviewees are familiar with Construction Regulations (2014). This can be deduced if they can identify the differences between Construction Regulations (2014) and the previous regulations. Given that the interviewees flag issues of 'delays in processing documentation for verifications, and cost and time implications', it can be assumed that their level of familiarity is acceptable. It is realized that the interviewees are familiar with Construction Regulations (2014), and also that interviewees could distinguish between the two Construction Regulations, this is since issues such as delays, permit to work system, processing and verification of documentation were some of the highlighted concerns among the respondents. Regarding the point of departure from Construction Regulations (2003), the respondents' mentioned that there is clear departure in which the permit to work system is the highlight. There is an indication that interviewees were aware of Construction Regulations (2014) and the point of departure from Construction Regulations (2003).

This question leads to that of compliance, which says "*Relying on your familiarity with Construction Regulations (2014), please discuss compliance issues in the industry*?" In response, the interviewees were of the opinion that lack of compliance to the new requirements will ensue, mostly SME contractors and thus, enforcement will have to be promoted by the DoL.

In addition, the DoL official interviewed was asked to comment on the enforcement aspect of the permit to work requirement. To quote the interviewee directly in response to this question, the official says *"No construction shall be permitted to commence without the site-specific official number allocated to it. Prohibition notice shall be served to the contractor to stop immediately. And if not displayed then we will issue a contravention notice, for the contractor to comply within specified time".*

In an elaboration, the official says that the DoL will issue a letter of acknowledgement for the permit request and issue the required number within 30 days. The interviewee further says that contractors must insist on the 1st page copy of their permit be stamped as proof of submission. When the permit to work requirement is operational, the official note that information advocacy sessions shall be conducted with all possible clients and principal contractors. The DoL will also engage all voluntary associations and statutory councils in the awareness drive. In the case of backlogs in application processing due to capacity constraints, the official says that "*There might be backlogs likely to be caused by unavailability of personnel, there might also be some minor backlogs since department still have to decide on personnel to be appointed for processing permits*". Given that this interview was conducted less than 3 months to the implementation start date, this sentence is not comforting to contractors.

In particular, the official was asked to briefly explain how permit application backlogs will be addressed if they manifest. The question was asked to assess if the DoL prepared for possible backlogs to be encountered at the commencement of the system. The official responded when he says "*The proposed plan is to have a principal inspector per province who shall assess the H&S specifications, baseline risk assessment and costs, and make recommendations to specialist inspector for granting the permit*".

5. Discussion

A concise cross analysis of the survey and interview findings is presented in Table 4, which shows that the survey respondents and the interviewee agreed on some of the issues. The survey reveals that stakeholders in the industry are familiar with Construction Regulations (2003). This finding is aligned to the findings by the CIDB (2009), which emphasise that Construction Regulations are perceived to have had a wide spread impact, and in particular increased H&S awareness and increased consideration by GCs. The survey also suggests that Construction Regulations should promote compliance to H&S in the industry, and that compliance with Construction Regulations (2014) requires specific competences. The study reveals that professionals who are responsible for the implementation of permit to work requirement of Construction Regulations (2014) need specific learning related to implementation. Relevant H&S education and training at all levels in the industry will empower people to make the requisite H&S contributions, which include the tertiary education of all built environment disciplines. More importantly, H&S enforcement agencies such as the DoL and the client such as the DPW should have the requisite construction expertise.

Table 4: Cross analysis of the survey and interview data

	Survey questionnaire	*Interviews*	*Survey questionnaire*	*Interviews*
	Differences		*Consensus*	
Construction Regulations 2003 & 2014			Construction regulations should promote compliance to H&S in the industry.	Clients must be informed on how to comply, principal contractors should be trained about H&S and appoint registered H&S professionals and designers' sets of documents must incorporate H&S.
Familiarity with Construction Regulations 2014	Industry role players are relatively familiar with construction regulations 2003. Industry role players are not relatively familiar with construction regulations 2014.	Industry role players are relatively familiar with construction regulations 2014.		
Permit to work System	Awareness of the permit to work system is low.	Awareness of the permit to work system is moderate.	Permit to work could delay project initiation and planning.	There would be implications to service delivery due to permit to work system. Possible impact on project initiation and planning will be in terms of the client as they need to get a permit before he/she starts a project.
Competency	H&S competency level required for compliance with construction regulations 2014 will influence procurement method choice and implementation.	Selection criteria that would establish the H&S competency level required is knowledge, skills, training, qualifications certification, necessary documentation, quality and experience.	Construction regulations 2014 requires specific competencies.	Consultants, clients and contractors need competency for construction regulations to work.

Source: Authors

According to Hughes and Ferrett (2008), clients must make sure that designers, contractors and others whom they propose to engage are competent or work under the supervision of competent people, and are adequately resourced and appointed early enough to fulfil their duties. The study suggests that competency level required for compliance with Construction Regulations (2014) will influence procurement method choice and implementation. The study suggests that permit to work could delay project initiation and planning, while it also suggests that delayed project initiation has economic and social impacts on the community. These issues affect the DPW as a public sector client and the DoL. While the DPW and the DoL are both governmental agencies in South Africa, their roles in the implementation of the regulations clearly differ. For the DPW, it is a client that must fulfil certain requirements in terms of the regulations. Key requirements include:

- Appoint a competent designer, CHSA, and principal contractor;
- Prepare a baseline risk assessment and H&S specifications by a competent SACPCMP registered CHSA;
- Apply and obtain a permit within time frames set out in Legislation (30 days) in order to roll out infrastructure projects.

These above mentioned obligations will serve and be verified by the DoL, who must assign duties of processing of permit to work application to competent officials who shall act within principles set out by the regulations; ensure permits are granted within time frames set out in regulations (30 days); and also educate the public about permit to work requirements in order to get optimum compliance. In order to enhance compliance, agencies such as the DoL need to be sensitive to the context within which they undertake their activities, their target audience and to the varying competencies and resources of those being regulated and have some awareness of those external resources (e.g. third party actors) that may be involved (Health and Safety Executive (HSE), 2008). The interviewees agreed that implementation of Construction Regulations (2014) needs stringent measures and DoL must closely police non-conformance. The CIDB (2009) highlights that the primary objective of any H&S legislation is the prevention of accidents with their consequences in terms of injury, disablement and fatality, and ill health within the work environment. The achievement of this objective depends on good legislation supported by effective, sensible and accountable enforcement. The attainment of the objectives also depends on proper H&S training, which has the capacity to improve compliance with the new permit to work requirements (Wilkins, 2011). According to the DoL, the purpose of the Construction Regulations (2014) is as follows: (1) cultural change by among others, the permit system; (2); involving client, agent / designers, principal contractor, contractor, and H&S officers at the initial stage and through the life span of a project regarding all matters of H&S (Maphaha, 2015).

6. Conclusions

The study reveals that Construction Regulations have strengthened inclusive H&S roles and responsibilities in South Africa. This is particularly true for principal actors in a construction project. For instance, sections 5(1) (a-d) of the Construction Regulations (2014) states that a client must prepare a baseline risk assessment and prepare a suitable, sufficiently documented and coherent site specific H&S specification based on the baseline risk assessment. The client must then provide the specifications to the designer and ensure that the designer takes the prepared H&S specification into consideration during the design stage; while 6(1) (b-c (i) states that designer of a structure must take into consideration the H&S specification submitted by the client before the contract is put out to tender, 7(1) (a) states that a principal contractor must provide and demonstrate to the client a suitable, sufficiently documented and coherent site specific H&S plan.

The study also found out that permit to work will have impact on project initiation and planning. The DoL is likely to experience backlogs because of unavailability of personnel required for processing permits. To ensure compliance, the DoL must have all internal arrangement for implementation in place – this will assist in closing all commencement gaps. Among other intentions, the permit to work system would ensure that suitably qualified personnel are involved in a project in terms of providing the required H&S cover for each project. However, the survey and the interview data of this paper shows that the DoL is not fully prepared for the roll out of the permit to work system given the fact that none of the interview and the survey respondents know how the system will unfold or is presently unfolding. Even the DoL official that was interviewed could not provide a clear implementation plan for the system. Taken together, it can be argued that the implementation of the permit to work system may not be smooth sailing and the compliance issues that have always hinder complete implementation of regulations may yet again become a stumbling block to the realisation of the intentions of the permit to work system.

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Using institutional theory to understand occupational safety and health practices in smaller construction firms in the UK

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Abstract

Despite the fact that small and medium-sized enterprises (SMEs) and micro enterprises play a key role in the construction industry and experience higher rates of work-related accidents than their larger counterparts, comparatively little is known about the factors that influence how such enterprises approach occupational safety and health (OSH) in the workplace. In this paper we use institutional theory to understand the factors that promote the survival and legitimacy of particular OSH practices amongst SMEs and micro enterprises in the construction sector in the UK. Our research involved analysing qualitative data from 44 interviews with participants from a range of construction firms, of different sizes and specialisms. The findings from our analysis suggest that the practices of smaller construction enterprises are influenced by a range of coercive, mimetic and normative pressures, however two factors were seen to be particularly influential: the coercive pressures exerted by principal contractors in larger supply chains, which serve to filter subcontractors; and on the job socialisation, a process that reinforces and ensures the survival of both desirable and undesirable OSH practices in smaller organisations.

Keywords: SMEs, micro enterprises, institutional theory, template analysis, interviews

1. Introduction

Despite the fact that small and medium-sized enterprises (SMEs) and micro enterprises play a key role in the construction industry and experience higher rates of work-related accidents than their larger counterparts, comparatively little is known about the factors that influence how such enterprises approach occupational safety and health (OSH) in the workplace. Developing a better understanding of these influences could help policy makers, OSH practitioners and larger contractors to design more appropriate interventions for encouraging and supporting smaller construction firms to work more healthily and safely.

In this paper we use institutional theory as a framework, or theoretical lens, through which to understand the factors that promote the survival and legitimacy of particular OSH practices amongst SMEs and micro construction firms. These factors are explored using data from a recently completed two-year study of OSH practices in SMEs and micro enterprises in the United Kingdom (UK), which was funded by the Institution of Occupational Safety and Health (IOSH). The study covered a wide range of industry sectors including logistics, healthcare and construction; however for the purpose of this paper we focus on the findings from 40 interviews with owners and employees in SME and micro construction firms.

We begin by exploring what is currently known about the influences on OSH practices in smaller organisations, both generally and specifically in the construction sector. We then describe the methods underpinning our research into OSH and smaller organisations and explain the reasons for using institutional theory as our analytical framework. The findings from our analysis are presented in section 4 and discussed in further depth in the conclusions in section 5.

2. Background

SMEs and micro enterprises comprise the vast majority of organisations in most countries. For instance, in 2014 smaller organisations *"... accounted for 99.3 per cent of all private sector businesses in the UK, 47.8 per cent of private sector employment and 33.2 per cent of private sector turnover"* (FSB, 2014). However, there is no universal definition of what constitutes an SME or micro enterprise, with categorisations varying from country to country. In the European Union (EU), micro, small and medium sized enterprises are classified as organisations employing less than 10, 50 and 250 people, respectively (Table 1). Although the EU also uses financial criteria sheet to categorise organisations, employee headcount is the most widely used criterion and is therefore used to classify enterprises in this study.

National and supranational statistics suggest that that accident rates are higher in SMEs and micro enterprises than in larger companies, with one study (WHP in Europe, 2001; p.21) finding that fatal accident rates were twice as high in small and micro companies than those in large companies. Similar differences in accident rates have also been evident in specific countries and sectors. For instance, Walters and Bolt (2009) found that firms with fewer than 14 people employed 40% of the construction workforce in Britain but, for the period 2003-08, two-thirds of fatalities were self-employed or employed by firms of 15 people or less. In other words, workers in such companies had a greater risk of fatal injury.

Table 1: Classifications of medium, small and micro enterprises (EC, 2003, p.14)

Enterprise category	**Headcount**	**Annual turnover**	**Annual balance sheet total**
Medium	<250	≤€50 million	≤€43 million
Small	<50	≤€10 million	≤€10 million
Micro	<10	≤€2 million	≤€2 million

However, despite the fact that smaller organisations are far more prevalent and experience a greater risk of accidents, traditionally researchers have tended to focus on OSH practices in larger organisations (Eakin, 1992). This discrepancy may be explained by the fact that SMEs and micro enterprises are less visible and harder to reach than larger organisations. It may also be that researchers have viewed SMEs and micro enterprises as smaller versions of larger organisations, thereby overlooking their distinctive characteristics and the different contexts in which smaller organisations operate (Eakin and MacEachen, 1998). Nevertheless, over the last two decades there has been a growing body of literature on the subject of OSH in smaller enterprises, covering a wide range of sectors and geographical settings, and involving a variety of methodologies and stakeholders[1].

Generally speaking, the literature paints a negative picture of OSH practices in smaller organisations, with previous studies finding, amongst other things, a lack of management commitment (e.g. Eakin and MacEachen, 1998; Holmes and Gifford, 1997; Parker et al., 2012), a lack of employee engagement (e.g. Barbeau et al., 2004; Champoux and Brun, 2003) and confusion about employee and management responsibilities (e.g. Bradshaw et al., 2001; Fairman and Yapp, 2004). Smaller organisations have also been found to have lower levels of awareness and knowledge of legislative requirements and regulations (e.g. Antonsson et al., 2002; Bradshaw et al., 2001) and have a tendency to underestimate or discount risks (e.g. Hasle et al., 2011; Fonteyn et al., 1997).

Of particular interest to us in this paper are studies that have shed light on the factors that influence OSH practices in smaller organisations. Such studies are important because they tell us *why* individuals and organisations act in particular ways, not just *how* they act. Vickers et al. (2005, p.152) argued that *"... more widely based studies that have sought to locate the development of policy in the context of a detailed and more holistic understanding of the factors that influence how small firms approach the management of health and safety have been much less in evidence."* In a related paper, Vickers et al. (2004) suggested that OSH practices in

[1] See Gibb et al. (forthcoming) for a more comprehensive review of this literature

smaller firms are influenced by a combination of internal characteristics (such as management style) and external pressures (for instance, from customers and regulators).

Smaller enterprises tend to be dominated internally by the interests and goals of owner-managers (Marlow, 2005), who often have a preference for informal and individualised practices (Hoque and Noon, 2004). For many owner-managers, the business is an extension of themselves - their ego, personality, motives and desires (Banfield et al., 1996). A number of studies have highlighted the impact of these interests and goals on the OSH practices of smaller firms. For instance, Eakin (1992) found that owner-managers in smaller enterprises wanted to avoid being paternalistic and, in some cases, felt that they lacked the authority to intervene to improve OSH practices. Similar issues were identified by Parker et al. (2012, p.474) who found that *"employers were conflicted about allowing employees a certain level of independence while also maintaining a safe workplace."*

However, whilst the insights from such studies are certainly valuable, contributors to the broader business and management literature have argued that *"...if we are to understand industrial relations in the small firms, then we need an approach that goes beyond simply looking inside the small firm and describing the (paternalistic) management styles used to control the labour process... it is necessary to consider both the environment within which small firms operate as well as the impact of this on, and the effect of, managerial choice."* (Barrett and Rainnie, 2002, p.427). Such arguments are based on the premise that smaller organisations are particular sensitive to the environment, or context, in which they operate (Baldock et al., 2006; Barrett and Rainnie, 2002).

For the purpose of this paper we used institutional theory as a framework, or theoretical lens, for understanding the external influences on smaller enterprises' OSH practices. Institutional theory has its roots in the work of Meyer and Rowan (1977), who suggested that *"... organizations are driven to incorporate the practices and procedures defined by prevailing rationalized concepts of organizational work and institutionalized in society. Organizations that do so increase their legitimacy and their survival prospects, independent of the immediate efficacy of the acquired practices and procedures"* (p.340). These institutional rules mean that, over time, organisations become homogenous or *isomorphic* – that is to say, their practices and procedures become more similar. Developing this idea further, DiMaggio and Powell (1983, p.150) argued that there are *"... three mechanisms through which institutional isomorphic change occurs"*, these being:

- Coercive – pressures exerted on organisations by other organisations upon which they are dependent or by society (e.g. through government regulations)
- Normative – in which organisations conform to the practices that are deemed legitimate in their field, in order for themselves be acknowledged as reputable.
- Mimetic – whereby organisations model themselves on other organisations that they perceive to be more legitimate or successful in their field

DiMaggio and Powell suggested that while there may be an interplay between the three mechanisms, "*... they tend to derive from different conditions and may lead to different outcomes.*" (p.150).

Institutional theory has been used in a diverse range of contexts in order to understand and explain why practices in particular sectors or professions become legitimised and dominant. Glover et al., (2014, p.103) argued that the *"... strength of institutional theory is that it offers explanations of why certain practices are chosen without an obvious economic return."* Ju and Rowlinson (2014) used institutional theory in their case study of safety management strategies of construction contractors in Hong Kong. Using data from 62 unstructured interviews with site personnel on a large-scale railway project, they found that *"Multiple stakeholders exert incompatible safety pressures on contractors through a variety of mechanisms, such as regulatory constraints, enforcement activities, normative force and cultural influence."* (p.734). These incompatible pressures were seen to result in a disconnect between the rhetoric of the safety management system and the reality of site practices.

Acknowledging the value of institutional theory for studying the influences behind OSH practices, our aim in this paper was to use this theory to understand the factors that promote the survival and legitimacy of particular OSH practices amongst SMEs and micro enterprises in the construction sector in the UK.

3. Research methods

David and Bitektine (2009, p.168) contend that *"... institutional theory represents a very large tent that houses a great variety of theoretical agendas and methodological approaches."* In this study, our approach to applying institutional theory involved coding interview data (transcripts and notes) using template analysis (see King, 1998) – a method that entails both deductive and inductive reasoning (Saunders et al., 2009). The deductive part of the template analysis involved coding the textual data in Nvivo 10 software using a pre-prepared list of themes – the themes in this case being the three isomorphic mechanisms identified by DiMaggio and Powell (1983). Inductive reasoning was then used to identify sub-themes within each of the main themes. Where appropriate, the template was amended by adding new themes. The final template is summarised in Table 2 and discussed in further detail below.

The data used in our analysis were collected as part of a cross-sector study of OSH practices in SMEs and micro enterprises in the UK (see Gibb et al., forthcoming). The study involved a mixed-method, qualitative approach comprising 149 structured interviews, nine short-term ethnographies and 21 semi-structured interviews with 179 owners and employees in smaller organisations from a range of industry sectors, including logistics, agricultural, healthcare and construction. Participants were selected purposively for maximum variation, that is to say they were chosen because they were likely to provide useful insights into a range of different work settings. For the purpose of this paper, our analysis focused on the 44 interviews with participants from the construction sector, including representatives from a large contractor and an industry body.

Adopting a qualitative approach in our research allowed us to tell the story of OSH practices in smaller organisations from the perspective of the actors concerned, and to understand how and why they came to have a particular perspective on OSH. Unlike Ju and Rowlinson's (2014) study – which focused on a single case study– our research focused on multiple organisations and work settings, in order to determine if institutional pressures vary across contexts within the same sector. Where possible, multiple interviews were held within the same organisation in order to access different perspectives (e.g. those of owners and employees) on the same issues. The interviews tended to be conducted in participants' place of work, enabling us to discuss their OSH knowledge and practices in context. In most cases, interviewees needed very little prompting and talked extensively about their experiences and understanding of OSH in their data-to-day work, providing us with a rich narrative for analysis.

4. Findings

Analysis of the interview data revealed a range of positive and negative institutional influences on OSH practices in smaller enterprises, as summarised in Table 2. **Coercive** pressures were mentioned most frequently by interviewees; however, such pressures took a variety of different forms. Many interviewees cited government regulations as a reason for adopting particular working practices, although individuals' responses to regulations were often mediated by other factors, such as an individual's attitude or work setting. For instance, one plumbing and heating engineer (sole trader) stated that:

> *"Obviously there are a lot of regulations and legal requirements and obligations which you have to fulfil... obviously it depends on your own personality. My personality is, if I do something, I wouldn't do anything different than what I'd do for my mother. So it's personally affected, if you like, but obviously you have the constraints of all the regulations and legal requirements."*

There was a perception amongst some interviewees that, in practical terms, OSH regulations were not always easy to implement in construction because of the varying conditions and that some degree of tolerance or flexibility was required.

Some principal or main contractors (usually medium-sized or large enterprises) were also seen to exert a positive coercive influence on the OSH practices of smaller organisations, both specifically through the strict enforcement of site rules and the use of method statements, and more generally through their contractor management and training systems. One subcontractor explained how he and his colleagues were required to tidy up after themselves when working on site, a behaviour that was enforced by the site manager. For smaller businesses, failure to comply with such requirements would mean that they would not be able work on larger projects with larger contractors. This coercive pressure was summed up succinctly by an apprentice electrician with a medium-sized contractor, describing how

> *"You're expected to follow the site rules and if you don't you're red and yellow carded so you could be off site. If it's someone working for a small company for*

themselves then it's in their best interest to follow the site rules and if they get removed off site they're losing money themselves."

Elsewhere, the owner of a micro mechanical engineering business explained how:

> *"We know we can't break any rules. We're like robots really in a certain way. We just don't anything that's wrong really, you know you can't get away with it. You've got to wear your hat, you've got to wear all your PPE, that's got to be worn, you know you can't go out there not wearing it. You know you can't surf on the scaffolds. You just can't do anything that's wrong. You know you're not allowed to just build scaffolds. You know what's dangerous and what's not. It's common sense more than anything else."*

Interestingly, some interviewees described how they would work differently when not under the influence of a large contractor, for instance when working in a domestic setting or on smaller construction sites. In other words, these smaller businesses would adapt their approach to OSH, depending on who they were working for. One sole trader working in the construction industry explained that he uses 110v power tools on larger building sites, because that is what the main contractors require, but when working for domestic clients he uses 240v power tools instead because he feels that he can work safely with them and that 110v tools are unnecessary.

Not all SMEs and micro enterprises choose to work with larger organisations. For instance, two sole traders explained how they did not like to work on larger sites as they found it to be too much about rules and regulations and constrained their ways of working. Instead, they worked for a small collection of clients they had built up over the years said that they had been offered jobs on larger sites but turned down the work because after years of experience they preferred to work on their own terms. In particular, they did not like the idea of anyone talking down to them or telling them what to do.

On the whole, the principal contractors were seen to have had a positive influence on OSH practices amongst smaller enterprises in the construction industry, raising the overall standard in the industry. A representative from a construction industry body observed that *"... the people that are within that supply chain of those big influential principal contractors and clients are – they're not there yet but they are – they're certainly on the road to getting there. And they're a country mile away from where they were, you know five, 10 years ago, something like that."*

An OSH manager in a larger construction company described how his company had begun working with a smaller subcontractor that had a very low standard of OSH, however within a year the subcontractor had won a *"best at health and safety award."* The OSH manager explained how the subcontractor had been given access to training and assistance in developing their OSH programme. Any guidance they needed they knew who to ask - this process was facilitated by being approachable and by using standardised forms and procedures that allowed the subcontractor to understand what was needed without fundamentally changing the way they ran their company.

Table 2: Summary of interviews themes and issues

Theme	**Positive**	**Negative**
Coercive pressures	Government regulations Enforcement of site rules Principal contractor requirements Monitoring of subcontractors	Time pressures from larger client/contractors
Mimetic pressures	Adopting good practices Seeking competitive advantage	Avoiding bad practices
Normative pressures	Protect reputation On the job socialisation Pride in the job	On the job socialisation
Economic pressures	Cost of potential accidents	Cost of implementing OSH management systems Under-pricing of jobs

It was also apparent that not all principal contractors have the same OSH standards and some micro businesses explained how they would avoid working with those that had lower standards, and actively choose to work with *"good"* larger companies within networks because they felt safer doing so. For example, one construction sole trader described how sometimes, when subcontracting for another company, he might not be provided with the proper scaffolding or platforms to work on. Another interviewee told us that working with bad contractors was like *"stepping back in time"* as you do not learn anything and you know you are going to get hurt - "*working with a good contractor can bring up your overall standard of safety"*. There were also instances of smaller subcontractors (usually highly-skilled specialists) influencing the practices of main contractors, for instance by refusing to operate on sites that were deemed unsafe, unless their OSH requirements were met.

Interviewees also made reference to **normative** influences on OSH practices in smaller businesses. It is clear that OSH practices are shaped by individuals carrying knowledge with them from previous jobs and projects. In some cases, on the job socialisation was seen to have a negative influence of OSH, with longer-serving members of the workforce continuing to use practices that are no longer considered to be safe because such practices were still deemed to be legitimate by their contemporaries. However, there was a perception that the same processes of on the job socialisation were also having a positive influence on newer members of the workforce

> *"Certainly helping has been the changes in college courses and education of people coming into the industry at the bottom level. That's been a big – 'cause there is an expectation now, with an awful lot people coming – well with the majority of people coming into the industry, that there is a way of doing things and that can influence how a company works quite a lot."*

This finding suggests that there might be a progressive improvement in OSH practices over time, as longer-serving workers leave the workforce and new members enter it.

Normative pressures also acted upon larger contractors, in the form of reputational risk, who in turn then placed requirements on their subcontractors, as discussed earlier in this section. A representative from one larger contractor explained how

> *"… you are only as good as your supply chain is. It's all very well making sure that your staff know what they're doing, especially in construction you work with an awful lot of subcontractors on site as well and if they're not singing from the same hymn sheet that you are then obviously they're - to a certain extent they're still representing your company. Because obviously we work for the main contractors, we may employ different subcontractors on site. But if the subcontractors do something wrong then it obviously still comes back to it's our responsibility because we're the people that employ them… "So I think it was just deemed that how important it is nowadays that everybody does need to be doing things in the correct way and we try to put it across very firmly that we expect the companies that work for us to have the same important - place the same importance on health and safety as we do."*

Larger contractors are more visible and there is an expectation in the industry that they act responsibly and lead by example, however many smaller contractors were also keen to be seen to working in a healthy and safe manner. In some cases, attitudes to OSH were intrinsically linked with people taking pride in their work and their desire to operate professionally and responsibly – not just a legal duty of care, but a moral responsibility to do the right thing.

Mimetic pressures were less evident in our interview data, but nonetheless seemed have an influence on OSH practices in some of the organisations in our study. For instance, one sole trader explained how he picked up OSH knowledge when working as a subcontractor on larger building sites, knowledge that he then used when working on smaller domestic projects. He described how he had learnt (informally) through word of mouth not to use leaded solder, information that he then verified by consulting the (formal) water bylaws. Larger contactors also described how they would adopt the good OSH practices of their peers, which they may experience when working on a project with them, and saw this as a means of maintaining their competitive advantage

> *"Yeah, I think initially you think it's not broke then don't try and fix it, don't you? And then you see another way and you're well, actually yeah, our way was broken and there is a way of fixing it."*

Principal contractors with higher OSH standards also actively encouraged feedback and suggestions from subcontractors. There were also examples of where experiences of bad practice had influenced the behaviour of smaller enterprises. For instance, owner of a micro enterprise explained that one of the reasons he had set up his own business was because he had experienced bad practices and corners being cut when working for other construction companies.

Our analysis has thus far focused on discussing the coercive, mimetic and normative influences on OSH in smaller organisations. However, economics also played a significant role in shaping OSH practices, both positively and negatively. For smaller organisations, keeping on top of the OSH requirements of larger clients and contractors can be expensive, especially in a competitive market where it is difficult to pass costs on to clients. One owner-manager of a micro enterprise suggested that some contractors price jobs too low and then subsequently cut corners in order to reduce the amount of time required to undertake the job. Another interviewee explained that

> *"Cost is still a big influence there, so an awful lot of the people on site, and probably the majority of people on site, are working piece rate. You know, they are paid by the amount of wall they lay, they're paid by the amount of hole dig, by the roof that they, you know, that they install, the plumbing that they install. So it's always about speed, it's always about how quickly can I get the cabling into this house, how quickly can I lay this wall. And anything that provides a delay to that is viewed negatively. You will get a huge negative reaction on a lot of sites to wanting to do a toolbox talk. It might only be 15 minutes long, but that 15 minutes is worth cash in hand to the people on that site. You know, it has a very clear monetary value to them, that 15 minutes, and therefore they look at it and think well toolbox talk or another £25 or whatever it might be."*

Although the cost of potential accidents was cited by some interviewees as a driver behind safer working practices, these tended to be representatives from larger contractors with responsibility for managing sites and subcontractors.

5. Conclusions

Our aim in this paper was to use institutional theory to develop a better understanding of the factors that promote the survival and legitimacy of particular OSH practices amongst SMEs and micro enterprises in the UK construction sector. Although based on a relatively small purposively selected data set, our analysis suggests that the practices of smaller construction enterprises are influenced by a range of coercive, mimetic and normative pressures, however two factors were seen to be particularly influential.

The first was the coercive pressures exerted by principal or main contractors in larger supply chains, who seek to positively influence the behaviour of smaller firms by strictly enforcing rules on construction sites, providing training to subcontractors and assessing them to ensure that they have the required skills and qualifications. Smaller enterprises that want to continue working as part of these larger supply chains are obliged to the comply with the rules – this approach could be interpreted as an example of what DiMaggio and Powell (1983) called 'filtering'. However, smaller enterprises choosing not to work with larger organisations is clearly a significant barrier to these coercive pressures and evidence from our interviews suggests that some subcontractors behave differently when working outside of a supply chain, an issue that warrants further research.

The second major influence was the process of on the job socialisation described by DiMaggio and Powell (1983), which seen to have both a positive and negative impact on OSH practices. For some longer-serving workers, on the job socialisation with colleagues can serve to sanction unsafe practices – they become the norm and are therefore seen as legitimate. However, on the job socialisation was also found to have a positive influence for newer entrants to the industry, particularly those that receive formal training and work on sites with higher standards of OSH. For such workers, working healthy and safely becomes the norm. This implies the existence of feedback loops that reinforce and ensure the survival of positive or negative OSH practices.

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Potential Strategies to Improving Safety in Small Construction Organisations

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Abstract

Efforts to improving safety in the construction industry have mainly been adopted by large organisations. As a result, these organisations have managed to substantially improve their safety performance. The construction industry, however, is dominated by small organisations. These organisations are facing difficulties to implement safety and, as a result, their safety performance is worse than their larger counterparts. Due to their large proportion in the construction industry, a small improvement among small organisations should have considerable impacts on the overall safety performance of the industry. This research aims to identify potential strategies to improve safety in small organisations in the context of the Australian construction industry. A questionnaire was developed based on a list of barriers and strategies identified from the existing literature. The questionnaire was then distributed to construction practitioners in Australia, particularly those working in small construction organisations, to obtain the perceived importance of each barrier and strategy. Open-ended questions were also included allowing the respondents to add additional barriers and strategies. Many perceived that external environmental factors are the key barriers that hinder safety implementation in small organisations. Improving safety, therefore, requires the support from influential stakeholders in the industry. Clients should consider safety as one of the key project objectives and include safety as one of the criteria in tendering. The government and regulatory bodies need to enforce safety regulations effectively and subsidise safety training for qualified small organisations. Safety performance should also be linked to insurance premium and licencing system in the construction industry. Finally, existing mandatory safety training needs to be evaluated and revised, while safety compliance for small organisations should be simplified and made practical.

Keywords: construction industry, improvement strategies, safety compliance, safety training, small organisations

1. Introduction

The majority of organisations in the construction industry are small businesses. For example, more than 98% of construction organisations in Australia can be considered as small businesses, employing fewer than 20 people (Australian Bureau of Statistics, 2013). These organisations are viewed as engines of job creation and economic growth (Hasle and Limborg, 2006; Sinclair and Cunningham, 2014). Arewa and Farrell (2012) found that small organisations constitute more than 90% of all businesses and account for 83.7% of employment and 67.4% of turnover generation in the construction industry.

Despite their significant economic and social contributions, small construction organisations have poorer safety performance than their larger counterparts (Hammersley and Sunindijo, 2015; Sinclair and Cunningham, 2014; Stiles et al., 2012). As a result, political and scientific interests in safety in small organisations have grown considerably since mid-90s. Many countries have launched programs and guidelines to support safety implementation in small organisations (Hasle and Limborg, 2006).

Despite efforts to improve safety in small organisations, research on this area is still relatively limited (Legg et al., 2015) and scattered among different disciplines and institutions (Hasle and Limborg, 2006). The research presented on this paper, therefore, is an initial step to systematically observe safety conditions among small organisations in the Australian construction industry. In particular, this research aims to identify key barriers that constrain these organisations from improving their safety performance and to identify strategies or interventions that can overcome the barriers and bring about improvements.

2. Literature Review

A number of search engines, including Google Scholar, American Society of Civil Engineers, Science Direct, Emerald Insight, and Taylor & Francis, were used to find relevant research publications on safety in small organisations published from 1991 to 2014. The search found 125 research papers and three books, which represent a wide range of industries, including agriculture, chemical, construction, manufacturing, mining, and transportation. Many of the publications also discuss small organisations in general instead of focusing on a specific industry.

It is interesting to see that the number of publications increases over the years, indicating that this topic is gaining popularity. There were 16 publications on safety in small organisations published from 1991 to 2000. The number increases to 53 in 2001-10 and increases further to 59 in 2011-14. More than 40% of the publications came from Europe, followed by Asia (20%), Australasia (16%), North America (12.5%), and Africa (8%).

Each publication identifies and, into a certain extent, discusses the barriers and challenges to implementing safety in small organisations. Economic consideration due to pressures to reducing price is a barrier put forward frequently. The fierce nature of competition in the construction industry makes economic survival through getting new works from clients the number one priority for many small organisations (Mayhew et al., 1997). As a result, the clients have high bargaining power and are able to use competitive tendering to compel small organisations to getting the job done with the lowest possible cost. Facing this industrial culture, small organisations are forced to opt for the only logical choice, making the clients happy no matter what, including neglecting safety to reduce costs (Torres et al., 2013; Wadick, 2010).

Many suggest that this barrier is the underlying factor that promotes the occurrence of other barriers. Due to economic pressures, owners of small organisations consider safety regulations and demands to improving safety as a heavy and unrealistic financial burden (Legg et al., 2015). Although large organisations spend more on safety than small organisations, but when the spending is calculated per employee, small organisations spend seven times more than large organisations (Health and Safety Executive, 2003). Therefore, the costs of compliance with certain aspects of safety regulations are considered too high in comparison to the perceived benefits and considered detrimental to the survival of their businesses (Walters and Lamm, 2013).

This negative perception towards safety results in poor safety culture. Owners and managers of small organisations do not consider safety as a priority because they are being inundated by other 'urgent' issues imposed by their clients. They do the minimum in terms of safety and even cut corners in order to reduce costs (Cagno et al., 2013). This condition is made worse by the lack of safety training because it is seen as expensive and unnecessary. Compulsory safety training is considered as inadequate or ineffective to gain the required safety knowledge and to develop positive safety attitudes (Hasle et al., 2010; Wadick, 2010). Business owners perceive that safety issues are bureaucratic concerns and are not their responsibility, but the personal responsibility of their employees (Kelloway and Cooper, 2011). This matter of responsibility becomes even more obscured due to subcontracting practices endemic among small organisations. Within these employment relationships, the responsibility for establishing and maintaining work health and safety becomes unclear (Mayhew et al., 1997). This work environment promotes a strong culture of autonomy and meeting the demands of contracts supersedes safety issue considerations (Kelloway and Cooper, 2011).

Essentially, small organisations have no knowledge, no time, and no resources to focus on safety. The absence of a professionalised human resource function limits the safety knowledge in small organisations. In most cases, the business owner is the human resource department and every other department of the organisation, thus it is unlikely for the owner to have specialised knowledge in work health and safety. The various roles that business owners have to perform and their small workforce mean that they have no time to participate and focus on educational, training, and workshop activities that require substantial commitments. The lack of resources prevents small organisations to hire consultants to solve problems and they will never have the resources (and time) to solve safety issues through experimentation and pilot studies (Kelloway and Cooper, 2011).

Besides discussing the barriers, intervention strategies have also been proposed in the existing publications. As economic reason is the underlying barrier, clients, who make key decisions on budget and other project performance criteria, are influential in supporting or constraining safety implementation (Lingard and Blismas, 2013). It is important for clients to allow for costs to implementing safety measures when selecting contractors, i.e., safety should be one of the criteria in the procurement process.

The government also plays important roles in improving safety performance of small organisations. The government should find a way to effectively monitor and enforce safety regulations. Without proper enforcement, small organisations that try to implement safety will be disadvantaged over those that cut corners (Mayhew and Quinlan, 1997). Linking safety performance with insurance premium, taxes, and licencing systems in the industry are potential incentive programs that can be used to encourage small organisations to focusing on safety (Hasle and Limborg, 2006). At the same time, the government should be aware of the fact that small organisations do not seem to have the ability or motivation to implement high levels of safety systems. Safety performance improvement, therefore, cannot be achieved by simply raising government safety regulations (Lin and Mills, 2001).

The existing safety training courses should also be evaluated. The costs of safety training and compliance are a barrier for small organisations because of their limited financial capacity and pressures to reduce costs. Free or subsidised safety training should be made available to small organisations. Furthermore, the effectiveness of existing safety training program, e.g., White Card, should be assessed. Although there is evidence to suggest that mandatory safety training programs have positive effect on safety culture in the construction industry, more robust training and refresher courses may be needed to further improve safety (Bahn and Barratt-Pugh, 2012).

3. Research Methodology

Quantitative research methodology was adopted for this research. Quantitative research emphasises quantification in the collection and analysis of data and entails a deductive approach to the relationship between theory and research, i.e., testing theories in the research context (Bryman, 2012). Aligning itself with quantitative research methodology, this research aims to test the relevance of the barriers and intervention strategies suggested in the existing literature in the context of small organisations in the Australian construction industry.

A questionnaire survey was the research method used in this research. The questionnaire consists of three sections. The first section enquiries the profile of the respondents. The second section consists of 13 barriers to safety improvement among small organisations, while the third section consists of 13 items representing strategies to improve safety performance among small organisations. The second and third sections use a five-point Likert scale format ranging from 'strongly disagree' to 'strongly agree'. Some open-ended questions were also included so that the respondents can recommend additional barriers and strategies, which have not been covered in the questionnaire.

The questionnaire was distributed online and through mails to 838 construction organisations in New South Wales (NSW). Convenience sampling was used because of the large number of construction organisations in NSW. One hundred and eleven responses were received, representing a response rate of 13%. Sixty per cent of the respondents were business owners or self-employed and nearly 70% worked in small organisations employing fewer than 20 people. The respondents' average work experience in the construction industry was 24 years.

4. Barriers to Implementing Safety

Table 1 presents the barriers to implementing safety in small organisations, which have been ranked from the highest to the lowest. A one-sample t-test was also conducted to determine which barriers were deemed relevant and which ones were not. The test value was 3, meaning neutral. When the significance value is lower than 0.05, it means the mean score is significantly different from 3. As shown in Table 1, the top four barriers were perceived as important by the respondents, while the lowest two barriers should not be considered as barriers.

Table 1: Barriers to implementing safety in small organisations

No	*Barrier*	*Mean*	*Significance*
1	*Subcontracting practice especially the use of best price to win projects*	*3.74*	*.000*
2	*Clients focus on other objectives, e.g., time and cost, rather than safety*	*3.60*	*.000*
3	*Safety is expensive to be implemented*	*3.50*	*.000*
4	*Fierce competition in the industry*	*3.46*	*.000*
5	*Poor safety culture in the industry, especially among small companies*	*3.16*	*.145*
6	*Safety law and regulations are not adequately enforced; thus disadvantaging those trying to implement them*	*3.08*	*.489*
7	*Safety law and regulations are impractical for small companies*	*3.00*	*1.000*
8	*Lack of management commitment*	*2.91*	*.390*
9	*Owners and employees of small companies have other urgent and more relevant issues than safety*	*2.87*	*.261*
10	*Lack of safety knowledge to implement proper safety measures as required*	*2.84*	*.083*
11	*Small companies are not able to translate and adapt safety laws and regulations into their safety management system*	*2.79*	*.070*
12	*Mandatory safety training is inadequate to give basic safety knowledge for construction practitioners*	*2.77*	*.024*
13	*Mandatory safety training is impractical*	*2.44*	*.000*

Path analysis was conducted using AMOS (Analysis of Moment Structures) to determine the interrelationship among the four important barriers and the result is presented in Figure 1. The probability value of the chi-square test is higher than 0.05 (p = 0.397) indicating that the model fits the data. Other fit indices are less than 0.001 for the root mean square error of approximation (RMSEA), 1.000 for the comparative fit index (CFI), and 1.004 for the non-normed fit index (NNFI). All indices indicate good fit (Hooper et al., 2008). The numbers on the arrows are the path coefficients, which represent the amount of change in the dependent variables per single unit change in the predictor variables (University of Texas, 2002). All path coefficients are statistically significant providing strong support for the hypothesised model.

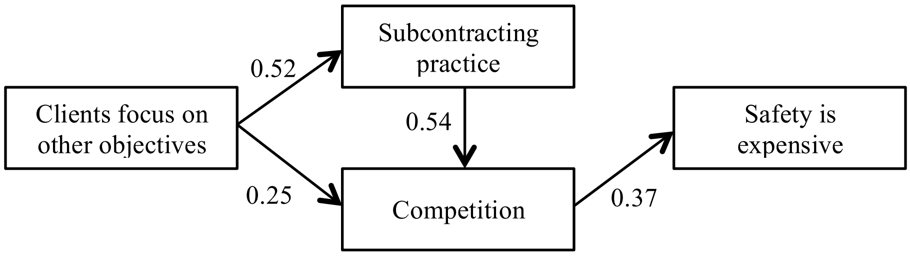

Figure 1: Interrelationship among barriers to implementing safety in small organisations

Figure 1 shows that the source of all the barriers is that clients focus on other objectives rather than safety. Clients of small organisations tend to focus on getting the job done as quickly and as cheap as possible. This characteristic affects the subcontracting practice in the industry, in which the lowest price becomes the main criterion to win projects. The demand for cheap construction services and the practice of bidding for jobs force smaller subcontractors to cut corners whenever they can (Torres et al., 2013).

This client-dominated industry together with the large number of small organisations worsen the competition in the industry, compelling small organisations to reduce their operational costs by any means necessary, including neglecting safety, to remain competitive. It is, therefore, not surprising to discover that safety was perceived as too expensive to be implemented by small organisations. Although they understand that poor safety has negative impacts on the financial performance of their organisations, they perceive that the costs of implementing safety are simply too high and are detrimental to their business survival (Walters and Lamm, 2013).

The responses to the open-ended question on key safety issues faced by small organisations reveal that many respondents felt that safety is expensive and impractical. Small organisations with their limited resources are subjected to the same safety obligations as their larger counterparts. They consider that the amount of paperwork is impractical because it leads to paper compliance, which does not translate into safer workplaces. At the same time, they are pressured by their clients to reduce costs and to complete the job quickly. All this causes small organisations to have negative perceptions towards safety. Safety is considered as a waste of time, which jeopardises their ability to compete.

5. Strategies to Improving Safety

Table 2 presents the potential strategies to improving safety performance among small organisations. As in the previous section, a one-sample t-test was conducted to determine strategies deemed important by the respondents. There are eight strategies that have potential to improve safety among small organisations, while the two bottom strategies should be excluded from the list.

Table 2: Potential strategies to improving safety in small organisations

No	*Barrier*	*Mean*	*Significance*
1	*Clients should consider safety as one of the project success factors*	*4.15*	*.000*
2	*Safety should be one of the criteria in tendering*	*4.03*	*.000*
3	*Government should subsidise safety training for small companies that meet requirements*	*4.02*	*.000*
4	*Safety performance and compliance should be linked to insurance premium*	*3.67*	*.000*
5	*Safety performance and compliance should be linked to the licencing system of construction companies*	*3.59*	*.000*
6	*Government should enforce safety law and regulations effectively*	*3.57*	*.000*
7	*Mandatory safety training should be more thorough and harder to pass*	*3.24*	*.023*
8	*Small companies should form a "safety responsible group" to share safety resources and to ensure that the each group member meets safety requirements*	*3.22*	*.026*
9	*Safety law and regulations should be less prescriptive to allow small companies to self-regulate safety*	*3.05*	*.612*
10	*Government should explicitly tell small companies what to do to implement safety*	*3.04*	*.735*
11	*Obtaining and renewing builder's and construction-related licences should be made tougher*	*2.98*	*.891*
12	*Harsher punishments or consequences to small companies that violate safety regulations*	*2.75*	*.023*
13	*Worker unions should pressure small companies to focus on safety*	*1.81*	*.000*

The top seven strategies require the support from the clients and the government or regulatory bodies in their implementation. This is understandable because the top barriers are external barriers in which small organisations have limited to no control over them. Therefore, strategies to remove the barriers should not only focus on activities that can and should be done by small organisations, but also on influential stakeholders who can change the norms and culture of the industry.

The first group of the influential stakeholders is the clients, which include typical home owners, government agencies, and also larger contractors. They are in the best position to drive the cultural change needed to bring about safety improvements as they are the initiators of project development. They make key decisions concerning budget, project objectives, timelines, and performance criteria, which can support or constrain safety implementation (Lingard and

Blismas, 2013). Votano and Sunindijo (2014) identify six safety activities that clients of small construction organisations can do to promote safety: (1) participate in site-based safety program; (2) review and analyse safety data; (3) appoint safety team; (4) select safe contractors; (5) specify how safety is to be addressed in tenders; and (6) perform regular checks on plant/equipment.

Looking at the responses to the open-ended question on what clients should do to promote safety among small organisations reveals one overwhelming response, i.e., clients should not use the lowest-price method when evaluating tenders. On a similar note, the respondents suggested that safety should become one of the criteria in tendering. During the construction stage, clients should also be realistic in setting project goals, particularly in terms of time and cost. Pressures to finish a project cheaply and quickly will encourage people to cut corners and neglect safety.

The second influential stakeholder group is the government and regulatory bodies. There must be stronger enforcement of safety implementation in practice. Without proper enforcement, there is no incentive for small organisations to focus on safety because safety is detrimental to their business survival. As shown in the questionnaire, the respondents also believed that linking the licencing system and insurance premium with safety performance is a feasible way to monitor safety implementation. The premium costs, however, should be comparable to the improvement costs to motivate small organisations to improve their safety performance. Furthermore, implementing this initiative requires effective enforcement and monitoring. Without it, these systems tend to lead to under- or non-reporting where injured workers are kept at work or discouraged to report their injuries (Probst and Estrada, 2010).

Training is another factor that falls under the responsibility of the government. The costs of safety training and compliance are a major barrier for small organisations. Therefore, the government should subsidise safety training for small organisations that qualify to get this benefit. The existing mandatory safety training is also seen to be too easy and inadequate to equip people who intend to enter the industry. The open-ended question on what the government should do to promote safety performance improvement among small organisations shows that some respondents consider this training as “a waste of time” and “a joke”. This shows that effectiveness of this training program should be evaluated, something which has often been neglected.

Besides suggesting for a more rigorous training and education system, the responses to the open-ended questions again sound a stronger call to simplify safety compliance. Safety regulations should be made more practical, particularly for small organisations that have limited resources and are currently facing external pressures, which force them to relegate safety as unimportant.

One thing that small organisations themselves can do is to collaborate and form a “safety responsible group” where the members can share resources related to safety. The group also serves as a control mechanism to ensure that each member meets safety requirements. By sharing their resources, the disadvantage faced by small organisations in terms of the economy of scale can be lessened.

An argument worth noting is that this research and past research indicate that small organisations tend to place the blame of their poor safety performance on other players and external factors. Although these factors are influential, there may be other initiatives that small organisations can do to improve their performance. Future research can investigate feasible methods and strategies that small organisations themselves can do to improve their safety. Perspectives from the government agencies and larger organisations can be useful to uncover more barriers and success factors improve safety among small organisations.

6. Conclusions

Improving safety among small organisations is essential to improve safety in the construction industry. Applying the same approach used in medium and large organisations is not practical for small organisations due to their unique barriers and constraints. This research found that the source of the barriers is the lack of interest from the clients towards safety. The use of lowest price method to award contracts worsens the situation because this approach compels small organisations to lower their prices by any means necessary, including neglecting safety. Due to this fierce competition, small organisations perceive safety as a burden, which is detrimental to the survival of their business.

External factors, in which small organisations have limited or no control over, are the main sources of these barriers. Therefore, strategies intending to address them require the involvement of leading stakeholders who are able to influence the norms and practices in the industry. Clients should see the value of safety and should actively participate in implementing safety. They also need to stay away from lowest-price mentalism when awarding contracts and include safety as one of the criteria in tendering. The government and regulatory bodies should find better ways to enforce safety regulations. Linking the licencing system and insurance premium with safety performance has a potential to promote safety into the foreground. Existing mandatory safety training programs should also be evaluated and amended. They are perceived as outdated and insufficient to equip construction practitioners with essential safety knowledge.

The respondents also strongly asserted the need to simplify safety compliance. Currently small organisations are expected to follow the same level of compliance as their larger counterparts. This approach was perceived as impractical because of the environment and industry norms where small organisations operate. The tendency to cut corners is the result of small organisations trying to work around impractical safety regulations imposed on them.

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Challenges for the FIFO/DIDO Workforce in the Australian Construction Industry: Impacts on Health, Safety and Relationships

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Abstract

Since 2000, Australia has seen a large growth in the mineral, resource and infrastructure sectors, with operations expanding to rural and remote locations, leading to an increase in demand for personnel to work fly-in, fly-out (FIFO) or drive-in, drive out (DIDO) rosters. Such models of work have become increasingly popular as it takes into account the relatively short lifespan of sites, and is considered more economical than building permanent accommodation or paying for rent, helping organisations remain economically competitive. While there are many organisational benefits to employing FIFO/DIDO rosters, there are frequently cited adverse effects on the workers themselves. The issues in employing these workforces are becoming more apparent, and include a range of physical, mental, psychosocial, safety and community challenges. The aims of this study were to: 1. Understand more clearly how employee family relationships are affected by the FIFO/DIDO working environment and investigating solutions. 2. Investigate the psychosocial health implications for employees in a FIFO/DIDO working environment and seeking recommendations for change. 3. Assess the impact of FIFO/DIDO travel on workplace health and safety incidents, and 4. Examine rosters, shifts, work hours, job design and productivity demands as to how best to design a safe, healthy and productive work environment for FIFO/DIDO employees. In conjunction with Australian government and industry partners, the projects agreed methodology consisted of four major phases. First, a desktop review was undertaken of the key documents including research literature and reports. Second, the information was used to help formulate a brief survey designed to examine psychosocial and organisational safety climate, rosters and shifts and integration of the frequently-used Copenhagen Psychosocial Questionnaire. Third, the review of literature also assisted in the development of semi-structured interview questions for the focus groups. The final phase was the analysis of the data and formulation of key recommendations. This paper addresses the research concerns and provides data and respondent commentary to more fully understand the impacts on workplace health and safety and the personal and social relationships of this workforce, and to explore strategies and actions that better meet the needs of employers, employees and their families.

Keywords: Construction health and safety; physical and mental health; social supports; work site communications; relationship maintenance.

1. Introduction

Since 2000, Australia has seen a large growth in the mineral, resource and infrastructure sectors, with operations expanding to rural and remote locations, leading to an increase in demand for personnel to work fly-in, fly-out (FIFO) or drive-in, drive out (DIDO) rosters. Such models of work have become increasingly popular as it takes into account the relatively short lifespan of sites, and is considered more economical than building permanent accommodation or paying for rent (Lifeline WA, 2013), helping organisations remain economically competitive.

While there are many organisational benefits to employing FIFO/DIDO rosters, there are oft cited adverse effects on the workers themselves. The issues in employing these workforces are becoming more apparent, and include a range of physical, mental, psychosocial, safety and community challenges. Research evaluating the impacts of fly-in, fly-out operations in Australia has been limited, and in February 2013 the Australian House of Representatives Standing Committee on Regional Australia made 21 recommendations aimed at improving these operations (Parliament of Australia, 2013). These are discussed in the desk top analysis. To date, none of the recommendations have been implemented.

Recent research into FIFO employees revealed that between 24 and 36 percent of personnel experience severe levels of psychological distress in the forms of anxiety, depression and stress symptomology (Tuck, Temple, & Sipek, 2013). Further, it was also found that 71.5% of these FIFO participants had planned to exit FIFO employment within five years. Based on the limited literature, potential impacts include loneliness, depression, satisfaction levels with onsite facilities and home contact, fatigue leading to safety concerns and strain on marital relationships. Construction workers, according to Doran, Ling and Milner (2015), are six times more likely to die from suicide then from an accident at work.

The concerns associated with FIFO/DIDO operations cover a range of variables, some of which are also prevalent in other industries (for example, manufacturing and nursing) and can broadly be described as having workforce and social and community impacts. The workforce areas of concern include roster schedules, shift work and work hours, sleep disruption, fatigue, safety performance, wellbeing both physical and mental, and workforce turnover. The social and community areas of concern include psychosocial wellbeing in personal and family relationships, and social and resource impacts on home and host communities. There is an early understanding emerging of the symbiosis of the workforce and social and community concerns but, as yet, very little evidence of how to translate the best aspects of this relationship into next practice.

The construction and infrastructure FIFO/DIDO workforce is facing challenges on several fronts with impacts on the individual worker (e.g. work productivity, safety, psychosocial resilience), the families of the workers (e.g. personal relationship challenges, remote parenting, health and wellbeing concerns) and companies themselves (e.g. difficulties attracting the right employees, increasingly unacceptable turnover rates).

Operations in regional communities utilising a FIFO/DIDO workforce are exposed to a myriad of concerns which are not only limited to their economic prosperity and survival, but also include the welfare of their contractors, employees, their families, and the home and host communities in which they operate. At the workplace these challenges include an understanding of the management of optimal roster designs for performance and employee satisfaction, the at-risk days and times to best manage tasks, hours of work including start and finish times to minimise sleep debt and fatigue, and the need for data on fatigue related work incidents and road accidents. There are challenges in relation to health and wellbeing for FIFO employees in ensuring the FIFO lifestyle is properly communicated and understood before engaging in FIFO work. No research to date has examined the linkages and relationships between workplace and personal relationships challenges in a FIFO/DIDO environment in the construction industry. In this regard, this research seeks to be aptly innovative.

2. Key Objectives

The objectives of the current study were to:

1. Understand more clearly how employee family relationships are affected by the FIFO/DIDO working environment and investigate solutions
2. Investigate the psychosocial health implications for employees in a FIFO/DIDO working environment and seek recommendations for change
3. Assess the impact of FIFO/DIDO travel on workplace health and safety incidents
4. Examine rosters, shifts, work hours, job design and productivity demands as to how best design a safe, healthy and productive work environment for FIFO/DIDO employees

This project sought to address in part some of these concerns and in particular to understand more fully the mutual impacts on workplace health and safety and personal and social relationships, and to explore strategies and actions that better meet the needs of employers, employees and their families.

3. Research Methodology

The project's methodology consisted of four major phases. First, a desktop review was undertaken of the key documents including research literature and reports. Second, the information was used to help formulate a brief survey designed to examine psychosocial and organisational safety climate, rosters and shifts and integration of the frequently used Copenhagen Psychosocial Questionnaire. Third, the review of literature also assisted in the development of semi-structured interview questions for the focus groups. The final phase was the analysis of the data and formulation of key recommendations.

4. Key Results

4.1 Desktop Review- Some of the key reports and research

Research evaluating the impacts of fly-in, fly-out operations in Australia's construction industry has not been conducted to date. In February 2013 the Australian House of Representatives Standing Committee on Regional Australia made 21 recommendations aimed at improving these operations. It points out that the remote construction industry workforce is primarily a short-term temporary workforce and many workers are employed on a fly-in, fly-out basis. This is supported by evidence from Mineral Council of Australia. Of these 21 recommendations, two (8 and 10) were particularly related to this research. Firstly, that the Commonwealth Government commission research to assess the health impact of fly-in, fly-out and drive in-drive out work on the workers and their lifestyles. And from this develop a comprehensive policy to respond to their particular needs. Secondly, that the Commonwealth Government commission research to assess the impact on children and family relationships of a long-term fly-in, fly-out/drive-in, drive-out parent.

Also, a discussion paper released by the WA Government's Education and Health Standing Committee into the mental health impacts of fly-in, fly out work in 2014 highlighted the lack of quality research on the mental health of FIFO workers. They felt research was needed into whether FIFO work practices were safe and how organisations managed psychological health risks. They noted that informal information indicated that there were 9 suspected suicides and that it was the organisation's responsibility to address issues related to mental health concerns. For example, the unaccompanied travel of at risk employees to their home base.

A research report in 2013 by Lifeline WA investigated the stressors and coping mechanisms of FIFO/DIDO workers. They found that 1 in 5 workers did not have on-site mental health or on-site counselling facilities in their industry and 1 in 10 did not have an Employment Assistance Program (EAP). It was also found that stress increased during rotation and was particularly high just before leaving work. The key stress of FIFO/DIDO work was family/home separation. Long rosters impacted significantly on this stress and increased when families with young children were involved. In addition, adjusting to long day/shifts disrupted sleep and led to fatigue. As a majority of the workforce are male there was the perception of 'suck it up princess, you just do it' approach to their FIFO role and coping. However, communication with family and friends was highly regarded as a coping tool. While there were clearly some negative effects, it was noted that there was also some benefits. According to FIFO/DIDO workers, the high financial return and the ability to have quality time with family at home was an advantage.

4.2 Survey Results

The survey data was collected across John Holland, RMS NSW and QTMR sites in Western Australia, New South Wales and Queensland. It covered a number of key areas and included the Copenhagen Psychosocial Questionnaire. These key areas included: Management's commitment to safety, Training and Procedures, Organisational Priorities, Rosters and Shifts, Psycho-social Factors, Health, Job Satisfaction and Work-Family Conflict. A total of 306 participants completed the survey. The table below highlights the key demographic information of participants who completed the survey. Typical of the workforce, a majority of respondents were male (94.8%), aged between 25 and 44 years, with an average age of 39 years. Approximately 61.2% of respondents said they were in a long-term relationship. The main survey results are presented below in Table 1.

Table 1: A summary of key results from the quantitative survey

Top 5 Highest Rated Questions

Management regard safety as an important part of operations	86.9% agree or strongly agree
Is you work meaningful	85.4% thought their work was meaningful
Do you know exactly what is expected of you at work?	66.3% agreed to a large extent or greater
Do you feel that the work you do is important?	65.7% agreed to a large extent or greater
Employees are able to openly discuss problems with supervisors or managers	61.2% agree or strongly agree

Bottom 5 Rated Questions

My work shifts interfere with my family or social life	66.7% agree
Can you trust the information coming from management	70.5% disagree
At your place of work, are you informed well in advance concerning, for example, important decisions, changes or plans for the future?	77.7% disagree
Do you feel that your work takes so much of your time that it has a negative effect on your private life?	83% or respondents say yes
Do you feel that your work drains so much of your energy that it has a negative effect on your private life?	85.8% of respondents say yes

4.2.1 *Copenhagen Psychosocial Questionnaire (COPSOQ)*

The shortened version of the COPSOQ is a tool for workplace assessment of psychosocial work environment. Lower scores (min 1 – max 5) identify areas where improvements can be made to the work environment. The results from the COPOQ are presented in Table 2.

Table 2: The results from the COPSOQ

Sub-Scale	Average
Quantitative Demands	4.01
Emotional Demands	2.66
Influence at Work	2.85

Social Support from Supervisors	3.34
Burnout	2.94
Stress	2.86
Tempo, Work Pace	3.24
Possibilities for Development	3.36
Meaning of Work	3.63
Commitment to the Workplace	3.45
Predictability	2.90
Rewards (Recognition)	3.19
Role Clarity	3.69
Quality of Leadership	3.41
Vertical Trust (Between Management and Employees)	3.34
Justice and Respect	3.12
Self-Rated Health	3.42
Job Satisfaction	2.97
Work-Family Conflict	2.69

4.3 Focus Group Results

The focus group data was collected using a semi-structured format. It addressed a number of key questions with prompts. These were:

- How do you feel employee family relationships are affected by the FIFO/DIDO working environment? In terms of partner relationships, relationships with children and parenting.

- (If negative) What are the solutions to this? In terms of communication while on-site, flexible workplace policies, professional support services for both the FIFO worker and their family, supportive groups for families at home and roster cycle.

- What do you feel are the psychosocial health implications (such as isolation, loneliness) for employees FIFO/DIDO working environment? Positive or Negative? In terms of work-life balance, management support, work pressure and family pressure, job satisfaction, personal and physical health, roster and work demands, sleep. The negative psycho-social health implications could be: family problems, mental health issues, divorce/separation, being overweight, tiredness, sickness or boredom. The positive psycho-social health implications could be: freedom from family pressure, financially secure.

- What do you recommend are the best ways to alleviate these implications? Including career development, professional support services (e.g. counsellors), links to family back home, broad band services, fitness equipment, private rooms, healthy food options, better rosters, links to host community and better work hours.

- What is the impact of FIFO/DIDO travel on workplace health and safety? In terms of fatigue, job performance and non-work time.

- What do you feel is the best design (in terms of rosters, shifts, work hours, job design and productivity demands) to ensure a safe, healthy and productive work environment for FIFO/DIDO workers? (In terms of rosters being symmetrical/asymmetrical, short/long; on either night/day shifts)

The focus group data was digitally recorded and transcribed. It was analysed using thematic analysis accompanied by relevant quotes. 15 focus groups of 5-6 participants were completed with employees across the mentioned partner organisations sites in Western Australia, New South Wales and Queensland. Results from the focus groups highlighted differences between temporary and permanent sites, as well as between FIFO and DIDO workers. Many of these differences can be considered due to the availability of different facilities and opportunities for social interaction. Five consistent themes to have emerged from the data are presented below in Table 3, with actual quotes from participants.

Table 3: A summary of themes from the qualitative focus groups

Theme	Employee Commentary
Isolation (from both family and co-workers)	• I think one of the biggest issues where we are based is communication. We are obviously based on a number of real camps and we know when you go back to real camp to you won't have reception. So you can stand outside on the phone and maybe if you are lucky you might get internet in your room and your landline might work if you're lucky so I guess that's the biggest thing. If you trying to communicate to your kids or anything like that you can really struggle. You might go nights and nights without contact with them because you don't get any reception.
Work related stress	• You know it's really worse, I've been doing my job for more than forty years and I've seen a trend, these days it's getting harder because these days because they are trying to save money and they seem to stretch the roster even further because there use to be a lot of projects with two and one moving to three and one.
Lack of management support	• It's an awesome program (Mates in Construction). It helped me out heaps up here but trying to put it between workforce and senior management stuff is stupid. I'm trying to get bloke in home because they're not well but management want to know what's wrong with them, who it is and it's got to remain anonymous, you know.

5. Discussion

This research found that workers psycho-social isolation in remote sites within the construction industry was a significant issue. Evidence from the quantitative data indicates that while formal communication from supervisors and management was good, workers level of trust in informal support from management was impacting on worker mental health. This isolation factor occurred across a number of levels, between the worker and their peers; between the worker and their direct supervisors and between the worker and their families. A comparison of FIFO and DIDO remote construction workers found that psycho-social isolation for FIFO workers was higher, this research found greater problems of worker mental health.

A common theme from the quantitative and qualitative data across all sites, regardless of whether the workforce was FIFO or DIDO, was a strong need for more training. In particular, this training was identified specifically around issues of financial planning/financial aid and realistic issues the workforce will face in regards to their health and well-being. As many of the current training and education methods were ad hoc, or learnt through experience whilst on the job, or discussions with their colleagues, there was a strong suggestion that the workforce needed more education and training on these key issues whilst employed as a FIFO/DIDO worker. Further, there was a growing need for more re-integration training for workers to return to the 'real world' such as mental health awareness training and family-work adjustment training.

Qualitative data also revealed that rosters were another area requiring change. Many of the FIFO workers for instance were unanimous in their support for having a 10 day off roster. This included having two consecutive weekends, as part of the 10 days. This was to allow for greater opportunity to have downtime and spend with their families away from work. While this was a common suggestion, many of the workers also said if this were possible, they had no qualms working the 3 or 4 weeks, as they understood they were paid to do a job. Of greater importance to them, was having the sense they had the opportunity to have genuine time off away from their work.

Data from qualitative component also indicated that organisations like Mates in Construction were seen as important to worker mental health. A number of workers recognised these supports as important and wished for their work to continue on-site. This recommendation is consistent with outcomes from the WA inquiry.

These researchers proposed four recommendations:

1. The improvement of communication between workers and management.
2. For the organisation to offer training to workers and in some cases their direct supervisors addressing finance, mental health and worker/family relationships.
3. For the organisation to offer rosters based on the worker's specific need.
4. For the organisation to continue support and promote external organisations such as Mates in Construction.

The four key recommendations presented in this paper are based exclusively on data from the focus groups and surveys of FIFO/DIDO workers. Several additional recommendations could be elaborated from the data, but the Authors felt that the main areas of expressed concern from the workers which they deemed as priorities, are those articulated in the four recommendations.

6. Conclusion

The results and subsequent recommendations indicate that mental health issues are an increasing problem for FIFO/DIDO workers in the Construction Industry. From this research we can conclude that for FIFO/DIDO workers in remote construction sites psycho-social isolation is of real concern. Higher levels of social capital (including communication, social networks and psycho-social trust) are required to combat the psycho-social isolation. If psycho-social isolation is not controlled, evidence indicates that this can lead to increased fatigue and stress upon the remote worker and a greater likelihood of human error.

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Health and Safety Management Practices in the Nigerian Construction Industry: A Survey of Construction Firms in South Western Nigeria

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Abstract

Despite the relevance of the construction sector in developing countries, the industry continues to record unacceptable levels of accidents and fatalities. The situation is no different in Nigeria where health and safety (H&S) management has been cited as a major contributor to poor H&S performance. Despite the need for improvement, there remains a dearth of research on the specific H&S management practices and elements of H&S management that need attention. This study thus provides insight into the H&S management practices of contractors in the South West of Nigeria. A questionnaire survey was used to investigate the H&S practices implemented by 115 construction firms. Results from the survey indicate that only a few H&S management practices are commonly implemented by contractors in South Western Nigeria. These practices include: informing employees about hazards on site before work starts; and communicating H&S information to workers through newsletters, leaflets and posters. H&S management practices that are less implemented include: providing H&S supervisors on site; site inductions for workers; rewarding workers for safe work behaviour; assessing the competence of workers and subcontractors; keeping incident records; investigating the causes of incidents, accidents and near misses; providing training programmes for H&S manager(s); and undertaking risk assessment for work packages or operations before they start. Overall, the research shows a gloomy outlook of the implementation of practices in key elements of H&S management (i.e. policy, planning, organising, risk assessment, implementing, performance measurement, and auditing). Contractors, relevant state authorities and industry bodies therefore ought to take collective action to improve H&S management by contractors.

Keywords: health and safety, health and safety management, survey, Nigeria

1. Introduction

Construction continues to be one of the main contributors to occupational related accidents, injuries and ill health. This is attributed to unsuitable working environments, unsafe worker behaviour, exposure to the harsh weather and other factors (Griffith and Howarth, 2001; Haslam et al., 2005; Manu et al., 2014). Particularly, in Sub-Saharan Africa, the occurrence of construction related injuries and fatalities persist in spite of Government sanctioned H&S standards (Idoro, 2008). Poor H&S performance remains at high levels as evidenced by a high number of injuries and work related illnesses. As a result there has been increased acknowledgment of the need for adopting H&S management practices that could help improve the situation. Despite improvements realised through the adoption of these H&S management practices in developed countries, it remains unclear the extent to which such practices are implemented by Nigerian construction firms. This study thus sought to address the research question of, "*what is the extent to which H&S management practices are implemented by contractors in Nigeria*". The study commences with an overview of the status of H&S in Nigeria's construction industry as well as a review of H&S management. This provides the foundation for the empirical phase of the study which is followed by the research findings and concluding remarks.

2. Health and Safety in Nigerian Construction Industry

Nigeria, being the most populous country in Africa and also the largest economy in Africa (World Bank, 2016), its construction industry plays an important role in the nation's economy. In 2012 the sector's contribution to national gross domestic product stood at 3.05% and in that same year the sector employed circa 6.9 million workers (National Bureau of Statistics, 2015). In spite of the socio-economic significance of the construction sector, it has an enviable reputation in terms of occupational health and safety. Accident and injury rates in developing countries like Nigeria are generally considered to be higher than in the developed countries (see Hämäläinen et al., 2009). This has been attributed to a lack of appropriate consideration of H&S management measures or practices in construction project delivery process (Belel and Mahmud, 2012). Despite being a party to the Geneva Occupational Safety and Health Convention 1981, Nigeria continues to lag behind in the implementation occupational H&S practices (Adeogun and Okafor, 2013). According to Idoro (2011) contractors with the best safety records in Nigeria still record substantially high numbers of injuries on their sites. A survey of 42 Nigerian contractors revealed such poor performance with rates such as 5 injuries per worker and 2 accidents per 100 workers even among some of the best performing firms (Idoro, 2011). According to Ezenwa (2001) these figures are often even worse in practice as a result of a culture of under-reporting and concealment. Other studies have further highlighted a high prevalence of non-compliance with safety regulations that require organisations to report accidents (Diugwu et al. 2012).

Whilst there have been occupational health and safety legislations governing work and work environments in Nigeria (e.g. Factories Act of 1990 and Employee's Compensation Act of 2011), some have attributed the poor safety performance to dysfunctional H&S laws and regulations (Diugwu et al. 2012). Compliance to and enforcement of occupational health and safety legislations have generally been described as poor (Idubor and Oisamoje, 2013; Okojie, 2010). Idoro (2004) also linked the country's poor H&S status to lack of concern, lack of accurate records and poor statutory regulations. Furthermore, these studies have generally highlighted the limited scope of H&S management by organisations which could be contributing to the poor H&S performance.

3. Health and Safety Management

Effective H&S management has been identified to have direct impact on H&S performance and resultant reductions in the number of incidents (Lingard and Rowlingson, 2005). According to Fewings (2013), good H&S performance in the construction industries of developed countries can largely be attributed to systematic implementation of H&S management practices stipulated in H&S management systems (Fewings, 2013). Gallagher (1997) further identifies the need for the adoption of the following practices in order to improve H&S performance: high level of senior management commitment; occupational health and safety (OHS) responsibilities known; encouragement of supervisor involvement; active involvement of a H&S representative who has a broad role; effective OHS committees; planned hazard identification, risk assessment and hazard elimination control; and comprehensive approach in inspections. In order to effectively implement H&S management practices there is a need for the adoption of an appropriate H&S management framework/system. One of the most commonly cited frameworks is the UK Health and Safety Executive's (HSE) framework for managing H&S (HSE, 1997). The key elements in this framework are H&S policy, planning, organising, risk assessment, implementation, measuring performance and review (see Table 1). This framework is similar to the BS OHSAS 18001: 2007 (BSI, 2007) and it has recently been revised to follow Deming's plan-do-check-act model (HSE, 2013) as shown by Table 1. Similar elements to the HSE's (1997, 2013) frameworks have also been shown by other H&S management models including the International Labour Organisation guidance (i.e. ILO OSH 2001) (ILO, 2001).

Table 1: Key H&S Management Elements

Management Practice Area/Element	***Management Practice sub-area/element ****	***Description and examples of practices****
Plan	*Policy*	*Written in-house H&S policy statement reflecting management's concern for H&S and detailing principles of actions to achieve H&S objectives e.g. policy document*
	Planning	*Planning for effective resource allocation e.g. pre-project H&S plans.*
Do	*Organising*	*The structural system to manage health and safety e.g. human resources, financial resources and equipment.*
	Risk Assessment	*Evaluation of risks and establishing necessary H&S measures to*

		avoid accidents e.g. risk assessments.
	Implementation	*Actual implementation of programmes e.g. training.*
Check	*Measuring Performance*	*Verification of the extent to which goals are achieved e.g. performance measurements metrics to include H&S targets such as number of accidents.*
Act	*Management review/Auditing*	*Reviewing in order to improve entire system e.g. External consultant reviews.*

**Sources: (HSE, 1997; Griffith and Howarth, 2001; Lingard and Rowlinson, 2005; BSI, 2007; Kheni et al., 2008; Cheng et al., 2012; Fewings 2013; Hinze et al., 2013, HSE, 2013)*

Several studies have highlighted the importance of the above elements to H&S (e.g. Kheni et al., 2008; Cheng et al., 2012; Manu et al., 2013; Agumba et al., 2013; Hinze et al., 2013). With regards H&S in the Nigerian construction industry, studies have mainly focused on other aspects of H&S such as regulations or performance (e.g. Ezenwa, 2001; Idoro, 2004; Umeokafor et al., 2014). It is therefore unclear the extent to which the elements of H&S management and their associated practices are implemented by contractors in Nigeria. This study therefore investigates the H&S management practices implemented by contractors in Nigeria.

4. Research Method

This research adopts a positivist paradigm by relating with facts, observations and figures via mathematical descriptive analysis. The positivist philosophical world view is known to be adopted for studies of this nature. This world view asserts that “knowledge of a social phenomenon is based on what can be observed and recorded rather than subjective understanding” (Matthew and Ross, 2010, p.27). Resultantly, quantitative approach was adopted for this study through the use of a questionnaire survey (Fellows and Liu, 2008). This approach was deemed appropriate for this study since the main answer to the research question pertained to "what" health and safety management practices are implemented by Nigerian contractors. According to Fellows and Lui (2008) questions relating to 'what' are most appropriately dealt with through quantitative approaches. In order to investigate the H&S management practices of Nigerian contractors, contractors' personnel in management roles were targeted for administration of a questionnaire. These professionals were specifically targeted as they are most likely to possess the requisite knowledge and experience relating to the management of H&S within their organisations. The questionnaire solicited these practitioners responses about the implementation of the H&S management practices associated with the above elements by their organisations. The structure of the questionnaire was in three parts: A, B and C. Part A was designed to collect general respondent and company information. Part B inquired about the health and safety management practices of the responding organizations. Both parts were designed to collect structured data to be analysed quantitatively. In part C responded were allowed to provide their opinions about challenges to implementing the H&S practices through opened ended questions. This was designed to allow respondents to elaborate on responses as well as their views about potential solutions. As it was impracticable to cover the entire Nigeria (due to its size - 36 states in 6 geopolitical regions), the study focussed on the South Western region which comprises 6 states. Due to difficulty in accessing an organised database/record of contractors in Nigeria, the participation of contractors was obtained via multiple channels including the Yellow Pages business directory and the lead researcher's contacts in the construction industry.

5. Findings

A total of 280 questionnaires were distributed to construction businesses within the target environment via electronic mail and hand delivery. A total of 129 questionnaires were returned. Out of the returned questionnaires, 14 were judged to be invalid (due to excessive missing data) leaving 115 useable questionnaires for the analysis. A sizeable number of respondents were construction managers, representing 42.60% of the total respondents. Others that responded were site managers (29.57%) and health and safety supervisors/managers (9.57%). Table 2 below gives a breakdown of the respondents' designated roles.

Table 2: Background of Respondents

Respondents role	***No.***	***%***
Company director	*17*	*14.78*
Construction manager	*49*	*42.60*
H & S supervisor/manager	*11*	*9.57*
Project manager	*4*	*3.48*
Site manager	*34*	*29.57*

40% of respondents had between five to ten years' experience working within the industry while 6.96% had over 15 years working experience. All the firms undertake private sectors works and 20% undertake public sector workers. A majority of the companies (i.e. 94.78%) undertake general building works and 42.61% undertake civil engineering works. Similar to the characteristics of construction firms in developed countries (e.g. UK, see ONS (2011)), most firms are small, having less than 50 direct employees (60.09%). While 24.35% employed between 51 to 100 direct workers, only 9.57% were large firms employing over 100 direct workers. A majority of the companies are relatively new with 66.09% of them operating for a maximum of 5 years. Only 2.61% of the companies have existed for over 15 years. Over 90% of construction firms do not have BS OHASA 18001 certification with only 7.83% possessing this certification.

5.1 H&S Management Practices by Contractors in South West Nigeria

The findings and discussion presented are based on the key areas or elements of H&S management as summarised in Table 1 above. In order to help identify the most widely implemented practices, the concept of academic degree performance is adapted to grade the survey results (e.g. UK masters, ≤ 49% = weak; 50-69% = pass to merit; 70% + = very good/ distinction). The level of implementation of the H&S management practices in Figure 1 and 2 were therefore categorised as: low (i.e. 0 - 49%); moderate (i.e. 50 - 69%); and high (70% +).

From this classification it was identified that the only elements of H&S management that have at least one practice being moderately or highly implemented are H&S policy, organising and risk assessment. This is presented in Figure 1 below.

Figure 1: Level of Implementation of H&S Management Practices within Policy, Organising, and Risk Assessment

5.1.1 H&S Policy

The survey revealed that half of firms have a formal company H&S policy statement. Top management involvement in H&S was observed to be low with only 18% of firms having a director with overall responsibility for H&S.

5.1.2 Organising for H&S

While some practices were performed by an appreciable number of construction firms (e.g. provision of health and safety communications to workers (62%) and displaying regulatory health and safety posters (60%) this was not reflected in other practices within this element of H&S management. Figure 1 above gives more details on the practices that have a low level of implementation.

5.1.3 Risk Management

The level of implementation of risk assessment practices amongst the companies was high or moderate for two practices and low for the others. For instance, whilst 90% of the companies inform employees about hazard before commencement of work, as low as only 13% review and update risk assessment during construction.

The results revealed very low levels of implementation of practices within the elements of planning and implementing, performance measurement, and review/auditing as summarised in Figure 2.

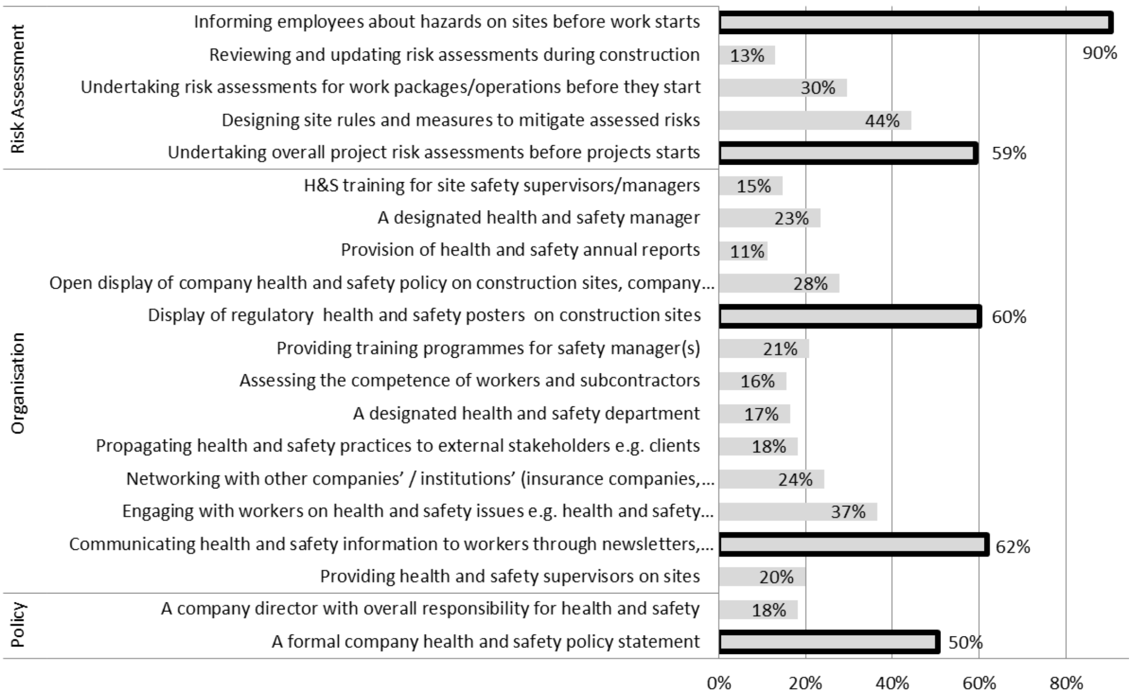

Figure 2: Level of Implementation of H&S Management Practices within Planning and Implementing, Measuring Performance, and Auditing

5.1.4 Planning and Implementing

None of the practices recorded over 40% with provision of sanitation and welfare facilities recording the highest level of implementation (i.e. 39%). Amendment and correction of health and safety plans during construction and rewarding of workers for safety behaviour however scored very low with 8% and 5% respectively.

5.1.5 Performance Measurement and Review

Similar to planning and implementing, none of the practices within this element recorded over 40% with publicising/sharing lessons learned from incident investigation recording the highest level of implementation (i.e. 18%). Keeping incident records on every project showed the lowest level of implementation (i.e. 10%).

5.1.6 Auditing

Similar to the above two elements, practices within this element of H&S management showed low levels of implementation with the highest being 20% for undertaking periodic safety management audits, and the use of in-house personnel for undertaking the audits.

5.2 Open Ended Responses - H&S Management Challenges

Challenges to construction H & S management was collated from the open responses. The challenges could be categorised under four main themes as given by Table 3.

Table 3: H&S Management Challenges

Challenge	***Sample Quote***
Cost	*"Only the bigger firms that land the plum contracts can afford it (certification and training). It's a luxury for small time contractors…" [Project manager].* *"We do our best with what we have and implement 'common sense' safety requirements" [H&S supervisor].* *"The cost and logistics of running onsite clinic facilities is out of the reach of most of us" [H&S supervisor].*
Bureaucracy	*"Reporting accidents to the authorities will often tie you down in red tape. The police and safety agencies just complicate things further" [Project manager].* *"Getting approval and accreditation for new safety standards takes a lot of time and money" [Project manager].*
Poor public health infrastructure	*"The government hospitals are poorly equipped and mostly on strike" [Site manager]*
Poor enforcement and awareness	*"I think it is unfair because while some of us put these requirements in place those that don't are not punished. Regulation that is not enforced is pointless" [Company director].* *"Many labourers do not wear protective clothing or know that they are supposed to. Even when these things are made available, they are not used properly" [H&S supervisor].*

6. Discussion

A cursory look at the results above reveals an overall poor H&S management amongst the participating companies. The structure of the participating companies mirrors the structure of construction companies in the construction industry of other countries as observed in the large number of the small and medium sized firms (about 84%) relative to their larger counterparts. Small-medium sized construction companies are described in Kheni et al. (2008) to be resource poor and barely able to survive in a capital intensive sector like construction. This is supported by the following comment regarding the cost of H&S management being a challenge for small companies: "*Only the bigger firms that land the plum contracts can afford it (i.e. certification and training). It's a luxury for small time contractors…*" [Project manager].

The BS OHSAS certification status of participating firms is also indicative of a sector where a large number of contractors lack the necessary policies, procedures and controls to effectively manage H&S. This correlates with research accounts in Idoro (2008; 2011), Kheni et al. (2008) and Umeokafor et al. (2014). The rather low involvement of top management in H&S is symptomatic of a low commitment of company management to protecting the H&S of workers. The importance of leadership support in management decisions and more specifically H&S

management is highlighted in Clarke (2013). Weak management commitment could undermine the other elements of H&S management and it is therefore not surprising that practices under planning and implementing, measuring and reviewing performance, and auditing recorded low levels of implementation (i.e. from 4% - 39%) amongst the surveyed contractors. The implementation of practices within the organising element range from low to moderate. Whilst there is moderate implementation of two practices (i.e. communicating health and safety information to workers through leaflets, newsletter and posters; and displaying regulatory H&S posters on site), there is low implementation of eleven practices indicating a generally poor outlook for the implementation of practices within this element of H&S management. This shows weak H&S management capacity with regards to organising for H&S which can lead to increased work related accidents. The poor outlook for practices within the organising element is out of sync with the situation in a similar developing country like Vietnam where Phung et al. (2015) and Nguyen et al. (2015) reported a moderate to high implementation for more practices within this element of H&S management. Whilst there appears not to be similar studies on the extent of H&S management practices implementation by contractors in a developed country context to aid comparison with the results from this research, it is expected that the situation in developed countries (e.g. UK and USA) would be relatively better given the better injuries record and health and safety regulation in these countries (see Hämäläinen et al., 2009; Abubakar, 2015). The implementation of the practices within the risk assessment element range from low to high. While there is moderate to high implementation of two practices, there is low implementation for three of the practices. That a low percentage of the companies undertake risk assessments prior to operations (i.e. 30%) and also review/update risk assessment during construction (i.e. 13%) shows that few companies take a proactive approach to dealing with H&S risks on projects. This could also have adverse consequences in terms of the occurrence of accidents, injuries and illnesses.

7. Conclusions

This research gives an insight into the H&S management practices of Nigerian construction firms, particularly those operating in the South Western Region. Results from the survey, although not generalisable to the entire Nigerian construction sector given the study's focus on a specific region, they suggest that very few H&S management practices are commonly implemented by contractors, particularly in the South Western Region. Generally, implementation of practices in all the key elements of H&S management appears to lagging. Elements that have a particularly gloomy outlook are planning and implementing, measuring performance and auditing. Action is needed by contractors to enhance H&S management in all the elements of H&S management. The support of state institutions and other relevant professional bodies (e.g. through provision of training programmes and awareness raising initiatives, and tightening of health and safety regulation) would be helpful. Public and private sector client organisations also have a key role in stimulating improvement in H&S management by including H&S requirements in procurement processes e.g. giving consideration to the health and safety competence/performance of contractors during contractor selection.

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An Investigation into Post-Accident Disputes Involving Migrant Workers in Singapore

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Abstract

One of the most vulnerable groups, in terms of workplace safety and health, are migrant workers who work temporarily in different countries and may not have the same level of protection as permanent residents. Their vulnerability can result in injured migrant workers being stranded in a foreign country without proper post-accident care and compensation.
Countries such as the Middle-Eastern countries, South Korea, Australia and China had reported vulnerability of migrant workers and different countries have different approaches to protect them. In the context of the construction industry in Singapore, employers of migrant workers are expected to take care of injured migrant workers, but there had been reports of migrant workers separating with their employers after an accident due to disputes on injury compensation. Many a times these migrant workers experience severe financial woes.

This study seeks to explore the injury compensation disputes that migrant workers face after an accident and the possible causes of the disputes. Sixty structured interviews were conducted with injured migrant workers at a NGO food programme in 2012-2013. These workers are generally construction workers (77%) or shipyard workers (33%). Most of the workers (93%) are from Bangladesh and some (7%) are from India. In addition, interviews with 2 employers and a lawyer were conducted. News articles were also studied to understand the issues involved.

The study provided insights on the different perspectives of the disputes. It was found that the main reason for migrant workers leaving their employer after their accidents was the fear of being repatriated by their employer without proper injury compensation. By leaving their employers, these migrant workers frequently end up with significant financial problems and mental stress. The possible underlying issues for these disputes were frequently lack of awareness of injury compensation processes and available assistance, unsound advice from lawyers that sought to represent the injured workers, and lack of trust between the workers, employers and regulators.

Keywords: injury compensation, labour dispute, labour relations, migrant worker, workplace safety and health.

1. Introduction

According to ILO (2015), there are about 232 million international migrants globally. The trend of increasing number of migrant workers will continue due to globalisation (Hämäläinen, 2009), economic inequalities, and other mega trends. Accordingly, migrant workers are an integral part of the Singapore industries since the 1970s (Piper, 2005). Similarly, the Singapore construction industry is heavily dependent on migrant workers. According to official statistics (Department of Statistics Singapore, 2015, Ministry of Manpower, 2015), the Singapore construction industry employs 98,200 residents and 322,400 migrant workers (work permit holders). That means migrant workers make up at least 77% of the workforce in the Singapore construction industry. It is noted that the work permit holders do not include higher skilled foreign workforce ("employment pass" and "S pass"). Besides Singapore, there are many countries with significant proportion of migrant workers and there are concerns that migrant workers are a vulnerable group in terms of workplace safety and health (e.g. Guldenmund et al., 2013).

Migrant workers are a vulnerable group in terms of workplace safety and health because they are in an unfamiliar foreign land, usually with language problems and they may not enjoy the same level of labour rights as permanent residents. Furthermore, many migrant workers moved to another country to earn money and they may be less interested in their own safety and health (Guldenmund et al., 2013). When a migrant worker gets injured, he or she may not receive the necessary level of protection and compensation (Harrigan and Koh, 2015). In addition, the construction industry is known for its poor safety performance. For instance, in 2014, 45% of the workplace fatal injuries in Singapore were from the construction industry. Such poor safety performance had also been observed in countries such as Taiwan (Cheng et al., 2010), the UK (Meliá et al., 2008), the US and Spain (Camino López et al., 2008). Having vulnerable migrant workers in the hazardous construction industry means that there is a need for more attention on post-accident protection of migrant construction workers to prevent abuse and assure that the rights of the workers are protected. However, there had been a lack of research on the how migrant workers cope with post-accident disputes and what are the reasons for the disputes.

As such, this study seeks to explore the factors influencing the occurrence of post-accident disputes between injured migrant workers and their employers. The issues highlighted provide basis for improvement of policies to better manage post-accident care of migrant workers.

2. Background

The terms 'migrant worker', 'transient worker' and 'foreign worker' have been used interchangeably in the literature. As defined by the Office of the United Nations High Commissioner for Human Rights (2011), a migrant worker is 'a person who is engaged or has been engaged in remunerated activity in a State of which he or she is not a national'. The term 'migrant worker' is used in this paper to align with United Nations' terminology.

2.1 Legal Framework

In Singapore, there are several regulations regulating the employment and management of migrant workers. The key labour relations legislations include the Employment Act and the Employment of Foreign Manpower Act (Attorney General's Chambers, 2015). In terms of workplace safety and health and work injury compensation, the main legislations are Workplace Safety and Health Act (WSHA) and Work Injury Compensation Act (WICA). The Employment Act governs the basic rights of the employees (e.g. minimum number of rest day and maximum number of workdays) and helps to ensure safety at work. The Employment of Foreign Manpower Act regulates the employment of all foreign employees with valid work passes and protects their well-being by specifying employers' requirement and obligations. For instance, the Employment of Foreign Manpower (Work Passes) Regulations (enacted under the Employment of Foreign Manpower Act) states that employer shall be responsible for and bear the costs of the foreign employee’s upkeep and maintenance in Singapore. This includes the provision of medical treatment unless the medical costs forms less than 10% of the employee’s fixed monthly salary and if the foreign employee’s agreement to pay part of any medical costs is stated explicitly in the foreign employee’s employment contract or collective agreement.

The Workplace Safety and Health (Incident Reporting) Regulations (enacted under the WSHA) requires the employer of an injured employee to submit a report to the Ministry of Manpower when the injured employee is granted more than 3 days of sick leave (consecutive or otherwise) by a registered medical practitioner on account of that accident or when the employee is admitted in a hospital for at least 24 hours for observation or treatment on account of that accident. On the other hand, the WICA provides an expedient, low-cost compensation system that is an alternative to claiming for damages under the common law. Employees can receive compensation as long as they were injured in a work accident or suffered a disease due to their work, and employers' liability can be capped. In general, the WICA assures payment for medical expenses and medical leave wages and compensation for permanent incapacity and death without the need to prove that the cause of accident is due to the fault of the employer.

2.2 Post-accident Disputes

Despite the legal framework to protect injured workers and to ensure that they are being taken care of after accidents, there had been reports of post-accident disputes that led to the injured workers being separated from their employers leading to hardship for the injured workers. According to Harrigan and Koh (2015), “Serious Mental Illness (SMI) is, in all likelihood, endemic” amongst their sample of 344 workers who had injury or salary claim workers lodged with the Ministry of Manpower (MOM). Even though the employers are required by law to provide accommodation and upkeep of the workers, 90% of the 344 workers were not living in the accommodation provided by their employers. These workers are mostly “runaway” injured workers, who had post-accident disputes with their employers. These workers do not want to leave Singapore because they are assisting with the MOM investigation on their injury compensation, but due to the regulation framework, the injured workers are not allowed to work for other employers. Harrigan and Koh (2015) found that the main causes of the mental stress among these workers (aside from the injuries) were due to lack of accommodation and threats of repatriation from employers. The findings by Harrigan and Koh (2015) were not surprising, because there had been numerous newspaper articles on the vulnerability of migrant workers. For example, Basu (2009) reported many injured migrant workers have to "fight to get compensation" and "some of them end up living on the streets while their cases are investigated - a process that can take anything from a few weeks to well over a year". Similar problems were also highlighted by Phua et al. (n.d.).

However, it appears that employers are not the sole cause of the problems. Migrant workers had been jailed for making false injury claims (Teh, 2007) and many false claims were hard to detect. Basu (2009) reported that some workers were suspected of faking work accidents to obtain a "special pass" to continue to stay in Singapore and earn more through moonlighting as "freelance workers". A special pass is issued by the Ministry of Manpower (MOM) to workers assisting in investigation or other relevant reasons. Special pass holders are not allowed to work, unless otherwise granted by MOM. Nevertheless, many injured workers still take up jobs while on special pass because their employers no longer pay for their upkeep. These workers were also suspected for abusing the special pass as an opportunity to extend their stay in Singapore to earn more money (Tan, 2013). Illegal work usually pay better because the illegal employers do not have to pay government levy for each migrant worker and mandatory insurance.

Similar disputes were also observed in other countries. For example, according to China Labour Bulletin (2007), migrant workers are known to "work in extremely hazardous conditions but when they get injured or contract a work-related illness, employers will often deny any liability and seek to avoid paying anything but token compensation". Kim (2011) also reported that migrant workers in South Korea, "some employers refused to pay for compensation, or in the cases where they paid for the compensation, the migrant workers were forced to sign an agreement stating that there would be no further compensation, and that the employer held no responsibility regarding the industrial accident". Furthermore, migrant workers in Middle-East (Hassan and Houdmont, 2014) and Australia (Reid et al., 2014) are also identified as vulnerable workers due to factors such as national culture, insecure job and payment to local recruiter. However, despite the severity of the issue, there was a lack of study on the post-accident care of migrant workers and disputes arising after an accident.

3. Research Method

This exploratory study consists of 3 main parts: (1) review of newspaper articles and online sources, (2) unstructured interview with 2 employers and a lawyer, and (3) structured interviews with 60 injured migrant workers.

The review of newspaper articles was focused on the main English newspaper in Singapore, The Straits Times (2015). Other online sources include online reports and webpages of NGOs, e.g. Transient Worker Count Too (TWC2), and the Ministry of Manpower (MOM). These articles and online sources were imported into NVivo, a qualitative data analysis software (QSR International, 2014), for systematic evaluation. More specifically, 11 newspaper articles, 4 online reports and a webpage were imported into NVivo. The coding was conducted inductively where text data were coded based on possible factors influencing the occurrence of post-accident dispute.

Telephone and email interviews were conducted with 2 employers and a lawyer to explore the causes of post-accident disputes. The interviewees were identified through the contacts of one of the authors. An unstructured interview approach was adopted to allow the researchers to explore the issues freely. This suits the exploratory nature of this study.

The structured interviews, conducted in 2012 and 2013, with the 60 migrant workers were conducted at two eateries where TWC2 was running their food programme for migrant workers. Each interview was conducted by one of the researchers based on a structured questionnaire. The questionnaire consists of 5 sections. Section 1 and 2 of the survey comprises the migrant worker's personal details. These sections provide the demographic of the foreign worker participated in the survey. Section 3 of the survey seeks to understand the nature of work the employer was engaged and aims at finding the relation between type of employer and dispute. Section 4 records the nature of the accident foreign worker involved and the medical care provided to them. Section 5 records the details of dispute and aims at finding the cause of post-accident dispute. The data and information collected from the 3 separated sources were input into NVivo and qualitative coding (Silverman, 2010) was conducted on them to derive useful insights and guide future research.

4. Data and Findings

4.1 Structured survey of injured workers

4.1.1 Profile of respondents

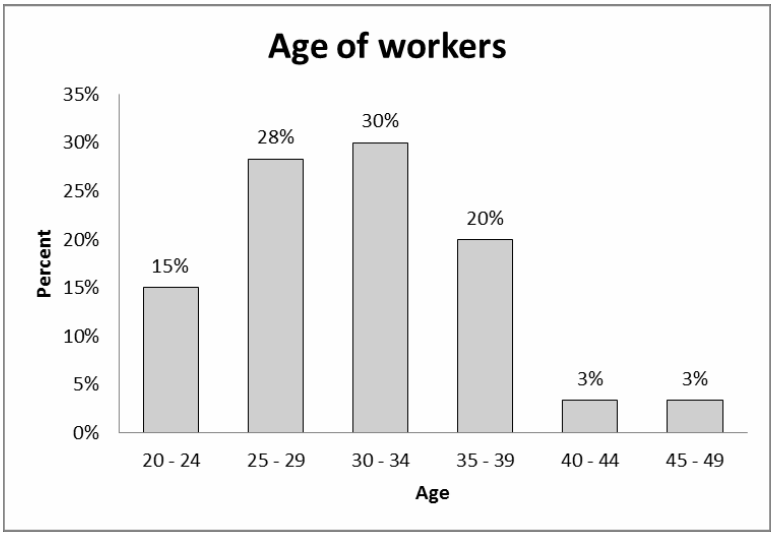

Figure 1 Distribution of age of surveyed workers

The following will present some of the key findings from the survey. Out of the 60 injured workers interviewed, 56 (93.3%) were from Bangladesh and 4 (6.7%) were from India. Forty-six (76.7%) of the workers were working in the construction industry and 14 (23.3%) were working in shipyards. Figure 1 shows the distribution of the age of the workers interviewed. As can be seen, most of the workers were relatively young at an age below 35.

4.1.2 Types of Employer

With reference to Figure 2, most of the respondents working in the construction industry were working for sub-contractors (45.7%), which is the most common type of employers in the construction industry. However, it is noted that 26.1% of the respondents were working for labour suppliers (26.1%), who provide short term labour to construction companies.

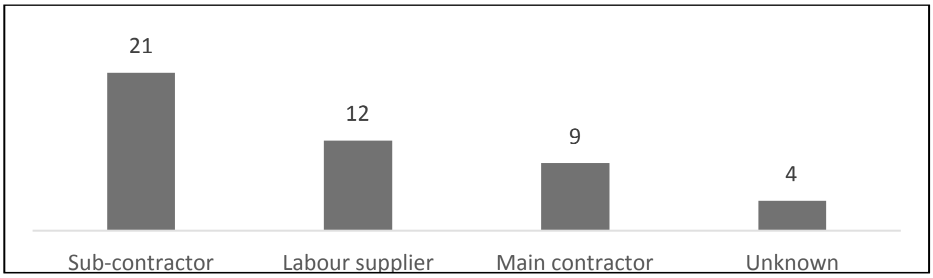

Figure 2 Types of employer

4.1.3 Factors causing runaway

Table 1 shows the ranked factors causing the post-accident disputes. Among the 7 factors, employer's threat to repatriate the worker was ranked as the most important factor in determining whether a migrant worker decides to leave his employer after an accident. Other concerns include the failure to pay salary during the injured worker's medical leave and employer refusing to pay for or provide medical treatment (including letter of guarantee for medical operations or treatment). Some of the workers also found that they were not given sufficient care during their recovery and decides to move in with their friends or relatives. For example, an injured workers having mobility problem was not given the necessary assistance while in the employer provided dormitory.

Table 1 Ranking of importance of factors causing workers to runaway

Factors leading to post-accident dispute	Sum of ranks	Importance
Employer threaten to repatriate foreign worker back	81	1
Employer refuses to pay salary during medical leave	110	2
Employer refuses to pay for medical bill	193	3
Employer refuses to provide medical treatment	242	4
Employer refuses to give Letter of Guarantee (LOG)	310	5
Being force to work when on Medical Leaves	350	6
Employer did not arrange for post-accident care during recovery	394	7

1=most important and 7=least important

4.1.4 Kickbacks

Of the 60 respondents, 47 were asked if they paid a 'fee' (kickback) for the job and all 47 (100%) indicated 'yes'. The remaining 13 respondents were not asked on this question because it was inserted after a review of the questionnaire. The average amount paid for the kickback was SGD4,687. According to some of the workers, the 'fee' ranges from SGD3,000 to SGD4,500. However, anecdotally, the 'fee' were reported to have been increased to about $7,000 for the first placement and the fee for subsequent contracts varies. One interviewed worker mentioned that for a subsequent job, there was usually a need to pay a fee of about SGD1,000 to SGD3,000. The survey finding is aligned with the results of TWC2's study (Transient worker count too, 2012), which found that despite MOM's enforcement, the problem of kickbacks was still very prevalent in the industry.

4.1.5 Involvement of Lawyers

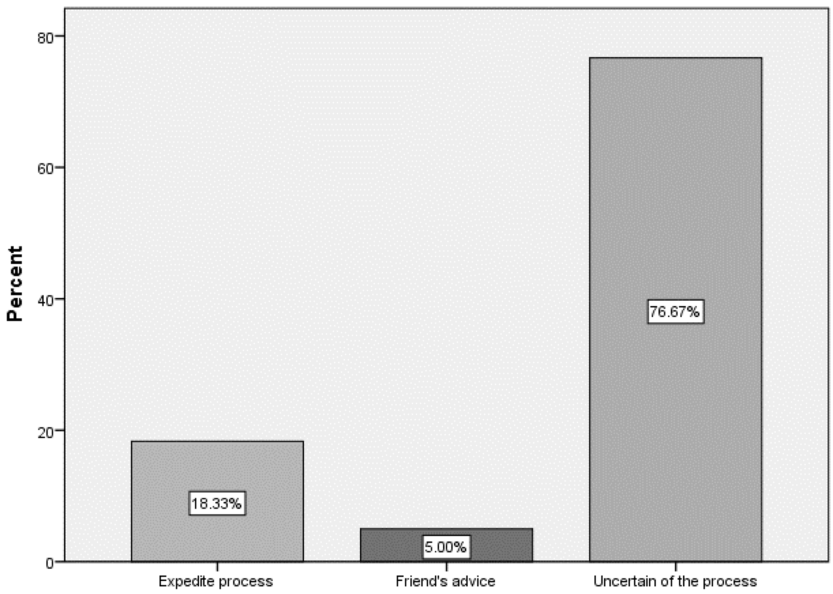

Figure 3 Reasons for consulting a lawyer

Out of the 60 respondents, 56 (93%) indicated that they engaged a lawyer to assist in their WICA claim. This contradicts the aim of WICA, which is meant to be a low cost and expedient channel to help injured workers obtain their compensation. For those that sought the help of lawyers (see Figure 3), 77% were uncertain of the compensation process, 18% were hoping that the lawyers can expedite the process and the remaining 5% engaged the lawyer based on the advice provided by their friends. The lawyers' assistance may be perceived to be necessary because of the disputes, but the legal fees will decrease the final compensation obtained by the injured worker.

4.2 Unstructured Interviews

Two employers (interviewee A and B) were interviewed. Interviewee A is the owner of a small construction contractor focusing on Bungalow construction. He had at least 1 incident of a worker running away after an accident. The injured worker claimed that he injured his back when carrying a bag of cement. The task was instructed by the main contractor and, according to interviewee A, the injured worker could not clearly specify who instructed the task. The worker also claimed that he was not allowed to see a doctor after the injury, but interviewee A insisted that this was untrue. Apparently, the worker got a relatively small compensation amount of SGD1,800, out of which the worker's lawyer obtained SGD1,200 for the legal expenses.

Interviewee A felt that the work injury compensation quantum was perceived to be very lucrative and the quantum can tempt some migrant workers into faking their injuries to obtain compensation. He also suspected that some lawyers may be promising a much larger compensation than reality. In terms of the illegal practice of repatriating a worker home to avoid accident reporting, interviewee A felt that it is not possible because repatriation companies are required by MOM to ensure that the workers do not have any outstanding issues, e.g. outstanding salary payment and injury compensation claims, before they can repatriate the worker. Interviewee A also shared that employers are required by MOM to purchase a SGD5,000 bond for each migrant worker, so if a worker runs away, the employer will lose the bond. This means that many employers will try their best to prevent runaways by providing proper accommodation and upkeep after an accident. However, he shared candidly that most employers may become "fed up *[sic]* because the injured worker cannot work for months and the employer has to continue to pay for the salary and medical expenses."

Interviewee B works as a sales general manager for a labour supplier company for about 5 years. His company has about 300 migrant workers and the company "loan them out" to construction companies with short term labour needs. He had about 2-3 runaway injured workers per year, but the number varies. According to interviewee B, many of these runaway workers did so on the advice of lawyers who teach them "tricks" to get higher injury compensation. One example is that he observed an injured worker who, after an injury, got only "light duty" medical certificate from a doctor. The "light duty" certificate indicates that the worker is not unfit for work and is an indication that the injury is relatively minor. Subsequently, the worker visits a government hospital and then obtain sufficient medical leave to make the injury reportable to MOM. Interviewee B noted that such "false claims" seem to be more common among certain sub-group of migrant workers (his opinion tallies with interviewee A's perception). He also shared that he noticed many of these injuries happen when "no one is watching" and investigators had to depend on the injured worker's word for the details of the accident. From what he knows, his company only had to repatriate workers that had "attitude problem" and these cases were not related to work injuries. He highlighted the following as possible signs of a worker moonlighting, (1) the worker is absent from work for a long period of time (e.g. one month), (2) the worker becomes uninterested in having over-time to earn more income, and (3) the worker insists that work has to stop at certain time.

The last interviewee (interviewee C) was a lawyer specialising in workplace safety and health for the past 10 years. However, he had not handled work injury compensation (WIC) cases. He shared that most of the injured workers were represented by various law firms ranging from small to mid-size firms as well as sole-proprietor firms. In terms of WIC dispute cases, interviewee C felt that the lawyer's main role is to obtain just and equitable compensation, but this role is relatively minimal. In terms of payment for legal costs, there are generally two categories: solicitor-client costs (S&C) and party-to-party costs (P&P). S&C costs are what the injured worker pays the lawyer and is subject to their agreement. The amount ranges between firms as it depends on the complexity of the case, experience of the lawyer, time spent on the file etc. In a civil suit, the losing party will typically be ordered to pay costs i.e. P&P costs. Generally, P&P costs are lower than S&C costs. It is not uncommon for some law firms to agree to bill the injured worker on a P&P costs basis i.e. the injured worker will not have out of pocket legal expenses.

4.3 Summary of Key Findings

The key issues gathered from the various sources, including newspaper reports and online articles, are summarised in Table 2.

Table 2: Summary of the key factors leading to post-accident disputes

Type of Issue	***Brief Description of Factors Contributing to Disputes***
Employer not willing to bear cost of accident or report accident	*- Injured worker becomes unproductive and employer not willing to pay for accommodation, medical treatment and salary*
	- Employer failed to purchase or renew work injury compensation for injured worker
	- Employer refuses to provide Letter of Guarantee as required by hospitals to conduct operations or treatment
	- Employer is concerned that the reported accident will attract MOM's inspections, or affect their safety track record leading to difficulties in obtaining new contracts or earning safety incentives.
	- Many injured workers are concerned that their employer may repatriate them without compensation for the injury. MOM has reported cases of repatriation companies being taken to task for forcibly sending workers home.
Labour suppliers	*- The labour supplier will typically require the main contractor to claim for the injured worker, but the main contractor may refuse to do so*
	- There can be confusion about where the injury was sustained and hence which company should be responsible for the compensation claim
Workers making false claims	*- Injury may be false, exaggerated, or not work-related. Worker may go to more than one doctor to ensure that he receives sufficient days of medical leave to assure compensation*
	- An illustration of the temptation to make false claims: compensation "for fractured fingers may be as high as SGD44,000, which is 75 years' pay for the average Chinese farmer" (Basu, 2009)
Medical certificates and light duties	*- Employers complain that doctors are giving medical certificates too liberally*
	- Doctors give light duties to injured workers, but employer has no light duties for injured worker. Employer may decide not to pay injured worker because he/she does not have light duties for the worker and the employer is not required to pay medical leave salary as the worker does not have medical certificate.

Workers encouraged to run away by friends and/or lawyers	*- Injured workers are generally uncertain about the work injury compensation procedures and may be encouraged by friends or lawyers to run away from the employer during the claim process. Employers feel that certain sub-groups among migrant workers are more prone to such problems.*
	- Lawyers are perceived by employers to be teaching "tricks" to injured workers and promising large amount of compensation. The lawyers can be paid on party-to-party basis by taking a cut of the compensation and the injured workers do not have to pay for any legal cost upfront.
Moonlighting	*- Runaway injured workers are typically on special pass and they are not allowed to work. As the investigation of compensation claim drags on, those that are well enough to work may be forced to take up illegal work to cover the cost of their accommodation and food.*
	- Injured workers may abuse the system to use the special pass to moonlight so as to earn higher income.
	- Ministry of Manpower offers a Temporary Job Scheme to help workers on special pass to look for short term work to sustain themselves.
Debts and kickbacks	*- As the supply of migrant workers to Singapore is very much higher than the demand for the workers, agents, training centres (workers are required to attend training courses prior to coming to Singapore) and employers may ask for illegal kickbacks from the workers. This causes many migrant workers to be severely debt-ridden and will be more motivated to make false injury compensation claims and/or moonlight.*

5. Discussion and Conclusions

As can be observed from Table 2, the problem of post-accident dispute is complicated and many parties, including migrant worker, employer, labour supplier, doctors, lawyers, authorities, and worker agencies are involved. On the migrant worker side of the story, they incurred huge debts paying for kickbacks and other costs to enter Singapore to work. They have very low bargaining power and they have very low income. Thus, one of the greatest fear that an injured migrant worker have is the possibility of being repatriated home without obtaining their injury compensation. On the other hand, accidents lead to unproductive workers and are costly to the company. Employers may suspect the injured workers of moonlighting or are making false injury claims. The employers face a lot of pressure due to market competition and their frustration can result in verbal or physical abuse of the workers, which further fuel the dispute. The employers failed to understand that their failure to care for the workers and their threat to repatriate the workers cause the workers to run away, resulting in more problems and trouble. This forms a vicious cycle of poor labour relations, disputes and lengthy investigation, which are detrimental to migrant all stakeholders.

There is a need for regulators to enforce their regulations to ensure that employers take care of their migrant workers after the accidents. At the same time, false injury compensation claims must be uncovered and dealt with severely. However, bearing in mind the vulnerability of the migrant workers, it is important to allocate sufficient resources to house and support the injured migrant workers that have separated from their employers and are having their injury compensation claim investigated. This role can be filled by NGOs, but government levy on migrant workers' employers should be used to fund the NGOs.

Education of migrant workers and employers are critical. It is important to be able to reach out to migrant workers and educate them on the injury compensation process. Letting them know their rights will reduce the need for lawyers' assistance, who may not add significant value and can be costly to the workers. Migrant workers can be trained as ambassadors to educate their own community on their rights and understand the dangers of moonlighting and false injury claims.

One of the most fundamental problems in the system is kickbacks, which place migrant workers in heavy debts and creating behaviours detrimental to workplace safety and health. For example, workers will only be focused on earning money as quickly and this can cause them to ignore their own safety during work. Migrant workers in severe debt can also be more easily tempted to moonlight or even make false claims. Tight enforcement and detailed employment guidelines must be established to prevent kickbacks.

This study surfaced several key issues behind post-accident disputes involving migrant workers. It is believed that these findings are useful inputs for countries that have a significant proportion of migrant workers. Future research should focus on designing interventions to assure faire and transparent handling of accident-related disputes involving migrant workers.

6. Limitations

This study has its limitations. First, convenience sampling was used to select interviewees and respondents. Second, communication with the migrant workers were done using simple English and there could be misinterpretation of information. These limitations were reduced through triangulation of the different data sources and the internal checks conducted between the authors.

7. Acknowledgement

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Behavioural Health and Safety: Links to Reporting of Close Calls in Construction

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Abstract

Over the last decade behavioural health and safety has become one of the construction industry's target areas for major improvement with countless systems created to attempt to combat the risks associated with poor behaviour. However, on their own, good systems do not ensure successful occupational health and safety. The reporting of incidents and close calls (sometimes called 'near misses) in particular can significantly improve health and safety through the sharing of experiences and learning from the mistakes of others. This study evaluated current systems and analysed the opinions of key construction stakeholders (n=104). The respondents included managers and workers across four different construction sites with two different principal contractors. The findings show that there is agreement that reporting close calls are an important factor in improving health and safety. However, at the moment, site operatives are not being given enough motivation to take time out of their paid work to report close calls. More convenient systems should be trialled and developed to find solutions that have more apparent benefit for the site operatives. To ensure successful teamwork everybody must be willing to participate. Any real industry-wide culture change would require the system of reporting close calls to be consistent throughout all construction sites across the country. This will then confront the issue of the transitional and itinerant nature of subcontractors and give them a system which they can become familiar with in their everyday work life.

Keywords: Behaviour, Health and Safety, Close Calls, Near Misses

1. Introduction

The construction industry by nature is a hazardous place of work. There has always been a need to improve the health and safety of the workforce. *'Over the last two to three decades, an increase in research and awareness in safety has reduced fatalities by over half. However, 22% of UK employee fatalities and 10% of reported major injuries are in the construction industry despite only accounting for 5% of British employment'* (HSE, 2012). These levels are high due to the nature of construction. Working with large-scale machinery and equipment has a much higher potential for harm compared to the dangers faced with other typical jobs sat behind a desk or even in a fixed-site facility. Therefore to enable the industry to continue to recruit good people, safety has been a major target for improvement. '*During this period, construction safety has reduced fatalities mainly through focusing on improving the managerial systems, policies and better safety technology e.g. nets, MEWPs, harnesses. However, in recent times, many organisations have realised that their accident rates have 'levelled off'. This has ignited a search for improvements in other areas to reduce accident numbers, leading to the research into behavioural safety issues of the workforce*.' (Oswald, 2013). Within any industry, even the best systems are not effective if they are not being cooperated with properly. Before any system can achieve its purpose it must be accepted and adopted by the workforce. The behaviour towards any system will decide whether it is successful or not.

Analyzing historical events can show that most loss producing events were preceded by warnings or close calls, sometimes also referred to as near misses, narrow escapes or near hits. However they are largely ignored because no injury, damage or loss occurred. McKinnon (2012), states that '*most health and safety policies are reactive not proactive. Companies wait for losses to occur before taking steps to prevent a reoccurrence. Employees are not motivated to report these close calls as there has been no disruption in the form of injuries or property damage.'* Recognising and reporting close calls can make a major difference to the safety of workers within construction. Behavioural health and safety then closely links to the reporting of close calls due to the fact that, for this system to work, it must have the full cooperation of the workforce. If the workforce does not behave in the desired way then the system will fail. Therefore the recent increase in demand for reporting close calls requires research into behavioural health and safety.

This study originated in the knowledge that there have been previous studies undertaken regarding health and safety reporting. This area within construction has always been difficult to gain full cooperation of the workforce. It has led to the requirement for research into ways in which to address this ongoing issue. A previous study by Williamsen (2013) showed that some site operatives believe reporting a close call may tarnish a workman's reputation. This ethical issue and the '*blame culture'* within construction could be seen as main reasons for the industry struggling with the reporting of close calls. However the full discussion of this topic is outside the scope of this paper. The intended benefits of the close call reporting system are very important. However, without cooperation from the site operatives these benefits cannot fully be achieved. The UK's Health and Safety Executive (2000) states that '*behaviour modification techniques are effective in promoting desired health and safety behaviours provided they are implemented thoroughly*.' This study considered different opinions and proposed potential solutions to achieving desired behaviour for reporting close calls.

2. Methods

The foundation of this research project was the assumption that there was an issue with behavioural health and safety with regards to reporting close calls, therefore a mixed methods, deductive approach was employed. A survey questionnaire was followed by interviews to gain the opinions of health and safety professionals from the industry. The following section describes the techniques and procedures for the data collection and analysis.

The main source of primary data came from a questionnaire to industry professionals in a variety of different roles including site operatives and site management. This was then compared with the current industry systems. The survey was designed to be straightforward in simple English to facilitate its completion. It did not require a computer and could therefore be completed at any time in any location to suit most construction operatives. The survey was emailed around to site managers who then handed it out to their employees. The completed surveys were then scanned and sent back to the researcher. The questionnaire included four statements with responses on a 1-5 Likert scale. The Likert survey enabled the required opinions to be extracted with a minimal amount of time or effort from the participants. The questionnaire was completed between September 2014 and January 2015. There was a 95% response rate achieved with 104 recipients completing the questionnaire across four different sites from a mixture of main contractors and building and civil engineering sectors. There were 59 managerial respondents and 45 site operatives with 50 having more than 20 years' experience and 54 less than 20 years' experience.

This second phase of the research involved structured email correspondence with two experienced construction health and safety professionals whose opinions could then be compared with existing literature and results from the questionnaire. Two main questions guided the interactions to enable the answers to be compared and critically analysed. The two professionals chosen had many years' experience were from different sectors of the UK construction industry to give a broader scope. Respondent A is currently health and safety manager for a major building contractor. Respondent B has over 30 years' experience in the construction industry working on a variety of building, civil engineering and infrastructure projects. He is currently health, safety, quality and environmental manager on a major civil engineering project.

Reviewing current industry literature and other health and safety research enabled insight into issues surrounding the nature of reporting close calls within the construction industry. This allowed the author to gain a broader understanding of the issues faced with reporting of incidents and close calls within the industry today. The UK's Health and Safety Executive was used as a reliable source of information to form the foundations of the study and provide an insight into how behaviour can have a major effect on health and safety. Other literature was used to compare this to close call reporting.

3. Results and Discussion

The results and discussion draw on the email exchange with the two experienced health and safety managers and the questionnaire survey (n=104) and is organised in line with the main questions that were addressed in the research.

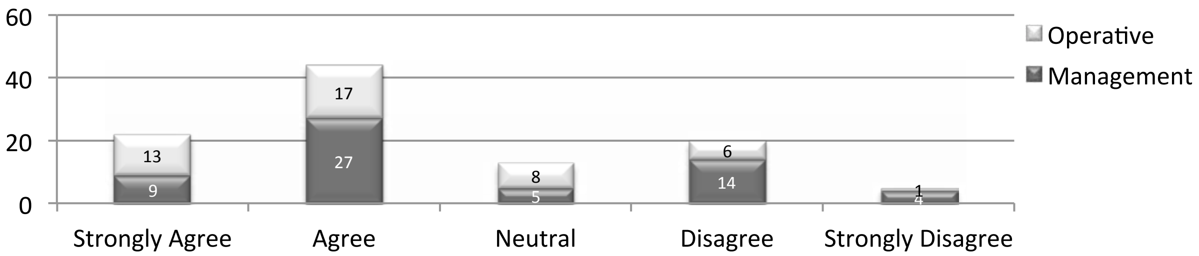

Figure 1:'Close calls get reported correctly according to the system in place' – Likert responses

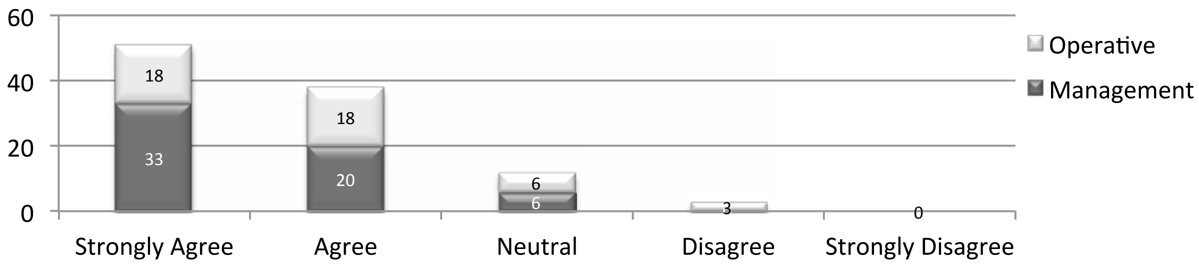

Figure 2: 'Reporting close calls reduces the chance of incidents occurring' – Likert responses

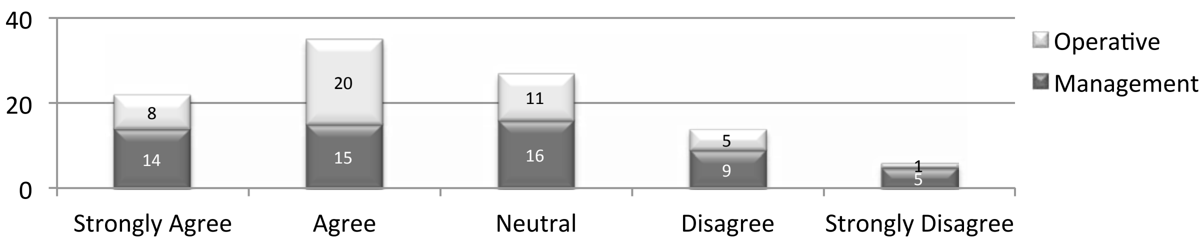

Figure 3: 'Reporting cards are the most efficient way to report close calls' – Likert responses

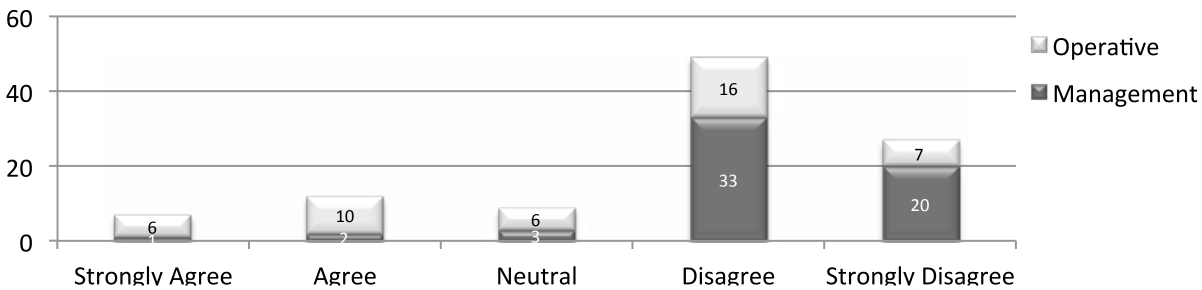

Figure 4:'Operatives don't have time to stop their works and report every close call' – Likert Responses

3.1 Do close calls get reported correctly?

Figure 1 shows a spread of results, however there is a trend towards agreement. Interestingly the responses that agreed largely came from both the site management as well as the site operatives, whereas the responses that disagreed came mostly from management. When surveying different construction sites the issue with close call reporting may be less apparent on some sites for various reasons with different managers enforcing the reporting systems in different ways. Alternatively they may not want to give the impression of a failing system and may answer survey questions with a more positive outlook so as not to cause any problems with upper management. Possibly because it is a recent system, older workers with an imbedded work routine may have had worse opinions regarding reporting close calls. Site based workers generally felt that close calls were being reported correctly and with a mixed response from management there are signs of disagreement. The difference in view of management and operatives can lead to issues and failure of a system. If operatives believe they are already complying with the system they will not feel the need to improve. Williamsen (2013) suggests *'one way to overcome issues with reporting is to actively involve the site workers and increase their participation in the process.'* This apparent disagreement would suggest that communication and involvement of both parties together has not been present regarding reporting close calls and is where the main issue of improper reporting may lie. If the reporting of close calls was properly discussed and communicated with the site based workers then they could have valuable input into the system. If there was effective communication of a failing system to the workforce they could collectively agree on ways to improve and reach targets that suits everyone involved.

3.2 Does reporting close calls reduce the chance of incidents occurring?

Figure 2 shows a strong trend of agreement from management and operative both having no participants strongly disagreeing. Out of both groups there were only three operatives that disagreed, showing how strong the trend of agreement is. Stating the key purpose of reporting close calls exposed whether current industry professionals agree that reporting close calls are important and have positive influences. This indicates that everybody is aware of the importance and benefits. However the ABC theory of behaviour (Flemming, 2002) suggests reasons why there are still issues to be faced. Even though there may be an understanding of importance in a situation, if there is a stronger influence at the time, e.g. knowing the supervisor is not enforcing the rules, the behaviour adopted may ignore the fact that reporting close calls is known to be important. With the significant trend shown in figure 2 it also suggests that all levels of experience agree with the fact that reporting close calls reduces incidents. Nobody within construction wants incidents or injuries, so any way to prevent them occurring should be a high priority on everyone's list. Albert's (2014) research presented an alternative reason for the issues faced. The analysis states that '*most construction safety management processes rely on the hazard recognition capability of workers. Hazards that remain unidentified can potentially result in injuries. Despite its importance, a large proportion of hazards remain unrecognized, exposing workers to unmitigated risks.'* Therefore, it is not so much the opinion of reporting close calls working as a system that is an issue. It is the education and collective understanding of what a defines a close call combined with the attitude that there is not enough motivation for operatives to stop their work and make close call reporting a priority.

3.3 Are reporting cards the most efficient way to report close calls?

Figure 3 shows a mixed spread of responses but the majority of responses generally agreed. This is most likely due to that fact that they are not aware of any other systems. The range of responses is relatively high across all 5 categories showing the spread of opinions. The only group to be in real disagreement is the management. There were a few management responses that were unhappy with the process and this is possibly because it can take up a lot of the supervisor's time filling out the close call cards and uploading them on to the company database. This is backed up by Williamsen (2013) who states that '*supervisors do not wish to be burdened by work of questionable worth.'* So in order to combat this inconvenience to the supervisors there needs to be a way of uploading close calls with minimal time consumed, or allowance in the day for the supervisor to take time away from site to upload all the close calls. With the increase in smartphone use today, it would make the process much more attainable if this technology was utilised for the system. If there was a smartphone app where site operatives can immediately take photos and share them with the site supervisor, he could then check and upload it on the data base with minimal amount of time or effort. It can be hard to keep tabs on whether closes calls are being reported properly due to the nature of the close call card system and the fact that no loss or damage occurs. If no supervisor witnessed it then it is very easy for operatives to shrug it off and carry on with their work. This is the required need for behaviour change and for operatives to start acting, there needs to be a system put in place that is convenient for them.

3.4 Do site operatives have enough time to stop their works and report every close call?

Figure 4 shows the responses to a statement that was thought to be a main reason why site operatives may not be happy about having to report close calls. Interestingly it shows a significant trend towards disagreement, unsurprisingly the majority being management. Management are almost entirely in disagreement with only 10% of all management participants surveyed not disagreeing. Meaning management feel site operatives have enough time to complete their work and report a sufficient amount of close calls each week. However figure 4 also shows there is a much more varied spread of site operative responses ranging across all five categories. There is a major difference between management and operative responses which is a significant finding with regards to operations within the industry. This then again relates to Williamsen's (2013) theory which indicates that site operatives have a desire to avoid work interruption because they have not got enough time in the day for unpaid distractions such as reporting close calls. The majority of operatives surveyed back up this theory and agree they do not have sufficient time to stop their works. This then contrasts with the management opinions creating a potential reason for friction on sites around the topic. If there is to be a successful system both operatives and management must agree. They must decide on a suitable number of close calls reports required that the operatives agree with and feel they can achieve without disruption to their works. Alternatively the system must be changed to find a way to take up less of the operative's time to report each close call. It could be argued that, regardless of how time consuming, it is a requirement of the operatives to report close calls and as such they simply have to report them. On the other hand, with the nature of the construction industry and the always increasing pressure on time, any reduction on time required away from measured works benefits everyone.

3.5 Is it possible to achieve behavioural safety perfection in the construction industry?

These following two sections present the findings from the email interaction with the two experienced health and safety advisors. Both respondents agreed that there is generally a negative opinion about behaviour when it comes to the construction industry. Both stated that, due to the transitional nature of construction workers it is almost impossible to embed behavioural safety into the workforce. Respondent A stated that whilst the industry has made great strides in trying to standardise construction through the skills card schemes, some businesses have very wide parameters in expectations of behaviours from the workforce. This coincides with Lin (2000) who states that '*employees must be actively involved in a system for it to have success.'* When operatives work in different places with different regulations every week it is hard to keep continuous positive behaviour. They cannot be involved within a behavioural system if they move around all the time.

Respondent A also stated that due to the wide gulf in expectations throughout the UK when subcontractor tradespersons who have not been exposed to health and safety culture come to main contractor projects, teams almost have to undertake a behavioural re-alignment and there is often too large a difference to overcome. The second respondent agreed that it is highly unlikely perfection will ever be achieved; however he stated that it is possible if the whole industry was committed to it. He admitted that efforts have been made to change such as The Construction (Design and Management) CDM Regulations and small steps have been made but there has been no accompanying cultural change. He stated that he believes organisations do things because they have to, not because they want to. He considered that we live in a 'tick box' industry where more effort is put into avoiding blame for an incident rather than preventing the incident in the first place. Daniels (1999) agrees that this is a major issue '*as motivation for something you have to do is much weaker than motivation for something you want to do.'* Too many individuals beyond the construction site are not motivated to make efforts to contribute to health and safety and are solely rewarded on financial performance.

Respondent A concluded saying that "unless the construction industry ever achieves the permanent employment status of nuclear, power generation, petro-chemical, which is highly unlikely, the best we can hope for is a core of workers who understand the principles of behavioural safety whilst we invest our time in trying to educate and change the behaviour of the remainder". Respondent B considered that the promotion of behavioural safety in parts of the industry in the previous 10 years had introduced significant benefits that extend beyond safety. The culture it encourages improves productivity and quality and that is why he thinks behavioural safety is still a worthwhile investment.

It is therefore a general agreement from these responses that too many people think safety is the responsibility of the contractor and only happens on site. Therefore getting everyone to commit to the culture change will be too much of a task. It is highly unlikely to ever achieve behavioural safety perfection but there are many benefits and safety improvements that can be achieved.

3.6 Is reporting close calls improving health and safety enough to invest in further?

From the responses it is clear that both respondents strongly agreed that reporting close calls is a fundamental process to improve health and safety within construction. Respondent B believed that it encourages everyone to get involved with safety and promotes a proactive rather than a reactive attitude. He felt it is a stepping stone to wide spread and continual hazard and improvement reporting. Unfortunately he also stated that there are very few motivated and suitably skilled people that can lead this process to ensure the potential is fully realised. He feels there is a lack of genuine high level effort meaning a lack of adequate resources to maintain a long term commitment that will see a cultural change. This supports Petersen (1993) who states that '*for a policy to become successful there must be sufficient support and commitment from upper management.'* Therefore, as Respondent B stated, without this support failure is more than likely. He believes the management of many large organisations are only interested in short term targets for personal gain rather than investing resources in something that may take many years to provide a noticeable return. Therefore although he stated that reporting close calls is worthwhile and beneficial he feels due to the lack of support from upper management there will not be any significant improvements any time soon.

Respondent A agreed with the fact that reporting close calls are a worthy investment and states that if a business is serious about behavioural safety and engaging with the workforce it must invest time and capital in maintaining a healthy close call process. He felt that there were clear indicators that an engaged and a 'listened to' workforce is more likely to work in a safe manner, so improvements in health and safety may be a by-product of having a robust close call process in place. Both respondents therefore had a common opinion: reporting close calls as a process itself may not always directly improve health and safety. However having the process in place actively involves the workforce and should naturally have a positive effect on their attitude towards safety on site.

In contrast to Respondent B's opinion that upper management are not actively committed to improving the process Respondent A stated how his health and safety management department are aiming to improve the process. He stated that, in his organisation, three times as many close calls are reported by direct employees compared to subcontracted workers. This disparity has led to a business target for 2015 to improve subcontractor reporting by 10%, by their site teams investing time during the induction, site briefings and Tool Box Talks in stressing the importance to their company that their partners tell them what is wrong. The success of this policy depends on the commitment from middle management to implement the process. But, on the whole, it is a step in the right direction to improving the behaviour of subcontractors.

4. Conclusions and Recommendations

The reporting of close calls is becoming increasingly valued within the construction industry as a preventative way of reducing property damage and injuries. However, this research has shown that the industry is struggling to keep up with the number of close calls being requested by managing directors of top companies with the UK. There are many views of the potential reasons behind this but mainly it comes down to the communication and participation gap between management and site operatives. The less communication and participation from the site operatives, the more problems faced when trying to achieve goals. Especially with the major issue that subcontractors are very transitional and never usually stay long enough on each site to learn appropriate (i.e. compliant) behaviour. Furthermore, as close calls have no real measure or specific description, they can easily be ignored. Therefore examples and standards should be set at all site inductions to ensure everybody is thinking along the same lines. The system then needs to be effectively managed by all to ensure close calls are not being ignored.

The other underlying issue with the process of reporting close calls is that it takes too long and is inconvenient for site personnel. It requires being brought up to date with current technology to become fast and efficient for everyone involved. By creating an easy way to report close calls, site operatives and supervisors will not be as inclined to ignore them and it can become part of the culture on site. As discussed in the analysis, an important opportunity is the use of smartphones. The creation of a smartphone app where site operatives could immediately take photos and write comments anywhere at any time would mean that they would not have to make such a 'big deal' about reporting. This should then increase the number of close calls being reported, resulting in valuable experiences being shared and learned. This should then lead to a reduction of incidents on a much larger scale, as is the desire of the industry.

This paper has only drawn responses from two of the top UK contractors and only from one geographical region of the companies. Further clarity of results would require a wider investigation throughout all regions of the UK and into all the separate disciplines. The next step would be for the these findings to be incorporated into systems within the industry. This would require an industry-wide initiative and trialling of new systems. A way in which to approach this could be the trialling of the smart phone app with the intention for it to be consistent throughout the industry. For there to be any real culture change industry-wide the system of reporting close calls should be made consistent throughout all UK construction sites. This will then confront the issue of the transitory nature of subcontractors and give them a system which they can become familiar with in everyday work life.

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Workaholics on site! Sustainability of site managers' work situations?

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Abstract

Site-managerial practice in construction has been depicted as a 'muddling through', being everywhere at the same time and skilfully solving problems as these crop up. The purpose of this paper is to explore work patterns and related well-being implications of site managers in construction. Drawing on the work-life stories of 21 site managers, which have been analysed using narrative analysis we argue that muddling through put high demands on these managers' abilities and possibilities of coping with and balancing their work situations. In all the accounts, several features of workaholism were identified as driving forces, often leading to negative well-being symptoms. The site managers were passionate about their work, but deplored organisational and institutional constraints, which mostly obstructed rather than supported or facilitated their work. This resulted in periods of exhaustion and stress, leaving little energy over for family and life outside work. We conclude that the warnings we perceive concerning the unsustainable work situations of site managers warrant further research.

Keywords: muddling through, site managers, stress, well-being, workaholism

1. Introduction

Recent studies (Styhre, 2011; 2012) have depicted the work of construction site managers as a "muddling through"; they skilfully solve problems as these inevitably crop up, and they try to be everywhere at the same time. It is argued that this behaviour is produced by the masculine culture in construction and puts high demands on managers' abilities to cope with their work situations. These and other studies witness that over the last two decades, little has changed in the behaviour and attitudes of site managers (e.g. Styhre and Josephson, 2006; Mäki and Kerusuo, 2015). What has changed, however, is the nature of site managers' work: more areas of responsibility and stricter accountability seem to be prevalent trends. Seen from a social sustainability perspective, the scenario does not bode well for the well-being of these managers. Research in the late 90s and early 2000 warned that apart from being one of the most demanding jobs in the construction process, requiring particular skill sets and experience, job dissatisfaction and stress among site managers seemed to be higher than among other middle managerial categories (e.g. Djerbani, 1996; Fraser 2000; Haynes and Love, 2004; Lingard and Francis 2004). These conditions are widespread still today (Styhre and Josephson, 2006; Dossick and Neff, 2011; Styhre 2011; Mäki and Kerosuo 2015), and warrant qualitative studies of the lived work-life situations of middle managers in the industry.

Drawing on the studies cited above and on interviews with site managers in several representative large and SMEs constructors in Sweden, we explore the work patterns and related well-being implications for site managers. Our data show that all the site managers interviewed exhibit one common characteristic: they are over-achievers, or as we argue workaholics. The aim of this paper is to examine the site managers' experiences of work and well-being, and reveal possible connections between (i) involvement with work, drive and work enjoyment and (ii) well-being.

2. Framing: well-being and workaholism

Research on well-being, especially within psychology is extensive. Journals such as Personality and Individual Differences report on its connections with personality (Garcia, 2011), attachment (Karreman and Vingerhoets, 2012), connectedness to nature (Howell et al, 2011) and emotional intelligence (Extremera et al, 2011), among other interesting themes. Well-being is also one of the core concepts in sociology and public policy (Jordan, 2008). Within business and management, and HRM specifically, it is a relatively new area of interest. The 'business case' has tended to trump the ethical or moral argument about 'employee welfare' or 'employee focus' (Van Buren III et al, 2011). While some models of HRM, such as the Business Partnering approach (Ulrich, 1997) perhaps began as an attempt to redress this imbalance, practice quickly revised the ideas, and so Ulrich's complete model became the three-legged stool. The business focus came to dominate, pushing well-being to the side.

Recent developments in the HRM literature have begun to engage more seriously with concepts such as well-being. The justification or rationale for this interest may stem from practical concerns about absenteeism and also presenteeism, and stress in particular (CIPD, 2013), but also renewed importance of ethics (Losey et al, 2005: 332). The practitioner press has become inundated with reports and papers on stress as a key concern in the modern workplace, and well-being initiatives are designed to address this issue (see for example the many CIPD resources, including reports and 'how to' guides on well-being at www.cipd.co.uk). However well-intentioned organisational well-being initiatives may just be treating the symptoms of much more severe concerns within the contemporary workplace instead of addressing the actual problems that lead to experiences of stress. On the level of the individual, 'workaholism' is one relevant construct that may explain workplace behaviours related to presenteeism and maintenance of patterns of work that lead to stress.

Workaholism is a term that refers to an employee's strong, irresistible inner drive that tends to result in working excessively hard (Spence and Robbins, 1992; Schaufeli et al, 2008:175). Behaviour patterns typical for workaholics include: compulsive-dependency, perfectionism and achievement-orientation (Burke, 2000). Over the past decades, workaholism has often been seen in a positive light, characterising the corporate ideal worker: "an employer's dream" (Bonebright et al, 2000; Burke, 2000). This view is based on the workaholic-triad that consists of work involvement, drive and work enjoyment (Spence and Robbins, 1992; Burke, 2000; Schaufeli et al, 2008). Different combinations of these three elements are said to produce six types of workaholism as shown in Table 1 below.

More recently increasing concerns over excessive work and related stress and potential burnout have initiated interest in examining the downsides of workaholism. Studies that consider workaholism and well-being outcomes tend to fall into two types: those that closely link workaholism and related well-being outcomes (e.g. Bonebright et al, 2000; Burke, 2000), and those that argue that the six types of workaholism and different types of well-being outcomes are best considered separately (e.g. Schaufeli et al, 2008).

The studies that closely link workaholism and related well-being outcomes (e.g. Bonebright et al, 2000; Burke, 2000) tend to argue that work context and managers play a significant role in developing workaholism and maintaining such behaviours (e.g. Burke, 2000), and that specific types of workaholism can be linked to particular well-being outcomes (Bonebright et al, 2000). For example the non-enthusiastic workaholics have been found to have significantly more work-life conflict and significantly less life satisfaction and purpose in life than non-workaholics (ibid). Also, enthusiastic workaholics have been found to have significantly more life satisfaction and purpose in life than non-enthusiastic workaholics (ibid).

In contrast, those that argue that the six types of workaholism (after Spence and Robbins, 1992) and different types of well-being outcomes are best considered separately (e.g. Schaufeli et al, 2008) show that workaholism and burnout (possible negative well-being outcome) and work engagement (possible positive well-being outcome) are not intrinsically linked. The relationships between the three concepts depend on

- working hours,
- job characteristics,
- work outcomes,
- quality of social relationships, and
- perceived health (ibid).

Table 1: Types of workaholics (after Bonebright et al, 2000; Spence and Robbins, 1992)

Type of workaholics (Bonebright et al, 2000)	Type of workaholics (Spence and Robbins, 1992)
Enthusiastic workaholics	• *Real workaholism* – high in involvement, high in drive and low in work enjoyment • *Enthusiastic workaholics* – high on involvement, drive and enjoyment
Non-enthusiastic workaholics	• *Work enthusiasts* – high in involvement and enjoyment, low in drive (resembling engaged workers) • *Relaxed workers* – low on involvement and drive, high on enjoyment • *Unengaged workers* – low in involvement, drive and enjoyment • *Disenchanted workers* – low in involvement and enjoyment, high in drive (resembling burned-out workers)

In this paper, we use this framework to explore site managers' experiences of their work role.

3. Study design and method

An interpretative approach was chosen, based on interviews. The data included in-depth interviews with 21 site managers. Most of the typical construction contexts and projects were represented, e.g. infrastructure, residential and commercial development projects. The data collection strategy was purposive: since we wanted to understand the unfolding of lived, everyday managerial practices on site, we asked CEO's and top managers from large and mid-sized contractors in Sweden to name their "best" site managers. We did not define what we meant by "best", but left it to them to decide. The result was 21 site managers of whom 3 were women aged 30 to 50. The rest were men: half of them aged 50 to 65 and the other half 25 to 40. The respondents were ensured anonymity in that all specificities enabling identification would be neutralised, and we offered them the possibility of reading the transcripts should they wish. The interviews were informal, taking the form of casual conversations lasting from 60 to 90 minutes each. They were audio-recorded and transcribed verbatim. The location for the interview was either a meeting venue or the respondent's office on location. A brief interview guide was used to keep interviewer intervention at a minimum.

The respondents were asked to provide the essential bio-data concerning career trajectories. After these preliminaries, they were encouraged to talk freely. Our prompts were open-ended; we wanted them to tell us about their workdays, how they generally went about planning and managing site activities, what issues arose and how they dealt with them. 'Free' storytelling has been suggested as an appropriate interview technique for the purpose we had in mind where interviewees' personal stories are allowed to evolve, and in which their underlying assumptions and beliefs guide the conversation (Clandinin and Connelly, 2000).

Drawing on Polkinghorne (1995) and Lindebaum and Cassell (2012), narrative analysis was applied on the data in order to identify and code the various fragments that made up the narratives. These fragments were then sorted under themes that linked to the overall plot concerning the narrators' coping with their work situations. *It is important to note here that the theme 'workaholism' emerged during our data analysis.* They were not asked to identify themselves as one type of workaholic or another, nor did we employ specific instruments to collect data to determine the respondents' involvement with work, drive and work enjoyment. During the data analysis we drew on the workaholic framework to sort the respondents' behaviours and associations to their well-being into workaholics types.

4. Findings

Three core themes emerged as central to the site managers' narratives of their work days: coping with their work situation, with their work-life and family, and their associations to their feelings of well-being. Overall the managers depicted their work situations as highly demanding with multiple expectations both from others and on themselves. They described how they were constantly being pulled between planning tasks, administration duties and the solving of countless ad-hoc problems, large and small, serious and trivial. Simultaneously, the respondents showed remarkable commitment and motivation for their work. They all took pride in the products of their labour, the final constructions.

> … seeing it [the construction] grow in front of me … that is something that can never be taken away from a site manager … that when I drive past the construction I can say 'I built that'.

Within these three themes, the two different types of workaholics: enthusiastic and non-enthusiastic according to Bonebright et al (2000) could clearly be identified. We have chosen to allow the voices of the respondents to be heard in this section since they express their views and feelings much more directly than we ever could.

4.1 Coping with work situation

The respondents described incredibly high workloads and very long working hours. Their work situations were demanding and fragmented. One manager mentioned a several-year long period when she worked practically 24/7.

> During the whole of last year, I got up at 4.30 am and left work at 7 pm, and went to bed at 9. How does one count work time from such a schedule? During the weekends I sat with the budget. During this period, I easily worked a 100 hour week. But that is extreme and isn't always the case […] on average, maybe I work 55 hours per week.

The respondents described how they developed ad-hoc strategies to cope with the abundance of work tasks, which differed significantly from the standardized approaches they were supposed to avail themselves of.

> You do what you can to make things work … you don't pay much attention to the role description, you just do…

> We have a business system and decision structures that we are meant to follow but there is no time for that. I have to take many shortcuts in order to get my workweek anywhere near to 40 hours.

There was a general consensus among the respondents that their managers in turn understood and accepted that they carried out their duties and responsibilities as best they could.

> They [superiors] understand that one does the best one can. But if there was to be an internal audit I would have to fill in the papers afterward so I don't get smacked on my fingers.

At the same time a strong sense of responsibility and commitment to work reveal a tendency among the managers to take on too many tasks, thus further straining their already heavy workloads.

> It is all about the projects. As long as I can work with what I want in the way I want, I enjoy working here. Today I am definitely in such a position.

> [the most tasking job is] … all the paperwork … but I have only myself to blame, for I let go of nothing. The purchasing I keep for myself, the economy I keep for myself… (…) It would have been a relief to get rid of the economy (Laughing)

> Despite everything, I enjoy the responsibilities I have … and of course you build your own indispensability … that's how it is. You're not indispensable in any way, but you make yourself memorable and see yourself as extraordinary in some sense.

A female respondent described the high demands on site managers in construction, and why it was difficult to fill managerial positions at the production level.

> What stops civil engineers from becoming production managers … or rather why we can't appoint them is that they are often on parental leave [days off when children are ill] especially when they have two children. We have some staff that are on parental leave approximately 50% of the time. No one on site has a clue about his or her planning and decisions. What materials are coming in, what cranes have been ordered etc … this is a huge problem for production.

Simultaneously, as another respondent stated, the managers felt guilty when they had to take parental-leave days:

> It is very tough for the site manager who is absent. We know that if we are at home things become difficult as hell for the others. You have to be really cold not to care about what's happening on site.

4.2 Coping with work-life-family balance

The respondents convey a mixed; yet rather negative view of their work-life balance situation.

> I have this work-family puzzle that needs to be managed, especially if a child becomes ill. During the weekday it works out ok. I leave at preschool and she picks up. Then you take care of children until they fall asleep and then you try to watch some TV before falling asleep. It is pretty hectic!
>
> As a site manager you are never free on weekends. You have maybe ten weekends per year where you don't open your computer and work. Most of us start on Sunday to plan for the workweek ahead.
>
> It has happened that I have slept at my desk waiting for a morning meeting … with work charts and drawings as covers to protect me from the cold.
>
> I have sat in front of Bollibompa [children's TV program] and worked. I see myself as there for my daughter even when I am working. That is something I am satisfied with.

The respondents complained about their work-life imbalance, and in some cases even expressed sorrow over how work has obscured their needs of recreational time and spending time with family and friends. One manager even went so far as to describe these impediments as collateral damage of work.

I don't have any alone time. I definitely don't have time to meet friends. My family I hardly see at all … so these bits are the collateral damage. I never go to the

> cinema; I don’t have time for those kinds of things. But I do travel a lot … that is my breathing space … that I always know that I will be travelling somewhere within a few weeks. That is when I switch off completely.

4.3 Well-being

The respondents’ reported worrying consequences of their hectic work lives on their health and well-being

> The previous year was chaotic. Then I was on the verge of quitting my job … I couldn’t cope. Then I worked … uhm … it was still at the time when I dropped of at day care. In principle I worked my 9 hours, every day, and then I also often worked [at home] from 8 pm until 12 pm many days a week … several weekends as well to get it to work. I was close to burnout then.

The respondents felt that there was little support from the organisation for their plight, and they felt that they had a large responsibility in procuring jobs for their subordinates.

> I have coped with it [the stress], but it was really a lot of work …I’m really tired. Time to train ... I never bloody well have time for physical training. That is why I don’t lose weight. Now I have to because I have a bad hip

> I can say this much. I had my second blood clot last year and had salmonella at the same time. I had a vomiting bucket with me when I went to work … that’s the way it is. So I go to work, and I have a bucket. It functions. I’m not that ill!

5. Discussion

All the respondents in our cohort exhibited evidence of workaholism, of which the six types are represented in the quotes. They showcase a representative sample. Specifically where we present the respondents’ experiences of their work situation, a diverse range of all six types of workaholism is identifiable. In our sample we thus include both enthusiastic workaholics and non-enthusiastic workaholics (after Bonebright et al, 2000), and find evidence of real workaholism, enthusiastic workaholics, work enthusiasts, relaxed workers, unengaged workers and disenchanted workers (after Spence and Robbins, 1992). There were many respondents that showcase high work involvement and work enjoyment. These respondents resemble engaged workers and can be categorised as *enthusiastic workaholics* or work enthusiasts. However, not all respondents talk of their work experiences in a positive light, hence these respondents have been sorted under the category *non-enthusiastic workaholics*.

With regards to ‘coping with work-life-family balance’ an interesting trend emerges: it is the respondents who fall under Bonebright et al’s (2000) broad category *enthusiastic workaholics* that reported most concerns with coping with work-life-family balance. This is not that surprising given that these workers were likely to prioritise work in balancing aspects of work-life-family blend and thus found it challenging to manage the balance. What is interesting is that they did consider and talk freely about their work-life-family balance concerns, which shows that these issues were of importance to them.

Those respondents who reported the most worrying consequences of their hectic work lives on their health and well-being all fall under the category *disenchanted worker*. Spence and Robbins (1992) identify this type of workaholism to be connected with low involvement with work and low work enjoyment, but high drive. This is a group that is clearly in the risk zone for ill health and burnout. Here a link with the organisational circumstances and job context emerges as a significant variable that influences the respondents' views, and therefore would warrant much more research and attention from HRM. The respondents referred to lack of organisational support, long working hours and presenteeism. Burke (2000) argues that it is these kinds of contextual circumstances that play a significant role in individuals developing workaholism and thereafter maintaining such behaviours.

The link between the job context and the managers' experiences can be understood through Styhres (2012) concept of 'muddling through'. The respondents expressed a lack of social support from superiors that they felt strained their work situation. These conditions caused them to work long hours, and bear responsibility for practically all the processes and relations on site, which further increased their feelings of stress. Styhre (2011, 2012) has argued that these conditions are due to the loosely coupled configurations in the construction industry, which increase expectations on self-sufficiency, autonomy and presenteeism of the manager. The site managers, thus, become the centre of all the activities on which the success or failure of the project revolve. Such conditions inevitably put considerable pressure on site managers.

The respondents complained about long work hours and referred to their job characteristics as both demanding and stressful. Work outcomes, however, tended to be described in positive terms, particularly in terms of organisational performance, yet this positive performance was often attained at the expense of strenuous and challenging effort by the individuals. The overall quality of social relationships and recreational outlets were unanimously seen as difficult to achieve. Many sacrificed time with friends and/or family as well as time for training to dedicate time to work or they referred to situations where they were multitasking, e.g. spending time with children while working. Several respondents conveyed that this caused them to neglect their individual and social needs, and in some cases this gave rise to poor health and well-being.

Besides the effects on the individual site managers, their workaholism may also have had negative effects on their subordinates and the organization. Site managers have formal responsibility for subordinates and for the work environment on site. They are responsible for preventing accidents and injuries. Our data indicate that site manager often work when they are ill, and they often have to take "shortcuts" to keep up with their workload. This raises concerns regarding safety issues on site, which would need to be further investigated. Furthermore, the industry is in need of recruiting new competent construction workers. In our data the ideal site manager is portrayed as a person who devotes his or her life to work and often neglects family and private life. This raises questions regarding the ability to attract a younger generation of workers more keen in upholding a balance between work and private life.

6. Conclusion

Using a practice lens, this paper has examined the work situations and possible related well-being implications of site managers in the construction industry. Site managers talked freely about their day-to-day activities, tasks and responsibilities, their interactions and interpersonal relationships with their subordinates, superiors and suppliers, and the difficulties they perceived in balancing work, family and personal life. All their accounts describe an all encompassing work context and managerial duties that put considerable mental and physical strain on them. Yet, these same accounts articulated a strong commitment to their work and sense of responsibility for all the workers on site. Their criticism concerning their excessive workload was mainly directed toward the organisational level and the increasing demands and control from the top down. The data indicated that the site-managers work conditions has and does lead to negative implications on their health and well-being, which in the long-run may prove costly for the organisation. The question which needs to be asked is how much of the strain is the result of organisational demands and how much is due to the demands the individuals put on themselves.

Inspired by the framework of workaholic types, we found representations of all the types described in the framework: both enthusiastic workaholics and non-enthusiastic workaholics (after Bonebright et al, 2000), and real workaholism, enthusiastic workaholics, work enthusiasts, relaxed workers, unengaged workers and disenchanted workers (after Spence and Robbins, 1992). An important finding is that linkages to negative well-being could be found in most of the site managers' accounts despite their strong feelings of involvement, drive and enjoyment in their work. High *enthusiastic workers* tended to experience increased work-life conflict and decreased time for recreation, which can be seen as negative well-being in terms of social relationships and health. It should be noted though that their high enjoyment of their work signalled positive experiences of psychological well-being. The data also indicated that *non-enthusiastic workers* are a risk group for ill-health and stress. Especially the group characterized as *disenchanted workers* are in a high-risk zone for burnout. Long working hours, lack of organizational support and presenteeism seem to be the reasons for these negative perceptions. These findings raise warning signals for the unsustainable work situation of site managers in the construction industry. This situation warrants further research on how an organizational context may 'force' managers to develop workaholic behaviours as a defence and/or rationalisation mechanism. It would also be very interesting to explore both the site context and individuals from a social psychological perspective: what is it that makes individuals fall into one or the other of these categories, and what can be done to prevent and support them? To sum up, what our data tell us is that 'muddling through' seems to be a lot more complex than the concept may lead us to expect.

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Part II: Constructing Commitment and acknowledging human experiences

Importance of Retaining Knowledge at Water Works - Findings from Finnish Water Works

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Abstract

Knowledge management has received some attention in the water sector during the last few years. However, its importance is still underestimated and the interpretations of knowledge management are versatile. Because knowledge management and especially tacit knowledge is a critical success factor for both water utilities as organizations and their personnel, this longitudinal research focused on the changes between 2004 and 2013 in a case water works. The objective was to find out what information needs and acquisition channels the personnel used, what was considered knowledge and tacit knowledge and how knowledge was shared.

This research was carried out by a qualitative method and a semi-structured questionnaire was used in the interviews. The research was conducted at Pori Water, which is a medium-size water works in Finland. The company's area of operation was expanded and the number of citizens served was increased by 10 per cent between 2004 and 2013. At the same time the size of personnel was decreased by 26 per cent.

Information needs and usage in the utility were versatile and depended on the tasks performed by the employees. The results of this research showed that the personnel used personal files, document collections, the Internet and the intranet more often in 2013 than in 2004. The shift from printed material to electronic material has increased over the years and that had happened in Pori Water, too. Surprisingly, discussion with closest co-workers and other personnel had decreased. Social media did not play any role in the case water utility.

Interpretations of knowledge management had changed from informing people to personal, individual property. The personnel were proud of the knowledge they had of water treatment processes. Several reasons were found why knowledge sharing was considered difficult. The most important difficulties mentioned included lack of time, competing priorities, a gap between older and younger generations and unwillingness to share. Knowledge management requires long-term planning and actions, which should be integrated in the strategy of Pori Water. Attention should also be paid to master-apprenticeship relationships, mentoring programmes, knowledge transfer processes and critical knowledge documentation practices.

Keywords: Knowledge Retention, Tacit Knowledge, Water Works, Longitudinal Research, 2004 - 2013

1. Introduction

Knowledge and information management have been discussed and debated world-wide since the beginning of the 1990's. Knowledge management has been studied especially in information and communication technology (ICT), information management, behavioural sciences, and business studies. The ICT sector has mainly used ICT in managing data and information. Information management has concentrated on individuals' and organisations' information needs, sources and use. Companies' key interest is in knowledge management, organisational learning, and information and knowledge flows. The role of tacit knowledge in personal and organisational development is significant. Several studies have shown that up to 80–90 per cent of decision making is not based on explicit knowledge.

The shared opinion is that in today's global and turbulent world both explicit and tacit knowledge form a key strategic asset for any company or organisation. The concept of knowledge management includes several other concepts, for example data, information, knowledge, wisdom, explicit knowledge, implicit knowledge, tacit knowledge, knowledge creation, knowledge sharing, intellectual capital, human capital, social capital. These concepts are understood differently depending on the context.

This longitudinal research focused on the changes between the years 2004 and 2013 in a case water works. The objective was to find out how the following themes have changed between these two focus points: the meaning of knowledge management in a water utility, the concept of tacit knowledge, sharing of tacit knowledge and the difficulties related to sharing tacit knowledge. In addition, the study focused on water utility personnel's information needs and knowledge acquisition channels.

2. Knowledge management and knowledge retention

2.1 Turbulent knowledge environment

In today's global and turbulent world both explicit and tacit knowledge comprise strategic assets for organisations which have to cope with a complex and turbulent knowledge environment. Turbulence is mainly due to the fast growing amount of knowledge and its fragmented and global nature. A complex knowledge environment creates both opportunities and threats. For example products may be developed to be more intelligent, services may include knowledge components, and Internet of Things will connect several systems, thus creating opportunities for new markets. One of the threats is that the lifetime of strategic knowledge will be short, and creating new knowledge may open doors for competitors. (Probst et.al. 2000).

In the future, turbulence at water utilities will be similar to turbulence in any other organisation. There are several things which pose challenges to water utilities, for example technological developments both in processes and analysing equipment, new legislative decrees and acts, more stringent environmental permits, demanding customers, economic constraints, digitalisation and ageing personnel. It is especially important in any water utility not to lose the personnel's expertise and knowledge.

2.2 Critical knowledge at water utilities

Critical knowledge will disappear, if not captured for example in case of retirement. Post and Breen (2005) used the expressions "inherent expertise" and "work legacy" when they emphasized the experience and hands on know-how of processes, equipment, and systems possessed by the leaving employees. This knowledge is undocumented yet crucial to the water utility and therefore it should be captured. According to Post and Breen (2005) the widest knowledge gap occurs in engineering, skilled crafts and trades as well as in technical expertise. Knowledge gaps can be severe, when water systems become more complex and technology becomes more advanced.

O'Berry (2007) emphasizes the fact that the livelihood of the utility depends on critical knowledge. Therefore, it is extremely important for them to know who has knowledge and what kind of knowledge they have. Blankenship and Brueck (2008) stated that critical knowledge cannot be written down, neither can it be learned by reading someone's notes.

According to Frigo (2006) critical knowledge at water utilities can be divided into three types of knowledge, i.e. technical, social, and structural knowledge. Individual capabilities and skills are technical knowledge, while relationships and working cultures are social knowledge. Structural knowledge is embedded in the organization, its systems, processes, policies, and procedures. Explicit and rule-based knowledge is typical of structural knowledge.

2.3 Tacit knowledge

Tacit knowledge is the most valuable asset an organisation possesses. Sustainable competitive advantages can only be developed by capturing and transferring tacit knowledge. Tacit knowledge is internalised in organisations and their people and processes, and is thus not readily or easily available and transferable throughout the whole organisation. There are several definitions for tacit knowledge which share the same elements. The existence of tacit knowledge has been known for a long time, but it has gained increasing attention since the beginning of the 1990's and is now also considered in organisational strategies.

2.4 Difficulties in sharing knowledge and information

There are several possible reasons why knowledge is not necessarily shared in organisations. They can be organisational or individual. Difficulties in sharing knowledge can occur, for example, in relation to the following aspects: hierarchical barriers, functional barriers, organisational strategies and policies, perception (personal knowledge), language, individual's talents and social behaviour, time, value, distance, attitude, willingness to share, organisational culture, power, resistance to change, atmosphere of trust, management and leadership, different generations, work norms, lack of training, lack of up-to-date information and communication infrastructures, vocational practices (compensation, recognition, ability utilisation, creativity, good work environment, autonomy, job security, moral values, advancement, variety, achievement, independence, social status), and knowledge drain when workers leave the company (Awad & Ghaziri 2004; Boiral 2002; CEN 2004; Devlin 1999; IRC 2004; Haldin-Herrgard 2000; Probst et.al.2000; Wilson 2009).

2.5 Knowledge retention

Knowledge retention is an important issue at any organisation. Blankenship and Brueck (2008) divided difficulties in retaining knowledge in technology-based, interaction-based, and learning culture-based categories. Difficulties in knowledge retention vary between these three approaches. Technology-based methods deliver information and facts, which are easy to capture and write down. It stands at the lowest level of a knowledge value chain. Blankenship and Brueck (2008) included also document systems and document repository forms of knowledge retention in this approach. Processes and practices are part of the interaction-based category, which includes the core competencies in a water works and which can be difficult to capture. A milestones reviews project is an example of processes and practices. However, the most difficult approach is the learning culture-based approach, which comprises knowledge in complex systems and best practices. Tacit knowledge incorporated in learning culture-based approach has the highest value in the value chain of knowledge. It gives answers to "know-how" and "know-who".

Tacit knowledge can be transferred by mentoring. Especially technical and operational knowledge, organizational culture, and leadership knowledge can be transferred effectively during a mentoring process. The best practices can be transferred in facilitated organizational learning and training sessions. Special apprenticeship training programmes have been used in integrating new personnel in water utilities. (Blankenship and Brueck 2008)

An easy way to keep critical knowledge within the utility is to make generations work together. Other knowledge sharing tools include training, mentoring, coaching, career development, and shadowing, where a younger employee follows how a senior employee works. Hurley et.al. (2007) emphasized open organisational culture, effective communication, and support from all employee levels in knowledge transfer. Post and Breen (2005) stressed not only the skills and knowledge but also enthusiasm and loyalty features transferred during mentoring.

Knowledge losses may occur in another case than retirement, too. Blankenship and Brueck (2008) anticipated that younger generations will have shorter tenures, because they seek other job opportunities. Their knowledge should therefore also be captured. Therefore, commitment and support by the top management is a basic requirement for knowledge retention. Water utilities need to develop workforce planning schemes, hiring practices, personnel level compensation, rewarding, recognition, and promotion actions that support knowledge retention. Development of workforce strategy should be one of the priorities in the utility.

Frigo (2006) has described the need for integrated knowledge retention strategies at water utilities. According to him the key focus of the top management should be placed on the strategies, which link together human resources processes and practices, information technology solutions and knowledge transfer practices and recovery initiatives. A knowledge retaining strategy and its implementation should be an ongoing activity in the utility.

3. Research approach

This research was conducted in a medium-size water works on the south-western coast of Finland. In 2004 Pori Water supplied water to about 76 100 inhabitants and treated their waste water and the waste water of several companies. The area of operation was larger in 2013 than it was in 2004, because of new municipalities and cooperatives connected to the water mains and sewers. In 2013 Pori Water supplied water to about 83 500 inhabitants, which was about 10 per cent higher than in 2004. However, between 2004 and 2013 the number of personnel decreased from 94 to 70.

The approach of this research is qualitative. The literature review deals with knowledge management, the role of tacit knowledge in water utilities and knowledge retention. A longitudinal case method was used in this research, because it provides information of in-depth events or individuals in one organization over time. In addition, data were collected by an inquiry. The questionnaire used in the research focused on the following areas: how the interviewees interpreted knowledge management and tacit knowledge and how they described knowledge sharing and knowledge retention at the utility.

The first empirical part of the research was carried out at Pori Water, where 61 employees were interviewed in June–October 2004. Individual interviews were conducted with all personnel groups. Altogether 66 per cent of the employees were interviewed. The second empirical part was carried out at the same water works where 33 employees were interviewed, representing 48 per cent of the whole personnel in September-October 2013. The interview process was the same in both empirical parts, and the same type of semi-structured questionnaire was used in the interviews. A question on social media was added to the questionnaire in 2013. The interviews were analysed by combining qualitative and statistical methods. The Microsoft Excel package was used to transcribe the interviews.

4. Results of the research

4.1 Information needs and acquisition channels

The personnel needed different kinds of information in their daily work. Some of it was related to decisions in Pori Water and its services, personnel policy and development. Some was related to terms and conditions of employment and terms of purchase. Legislation was also very important: the water works must obey laws and regulations in delivering good quality water to its customers and treating wastewaters and discharging them into water bodies. Information needs depended on the tasks the employees were performing. Table 1 summarizes the changes in the use of information channels among all interviewed staff members at Pori Water from 2004 to 2013. The table shows only non-users, daily users and weekly users (once a week or a couple of times a week). All other users (once or twice a month or a couple of times in a year) were left out. Thus the total percentage does not add to 100 per cent.

Table 1. Change in the use of information channels at Pori Water. Only daily users, weekly users and non-users are reviewed. Thus the total percentage in different information channels does not add to 100 per cent.

Information channels in 2004 and in 2013	*Daily users %, 2004*	*Daily users %, 2013*	*Trend*	*Weekly users %, 2004*	*Weekly users %, 2013*	*Trend*	*Non-users %, 2004*	*Non-users %, 2013*	*Trend*
Personal files/collections	*23*	*39*	↑	*23*	*18*	↓	*23*	*15*	↓
Library/document collection of Pori Water	*0*	*6*	↑	*3*	*15*	↑	*84*	*70*	↓
Local libraries	*2*	*0*	↓	*0*	*0*	–	*84*	*94*	↑
Discussions with closest co-workers	*84*	*82*	↓	*98*	*91*	↓	*2*	*6*	↑
Discussions with other staff members in Pori Water	*15*	*15*	–	*20*	*15*	↓	*11*	*18*	↑
Discussions with personnel of other water works	*0*	*0*	–	*3*	*0*	↓	*48*	*39*	↓
Discussions with other experts outside Pori Water	*5*	*0*	↓	*18*	*30*	↑	*34*	*27*	↓
Technical journals	*0*	*0*	–	*3*	*0*	↓	*61*	*79*	↑
Professional books	*3*	*0*	↓	*3*	*6*	↑	*59*	*70*	↑
Pori Water internal reports	*7*	*3*	↓	*8*	*12*	↑	*20*	*52*	↑
External reports (outside Pori Water)	*0*	*0*	–	*3*	*6*	↑	*55*	*61*	↑
Conference and seminar papers	*2*	*0*	↓	*0*	*3*	↑	*59*	*61*	↑

Equipment manuals and brochures	*7*	*9*	↑	*5*	*18*	↑	*20*	*39*	↑
Pori Water notices/bulletins	*2*	*9*	↑	*8*	*15*	↑	*25*	*36*	↑
Intranet of City of Pori	*12*	*21*	↑	*28*	*18*	↓	*52*	*27*	↓
Internet	*26*	*52*	↑	*16*	*15*	↓	*41*	*27*	↓
Standards	*5*	*3*	↓	*5*	*3*	↓	*66*	*82*	↑
Patents	*0*	*6*	↑	*0*	*0*	–	*95*	*91*	↓
Electronic databases	*15*	*27*	↑	*7*	*12*	↑	*64*	*55*	↓
Chat channels, discussion forums	*0*	*0*	–	*0*	*3*	↑	*98*	*88*	↓
Others	*10*	*15*	↑	*3*	*0*	↓	*60*	*70*	↑

The use of personal files, document collections, the Internet and the intranet has increased over the years, while the role of discussion with closest co-workers and other personnel has decreased. Contacts with other water works and attendance in seminars were not considered at all important. All kinds of equipment manuals and brochures especially in electronic form were the most important information sources in 2013. The personnel relied on outside experts more often in 2013 than in 2004.

The concept of social media was included in the interviews in 2013. Twenty- one per cent of the interviewees could not give any definition of social media. More than half of the interviewees (55 per cent) referred to Facebook and Twitter communities as social media. Twelve per cent considered general information forums as social media and six per cent thought that newspapers and broadcast news are part of social media. The remaining six per cent referred to it as unnecessary activity.

4.2 Interpretations of knowledge management

In 2004 very few interviewees knew what knowledge management really meant. Altogether 38 per cent of the interviewed employees said that knowledge management means informing the personnel. In 2013 fifteen per cent connected knowledge management to computers and data management systems; 73 per cent said knowledge management is a personal issue and 12 per cent could not give any definition at all. The percentage of answers referring to individual property increased considerably from 2004 to 2013.

The responses concerning knowledge management were grouped as follows: individual property, organisational property, system information, and miscellaneous. Almost all of the interviewees indicated that knowledge management is controlled individually. The knowledge part was equated with information. They utilise their own knowledge in their work and are always eager and ready to learn more. The type of information was emphasised. They valued in particular information related to practical tasks.

The management part was associated with personal filing systems – either mental or document filing systems. Most of the interviewees referred to their own memory as the store of information from which they find the needed pieces of information. Many also said that knowledge management is related to their own work. In other words, how well they can perform the given tasks and whether they are sure they are doing the right things. In their opinion, it is also knowledge management, if they can manage their knowledge and use it in the right way. They emphasised that water treatment processes are so complicated that one should understand what is really happening in the process, not just turn the button routinely.

4.3 Interpretations of tacit knowledge

In 2004 tacit knowledge was rather unknown to most of the employees at Pori Water. Some 47 per cent of the interviewees had either never heard the word or could not define it. Twenty-three per cent said that tacit means that you keep quiet and say nothing even if you know something. The remaining 30 per cent could explain the word tacit knowledge. When the question was formulated in a different way, all interviewees understood it to mean the knowledge and skills gained over many years at work. Some employees told spontaneously about situations or instances that included a tacit component.

In 2013 as many as 82 per cent knew the concept of tacit without any reformulation, three per cent did not know the concept and 15 per cent thought it means keeping quiet. The concept of tacit knowledge has been discussed in different media, both written and broadcast, during the past 10 years. It has often been linked to the retirement boom with the conclusion that tacit knowledge walks out of the office with retirement. In conclusion, as a result of the public discussion on tacit knowledge the personnel at Pori Water have often heard the word "tacit knowledge" since the year 2004.

Tacit knowledge takes many forms. Based on the interviews in 2004, tacit knowledge could be associated with the following: work experience, craftsmanship, co-workers, something in your head, something not told anyone and miscellaneous. The interviews in 2013 highlighted two new aspects, namely "something not heard" and "hidden".

Tacit knowledge was associated to the following:

- noises that pumps make: an experienced employee could tell from the noise whether a pump is working properly or the problem with it

- noises from structures: an experienced employee could tell from the noise, if there is a problem or the kind of a possible problem
- smell of the waste water process: a certain type of smell indicates process failure
- colour and structure of activated sludge indicates how the process works
- colour of the foam indicates pH value
- valves and their location in buildings: several valves have special features known only to those working in the area
- network information; all data is not available in maps, so information should be drawn from employees or through site observation.

Tacit knowledge based on work experience is knowledge workers have gathered over several years when doing the same tasks. Workers know on the basis of previous tasks and from their long working experience, how they should handle the tasks they are facing. Experiences, trials and errors have developed into tacit knowledge. It is personal and shared only if someone asks for it. The value of work-based tacit knowledge was considered high and was somehow considered much better than other knowledge. Workers work instinctively to some extent, and as one of them said, they could do the work with their eyes closed. Their work involved some routine phases and the procedures have been developed over the years.

4.4 Sharing of tacit knowledge

Tacit knowledge was mainly shared during daily tasks. The personnel highly valued the professional skills and knowledge of the employee who had a long working history at Pori Water. Tacit knowledge sharing happened at the actual work site where problems arose. The work procedures were demonstrated step by step, if necessary. There was no way of learning the tasks and tricks from books or in the office. The closest co-workers were the key persons whose help was asked.

Knowledge, in particular, tacit knowledge was shared automatically during normal work. As one of the employees said, it is a question of transferring a tradition. There seemed to be an established practice of performing tasks and documenting them in a fixed format.

The role of a more experienced co-worker was emphasised both in 2004 and in 2013. Knowledge sharing took place between newcomers and those with long work experience. Sharing was also common between co-workers. Some of them had been working with the same team, person or persons for more than ten years. However, the research showed that there are some difficulties in knowledge sharing practices. They are summarised below:

- high retirement rate, distorted age structure, mean age close to 50 years
- new personnel not employed, no one to share knowledge with
- no master-apprentice system
- management and organisational structure does not favour sharing

- exceptional cases or problems – for example manual operation of processes or special situations with processes seldom occur and they are always case sensitive, in other words exact knowledge cannot be documented
- lack of time due to work burden
- network maps partly out of date, older employees have knowledge which is not documented or shared
- negative attitude towards sharing, unwillingness to share, employees prefer to keep knowledge as their private property
- internal information flow incomplete, supervisors do not get information, for example of problems occurring with the equipment
- gap between older and younger generation – they do not speak the same language
- personal characteristics and inactivity, people do not seek knowledge actively.

Both in 2004 and in 2013 many of the interviewees tackled the question of a generation gap between younger and older employees, where the older do not necessarily understand the younger and vice versa. The inability of older employees to absorb new knowledge quickly enough may irritate the younger employees, while the know-it-all attitude of the young irritates the old. Teams were also so inflexible in their working procedures that instead of integrating younger members into teams, they tended to direct younger employees to other tasks. Some of this behaviour was explained by older employees as reluctance to guide the younger ones. On the other hand, younger people should be able to discuss and treat older workers in a certain way. They have to know "how to fish for knowledge" from them. Also, decision makers should start to pay more attention to ageing and its implications.

4.5 Knowledge retention

On the one hand, the personnel were fully aware of the importance of undocumented data, information, and knowledge. On the other hand, they were not certain about which information and knowledge are valuable enough to be documented.

Tacit knowledge was both shared and concealed. Some said that they actively shared any information and knowledge they had. Others emphasised that sharing depends partly on the receiver: the receiving person had to be active him or herself and be brave enough to ask. Some were not willing to share knowledge at all.

Difficulties in sharing tacit knowledge were revealed by the interviews indirectly. Personnel, from top to bottom, were concerned about the ageing of the personnel and knowledge disappearing with them the day they retire or otherwise leave the utility. Few new employment contracts were made and this was one of the main reasons why tacit knowledge sharing was insufficient: there is no one to transfer knowledge to.

The knowledge retiring employees had, was revered. Mentoring and master-apprentice systems could be a good means to share knowledge between a newcomer and the personnel retiring soon. The young and old working side by side has been applied at Pori Water, but the time allocated for simultaneous working was too short according to the interviewees.

5. Discussion and conclusions

Information needs and usage in the utility were versatile and depended on the tasks performed by the employees. This research showed that the personnel used personal files, document collections, the Internet and the intranet more often in 2013 than in 2004. The shift from printed material to electronic material has increased over the years and this development was also evident in Pori Water. At the same time discussion with closest co-workers and other personnel had decreased. Social media did not play any role in the case water utility.

Interpretations of knowledge management had changed from informing people to understanding knowledge management as personal, individual property. The personnel were proud of the knowledge they owned of water treatment processes. This knowledge is considered technical knowledge, which is critical to the livelihood of the utility. In this sense the research corresponded well to other research findings.

In 2004 tacit knowledge was an unknown concept while in 2013 the concept was quite clear to most of the personnel. Tacit knowledge was highly valued and it was associated with the skills and knowledge gathered over the years working at the same water works. Tacit knowledge was shared in normal daily work and especially during malfunctions. Unfortunately, part of the personnel still thought that tacit knowledge means that they should not tell anyone what they know. The personnel also worried about the retirement boom and loss of knowledge. The situation with ageing water utility personnel is similar all over the world. Water utilities do not attract younger people, and the retiring people's valuable know-how disappears if water utilities do not properly address this problem.

The research showed that there were several reasons why it was difficult to share knowledge, especially tacit knowledge. The difficulties included for example lack of time and competing priorities. People also mentioned the gap between older and younger generations, managerial and organisational barriers as well as problems in gaining information and unwillingness to share knowledge. These results are in line with other research findings.

Knowledge management requires long-term planning and actions and they should be integrated in the strategy of Pori Water. They should also pay attention to master-apprenticeship relationships, mentoring programmes, knowledge transfer processes and critical knowledge documentation practices.

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Nuisance in communication between facility users and builder: a language barrier

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Abstract

The aim of this research is to observe the barriers in communication between the construction project organisation and facility user organisation. Along the project the user organisation and the construction project organisation have many occasions where they communicate about the future premises but their perspectives are quite different: the user organisation's main concern is how the premises can be used whereas the construction project organisation's main concern is how the premises can be built. Moreover, both organisations deal with the concerns with their own professional jargons. The research question is how the communication and terminology should be established in order to co-create a mutual goal for the project?

The method of the research is case study. The case is a learning space retrofit project in the Musica building that is located in the university campus in Jyväskylä, Finland. The new learning space was co-created through user-centered design workshops. The case is studied by using content analysis to various documents. Documents include materials produced during design workshops (drawings, summaries of discussions, expert-evaluations, and concept designs), memos from official meetings and the user-satisfaction survey comprising statements and open-ended questions regarding the new space and its potential.

Results are indicating that the construction project organisation struggles to understand which features of the project are necessary from the user organisation's point of view. In addition, there are indications that the success of the project is understood very differently between these organisations.

Keywords: retrofit, user-centered approach, co-creation, construction project management, customer satisfaction

1. Introduction

The focus of the builders and the users of the buildings can be very different from each other. So can be the language they use. The communication problems have been identified as a major element in problematic cases (Thomas et al 1998) and consequently, there are studies of communication tools (e.g. Nitithamyong and Skibniewski 2004). However, the perspective of the language used in everyday communication of building projects has not reached such interest. There are some studies about how cultural differences including language problems may make project management more difficult (Ochienga and Priceb 2010), but the language barrier may exist even if the stakeholders have a common cultural background. The purpose of this research is to provide additional understanding about communication problems by studying the differences of the language and jargon that is used by the construction professionals and the users of the building.

The building project team consists of stakeholder with different roles. There are at least the roles of designers, implementers (builders), property owners and users (tenants) (Savolainen et al 2015). In addition, there are the roles of project management and design coordinator, who orchestrates all the other roles. As the value chain goes the tenant organisation pay rent to the property owner who does the investment and pays to the designers and implementers. It is understandable that each stakeholder develops their competence and communication in relation to their purpose of existence i.e. in stem with the value chain.

The roles can be divided into two categories according to the purpose of existence: the users and the others. The purpose of all the others is to ensure that there will be premises to use whereas the users' purpose of existence in most cases has nothing to do with the existence of the premises. Premises are simply one tool among others and the user could implement its purpose in any other premises as well. Thus, the competence and jargon of the users have a little to do with the competence and jargon of all the others. The purpose of the existence also determines the focus of each stakeholder: The users focus on how the premises may be used whereas all the other roles focus on how the premises may be built up.

The data of this study consists of the documents from co-creation workshops that were used for concept designing, the meeting memos of the technical designing and construction phases and the satisfaction survey that was implemented after the occupation of the premises. In the concept design phase, the user role was well represented and the documents are written in users' language. In the technical design phase, the user was still represented, but the focus in the documents was shifted into the accomplishment of the project. In the construction phase meetings, the user role was absent. The user role was re-established immediately after the contract handover when the user group took over the premises and the occupation begun.

The satisfaction survey was implemented twice in the first half year of occupation. The survey was designed so that on the one side there were questions that evaluated the premises' fitness for the activities it was designed for, and on the other side, there were questions to assess the success of the design and implementation. That way it was possible to observe differences in satisfaction expressions between the evaluation based on activities (users' language) and the design and implementation quality assessment (construction professionals' language).

The research gave an interesting insight into the fundamental problems of communication between the professionals of the construction industry and real-estate management and their clients. It gave a novel understanding about how the professionals and their clients view the result of the building project from significantly different perspectives.

2. Theoretical background

2.1 Understanding the importance of professional communication and language

The ways in which experts in the field of real-estate project development understand communication and language, as a dimension of their professional competence, are questions barely explored. In our current knowledge-intensive and meaning-based work culture where shared understanding becomes extremely important, work processes are fundamentally communicative (Kostiainen 2003). Alongside to concrete matters considering the building projects experts in the field of real-estate project development must be capable of abstract and symbolic thinking when doing business with various clientele. Communication and language have a very important role when users evaluate and construct their experience of built environment, spaces and places (e.g. Airo 2014, 12). Information has to be shared for the benefit of everyone who needs to exploit that information in the user-organization. Information mediation and development happen in diverse interactional situations in which appropriate communication competence and understanding of each fields' professional language is needed.

Thus, evaluation of professional competence is less based on employees' status or activities than on their skilful expression of competence in various contexts. Professionals must speak on behalf of themselves and the results of their work, which may be very abstract ideas as well as the creation of common knowledge. The impression of an employee's competence or incompetence in their work is increasingly based on interaction with others. (Kostiainen 2003; Laajalahti 2014.)

In general, communication processes in working life can be considered from the point of view of information exchange or meaning (see Frey et al, 2000, 27-28; Littlejohn, 1999, 6-9). The former emphasizes communication as a tool for transferring information from one source to another. Communication is seen as intentional message production and information exchange. A meaning-based perspective, on the other hand, emphasizes reception and interpretation. As Airo (2014, 19) states 'the built environment is always the institutionalised object of a social process'. Thus, in the field of real-estate project development, the communication process should primarily be seen as a receiver-centred, and as user-centred sense-making process. Nowadays it is extremely important to have a profound understanding of the connection between communication, language and ones' expertise in built environment business and management.

Interpersonal communication in relation to professional competence is increasingly a theoretical as well as a strategic way of thinking, understanding and orientating oneself, as well as a way of taking a stand, viewing and comprehending work and interpersonal relationships there. In relation to interpersonal communication competence, it is less important to define how we should do something or what we must able to do, than what kind of thoughts about communication we should hold. (Kostiainen 2003.)

2.2 Users' role in construction project

Cherns and Bryant (1984) point out that the role of the client is hard to examine because there are things that people are willing to state differently depending whether they are talking privately or in public. Their research is based on private confidential discussions, and thus, it is supposed to give quite an accurate image of the essence of the client's role. About the role, they point out that the client should not be regarded as a unitary concept. Even though the project would be organised so that there is only one nominated contact person who communicates with the construction professionals, behind of that is a complex system of interest groups that sometimes even compete against each other. As the construction project organisation is temporary multiorganisation (TMO), which means that there are lots of people from different firms that are gathered together to accomplish a project within a limited time period, the construction professionals have very limited time and mental capacities to take over all the complexities of the client organisation. That makes them impatient and vulnerable to oversimplifications. The involvement of the client system and its influence within the TMO is high in the initial phases. Thereafter involvement tends to be remitted to the lower levels of hierarchy within the client system which retreats into a reactive mode. So in many cases, the objectives may be initially insufficiently understood because of the oversimplification of client organisation and needs, and the client organisation is not suggested to correcting the misunderstandings as they are supposed to be in a reactive mode. (Cherns and Bryant 1984)

Of course, this is just a general description and there have occurred initials to break this vicious loop of oversimplification and reactive mode. Lindahl (2004) for example has described the method of workplace design that originates from the 1970s. Initially, the workplace design meant that the architect concentrated on employees' perspective and the quality of working environment was embraced. The embracement of the employees' perspective leads to the development of the participatory design methods, especially in Scandinavia. But even though the participatory methods did enhance the possibilities to understand the complexity of the client organisation such elaborate design has not necessarily guaranteed the promised improvement in the performance of work. On the other hand, some workplaces without perfect working conditions or carefully designed aesthetics are recognized as well accepted by employees and effective environments. Hence, Lindahl (2004, 254) suggests that "there is a lack of terms that facilitate a discussion on workspace design and organisational performance". In the research there are identified four aspects to categorize terminology and discussion: Work environment qualities (health and safety), metaphoric and symbolic qualities (corporate image), dynamic and contextual interdependence (actions of the organisation) and degree of participation in the design process (Lindahl 2004).

There has emerged quite significant interest in many industries towards co-operating with the customer. For example, the service dominant logic that states that "customer is always a co-producer" (Vargo and Lusch 2004) has gained recognition as a key marketing concept (Grönroos and Voima 2013). Prahalad and Ramaswamy (2004, 1-2) takes the level of co-operation a bit further as they embrace the significance of co-creation as a driving force for competitive advantage. The basic distinction is that Vargo and Lusch (2004) suggest that customer may be part of the value creation process in every stage of the production whereas Prahalad and Ramaswamy (2004, 49-50) suggest that production process should be designed so that it is actually a chain of value co-creation experiences. Grönroos and Voima (2013) points out that there are still lots of unambiguous concept definitions missing, like the concepts of value and value creation, that are needed in order to find usable managerial implications.

3. Data and Methods

3.1 Case study description

In this case study, 400 m2 premises were retrofitted at the University of Jyväskylä, Finland to better support the core activities of the organization. Before the project, there was a quite popular lunch café at premises, but the café was moving to another building at the campus, so there were well know premises becoming vacant. All other premises in the building were occupied by the department of music so it was decided to develop the premises to support learning, presenting and exploring music.

In our research case, the property owner University Properties of Finland Ltd. recognized that the users' vast knowhow about learning, presenting and exploring music cannot be embedded into architectural designs with traditional design processes. Therefore, a facilitated design workshop method called charrette was chosen as the main approach in order to improve the quality of the design and to find opportunities to co-create value-in-use. The co-creation project is divided into four phases that follow each other: visioning and concept design, technical design, construction and premises in use. The visioning and concept design phase of the project comprises the initial meetings with the key stakeholders and the charrette co-creation workshops. The technical design comprises the steering group and design meetings. The construction includes both construction and final planning ending with the handover, which started the final phase with the location in use. The co-creation project was part of a national Indoor Environment research project that aimed at designing evidence-based educational spaces for knowledge creation.

3.2 Research method

This research case was divided into three steps:

Step 1: What kind of guidelines and aims for the project were outlined and what kind of needs were generated during participatory workshops (charrette)?
Step 2: Was the evaluation of achieving those aims successful using a satisfactory survey?

Step 3: What kinds of observations were made related to language and communication in the project documentation?

Various types of data were gathered systematically throughout the project in order to examine the whole process: charrette material (data produced during design workshops), memos and minutes and satisfaction survey. All this data combined forms a rich base for the analysis and offers essential information about each phase of the project.

Materials from technical design and construction phases comprise all the memos and minutes from various project meetings. These materials can be seen as a perception of the person responsible for managing the project at the time. It reveals the builders' perspective and their jargon. During the next six months after the implementation, user-experiences and first impressions were gathered by using a satisfactory survey.

The survey was designed so that there were on one side statements that evaluated the premises' fitness for the activities it was designed for (fitness for purpose). On the other side, there were statements that assessed the success of the design and implementation as well as included five open-ended questions regarding the possible use of the space in the future, the atmosphere of the space, the positive and negative aspects of the space and other comments. That way it was possible to observe differences in satisfaction expressions between the evaluation based on activities (users' language) and the design and implementation quality assessment (builders' language) (Step 2). A total of 54 users answered the survey. The majority (f=32, N=54) of the respondents were students from the Faculty of Human sciences, which includes the Department of Music. Altogether, 48 students, five staff members and one musician completed the survey.

Charrette materials and open-ended questions from the survey were analyzed using a predominantly inductive content analysis (e.g. Thomas, 2006) in order to identify the aims of the design, e.g. requirements for the space. Data was segmented into meaningful analytical units that were encoded. Codes were then divided into (one or more) categories.

The analysis of the multiple choices was conducted by applying the logic of Net Promoter Score (NPS). NPS is developed by Reichheld (2006). The main logic is to divide respondents into three categories: promoters, passive and detractors. The score is calculated by subtracting the number of detractors from the promoters and dividing the sum by the number of all respondents. Those respondents that give undisputedly positive signal on satisfaction can be recognized as promoters. By following that logic, the analysis was conducted by examining the strongest positive answers in relation to other answers in each question.

4. Findings

4.1 Communication in the project

The broad vision of the new space was constructed during the visioning phase that was implemented by participatory workshop process called charrette. The result of the charrette was a spatial concept which included several spaces with different purposes: the stage which was place for presenting live music, the club which was place for both studying in groups and listening the music played on stage, the studio for focused working, the bar that could be used for refreshment providing in organized event or for making coffee if the club was on study use, the show room for place where achievements of the university's department of music, and entrance that would welcome the visitor to building. Analysis of the charrette materials revealed the framework which comprises four guidelines for the concept design: future-orientation, music-orientation, research-orientation and academic-orientation. Later three more defined goals for the project were created: 1) increased use of space, 2) sense of ownership and, 3) improved image of the discipline. In the visioning and concept design phase goals, guidelines and users' needs were communicated in users' language within their context.

At the end of the concept design phase, the objectives of the development were shaped into a form of feasible project. Also, the way of managing the meeting was changed. The focus was shifted from the creative discussions of what should be done into how to accomplish the project within the schedule and the budget. But despite this shift, the user perspective was not forgotten during the technical design phase. However, when the construction phase begun, the users' role was diminished so that they were present in hardly any meetings. User group was reorganized after the handover meeting. The minutes of the user group meeting, which was held immediately after contract delivery handover meeting, present indisputably that there has been a major misunderstanding between the users and builders, and the project management organisation was not capable of dealing with it.

We don't present all the possible misunderstanding that there were, but we take three enlightening examples to present the nature of the language barrier between the users and the construction professionals: curtains, fire detector system modification and outdoor speakers. Common to these three examples is that users' requested all of them in the technical design meetings, but only the fire detector system modifications were delivered. Curtains were discussed in the design meetings because blocking the windows was considered as a vital part of the acoustics. There was a written statement in the minutes that the acoustical curtains will be included in the construction contract. The curtains were also presented in the contract drawings but they were not delivered by the handover. The story is quite similar to the outdoor speakers. They were decided to include in the project because it is important to the place's image that there is an option to play music from the stage straight to the outdoor. The procurement divided so that the user should provide the speakers and the contractor should install the cable and arrange the demolitions and fix-ups for the cable route. Both the speaker cable and the curtains were installed after the handover.

The story of the fire detector modifications was a bit simpler. The modification for the detector was needed because the artists want to use theatre smoke at the stage. It was stated that this can be done by changing a couple of detector units and adding a module to the central unit of the system. The modifications were implemented according to the plan. When comparing these three stories there occurs a question, whether this is random behaviour to accomplish some assignments and ignore others or not.

4.2 Satisfaction expressions

Answers to the open-ended questions were divided into three major categories: infrastructural, practical and emotional. These categories have been described below. The answers were analysed by first recognizing which category each comment fall into and then forming a comprehensive picture of the content of each category.

Emotional factors were mentioned 140 times in the satisfaction survey. Emotional factors refer to experiences through senses by comprising visual, auditory and tactile sensations, as well as cognitive processes and subjective experiences. Comfort was the most commented theme, especially the atmosphere and aesthetics. Respondents described the new space as peaceful, casual and welcoming. Most of the responses were positive but there were also negative aspects. Few respondents stated that the space is uncomfortable or even depressing.

Practical factors were mentioned 117 times. Practical factors refer to elements that are related to or resulting from action. It comprises the key activities and factors that facilitate the core processes of the organization, in this case, learning, presenting and researching. Practical factors were related to all the same themes as in the charrette material: information sharing, learning, the new culture of activities and layout. New space was seen also seen as an environment for creating new cultural activities and organizing music events as well as deep cross-disciplinary cooperative learning and co-teaching.

The infrastructural factors were mentioned 8 times. They refer to the fundamental underlying systems and services necessary for a built environment to function. It compasses all the services and technical structures that enable activities in the space. These comments were related to information sharing and facility management.

Maybe the clearest indication of the significance of the language used can be found in the multiple-choice questions. When comparing the first survey answers to the second survey answers the change in the proportion of the best 5 = “completely agree” answers is striking. However, the development from the first survey to the second one is opposed between the question sets. The satisfaction seems to increase in the set that evaluates the usability of the premises (fitness to purpose) and decrease in the set that assesses the quality of design and implementation. The logical reason was searched from the terminology, and it seems that user is more capable of doing evaluation if the question directs to think the activity first and the space after that. The second set instead directs to think the space first and the effect on action after that.

When the question sets that evaluate usability are compared, it can be observed that the proportion of the best 5 = “completely agree” answers is significantly increased in the second set. This increase can be observed best in the questions “supports individual studying”, “supports small group studying”, “increases the wellbeing of the students” and “Increases the free association among the students”. It seems that during the first half of year the users became familiar with the space and the satisfaction of using the premises grew alongside.

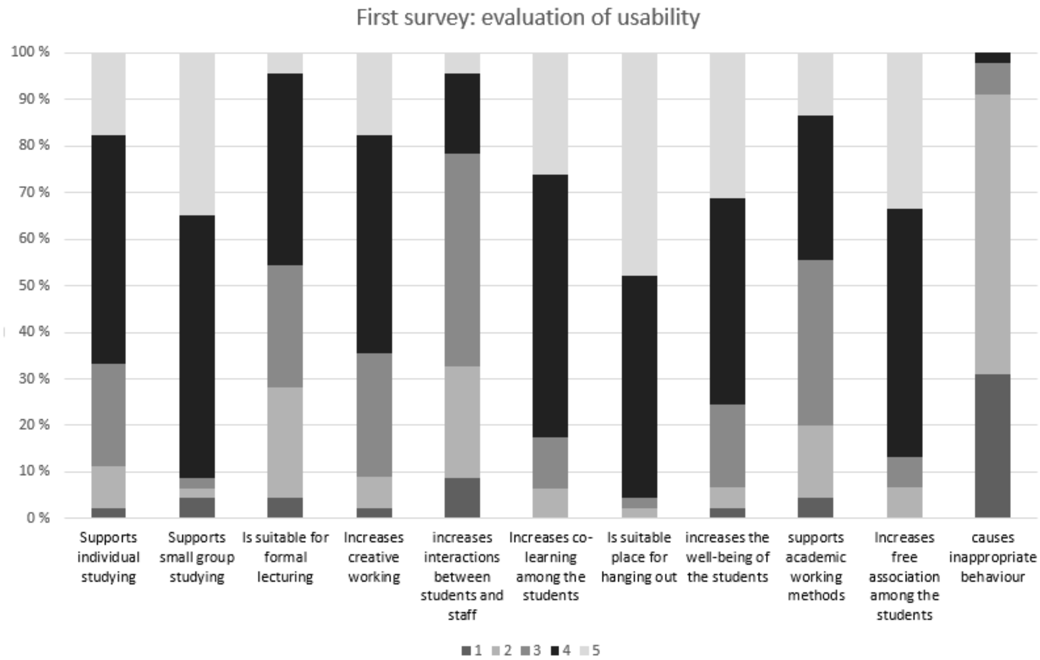

Figure 1: Evaluation of usability question set from the first survey

The growing share of extremely positive answers indicates that the growing satisfaction is not just about the increased understanding how the premises work, but that users actually like to work there i.e. they have become emotionally attached to the premises. Even though the development of the sense of ownership was expected, the result of the first set of the questions (evaluation of usability), the results of the other set (design quality assessment) was not. The best 5 = "Very good" answers had almost disappeared.

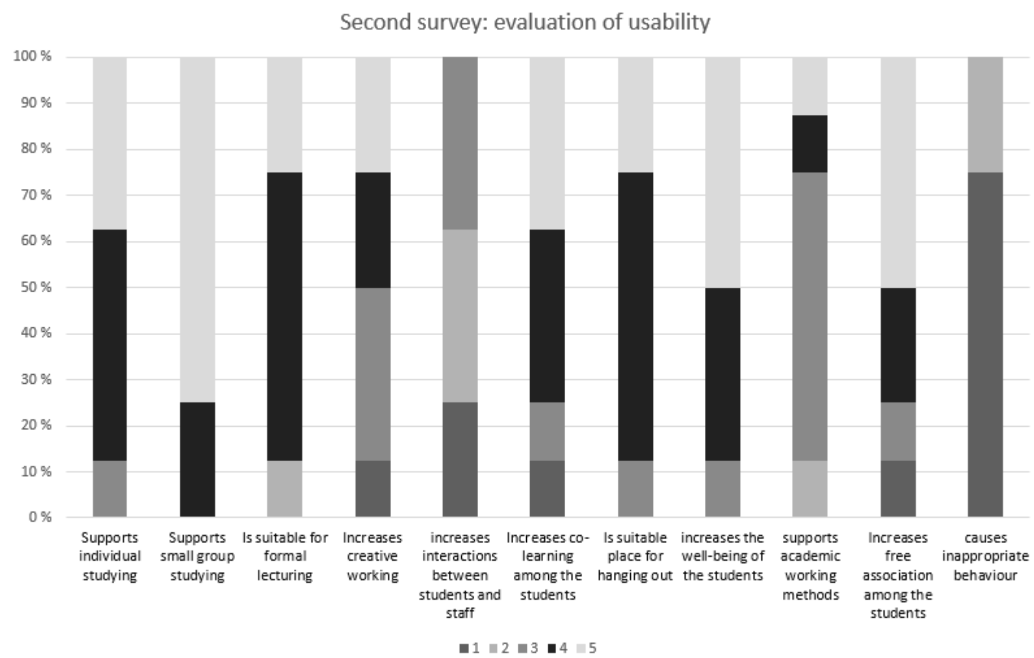

Figure 2: Evaluation of usability question set from the second survey

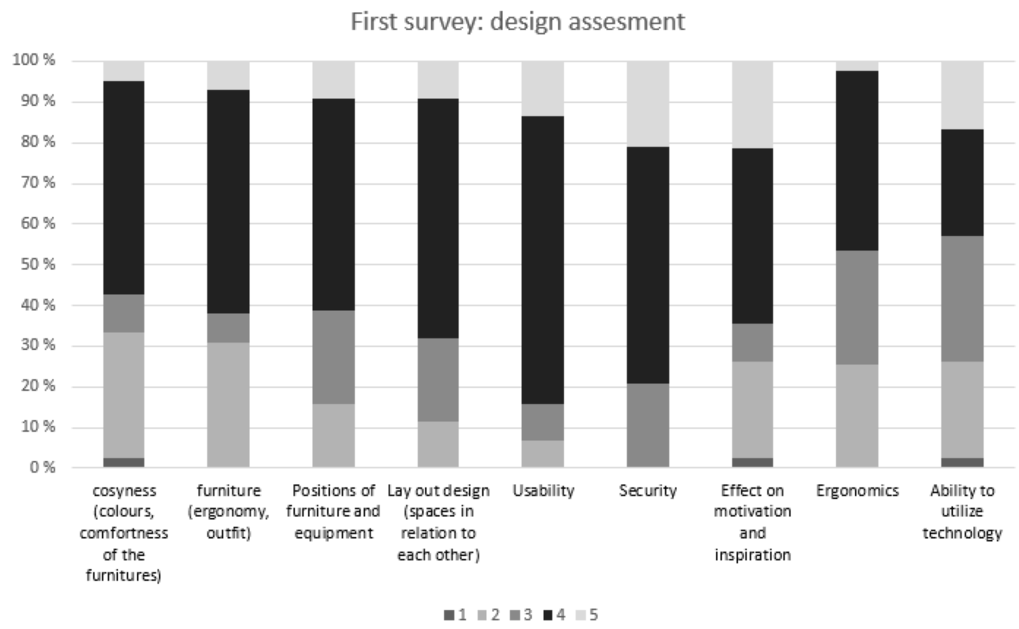

Figure 3: Assessment of the design and implementation question set from the first survey

The best answers were still present only in three questions "lay out design (spaces in relation to each other)", "security" and "ability to utilize technology". And the amount (around 20 %) was small compared with the results of the other set (around 50 % - 70 % at best). The greatest surprise was that even though the increase had been observed in the emotional attachment and sense of ownership, the question "effect on motivation and inspiration" totally lacked the 5 = "Very good" answers. So even though the space is an extremely popular place, the popularity is not perceived as a feature of the space.

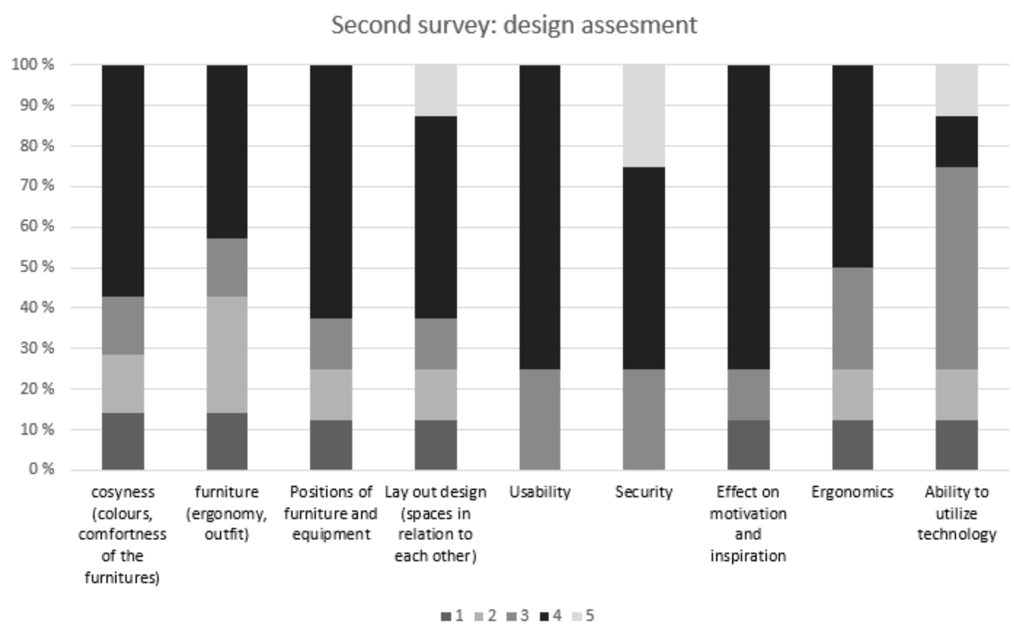

Figure 4: Assessment of the design and implementation question set from the second survey

5. Discussion

Our research supports Lindahl's (2004) perception of the user need categorization. The research confirms that there are needs concerning mainly health and safety (we call these infrastructural needs), needs concerning activities of the user (practical needs) and needs concerning metaphoric qualities and symbols (emotional needs). Lindahl (2004) also presents the fourth aspect that is a degree of participatory in the design process. Our research supports the assumption that it is a crucial aspect, but we would rather separate it from the first three. The first three aspects can be understood as user needs whereas the fourth one may be understood as a meter of which level of needs the service process has reached.

Our three examples of how user needs were treated during the design and construction phases (curtains, fire detector system modification and outdoor speakers) indicate that construction professionals tend to deal only with the features related to the infrastructural needs. There was no significant difference between these three tasks in schedule wise or budget wise. Neither there was a difference about how they were stated in the meetings. It was made clear that all of these are important for the user. The need for the fire detector system modification was related to infrastructural needs whereas the other two was related to practical and emotional needs.

6. Conclusions

Our study and our results are all but comprehensive description of the communication problems between construction industry professionals and their clients. Despite the fact that there were only eight answers in the second survey, our research provides evidence that the emotional attachment and sense of ownership are such qualities that are hard if not impossible to embed into space. The culture of the user group seems to have much stronger relation to these qualities than the premises itself.

If the infrastructural needs are compared with the other two categories, it can be realized that engineering safe and healthy indoor climate differs quite a bit from designing how the premises effect on human behaviour or human emotions. It may be that most of the engineers are willing to settle for handling the infrastructural needs: The outcome is much more predictable and needs much fewer adjustments afterwards. That way the engineer can be sure about the value he/she has to offer. But the downside is that the service and the terminology concerning the practical and emotional needs remain underdeveloped. As the oversimplification of the communication problems is supposed to be malicious, these problems will require a lot more research in order to find ways to offer services not only to the infrastructural level of needs but all the needs users have. We suggest that project management service providers could gain significant competition advantage via better understanding of needs.

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Exploring Dimensions of Job Satisfaction and Relationships with Performance: Evidences from Construction Professionals

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Abstract

Theoretical explorations and empirical demonstrations of the nexus between job satisfaction and job performance have never ceased. Some argue "happier workers produce more", while some insist that workers with better performance achieve satisfaction through bigger chances of rewards. In a review of previous studies, weak empirical evidence may be attributed to changing definitions of concepts. This study conducts a fine-grained analysis to propose a new conceptual model based on the S-P nexus. Firstly, job satisfaction is divided into economic satisfaction (ES) and production-related/noneconomic satisfaction (PS). This assumption is validated in this study by principal component analysis of empirical evidence from a questionnaire survey of construction professionals in China. It is found that the effects of ES and PS on job performance are different and warrant further study. The proposed model will be helpful to both academics and practitioners when investigating the nature of the satisfaction-performance nexus and making strategic decisions on personnel management.

Keywords: Job satisfaction, job performance, questionnaire survey, fine-grained analysis, construction professional

1. Introduction

The relationship between job satisfaction and performance (S-P) has been an important topic of study for academics and organisation managers for many decades since the Hawthorne studies and the human relations movement in the 1930s (Judge et al., 2001). It is initially proposed that “happier workers produce more” which gains popularity as an argument because of its consistency with intuition. In the 1960s, some researchers (Lawler and Porter, 1967) argued that job satisfaction was induced by performance for rewards, and that good performers gain more rewards and are happier. Both opinions are supported by theory. The former opinion is supported by the theory of reciprocity — that an employee has a natural intention to respond reciprocally to perceived kindness and unkindness (Falk & Fischbacher, 2006). The latter opinion is based on motivation theory, which reasons that rewards, led by the job performance of employees, result in satisfaction and even higher subsequent performance in response to the effects of organisational commitment and goal setting (Latham & Pinder, 2005). However, convincing empirical evidence for both assumptions are still lacking. Some researchers (Fisher, (2003) describe the S-P nexus as simple "folk wisdom".

Reviewing previous studies, weak and inconsistent empirical evidence for the S-P nexus can be attributed to changing definitions of concepts and divisibility of abstract terms. For example, satisfaction may have several facets, especially economic satisfaction (ES) and production-related/noneconomic satisfaction (PS) (Xiong et al., 2014). Similarly, dimensions of job performance include task performance, organisational citizen behaviour and even anti-productive behaviours (Viswesvaran & Ones, 2000). This study divides job satisfaction into economic satisfaction and noneconomic satisfaction, and uses task performance (TP) as the measure of job performance. It is proposed that PS increases TP and then TP increases ES. A literature review is firstly conducted and then a conceptual framework is proposed. Statistical analyses are further applied to validate the hypothesised model.

2. Literature review

2.1 Linkage between individual satisfaction and performance

Studies on the relationships between job satisfaction and job performance comprise an appreciable portion of behaviour research in management (Organ, 1988b). Additionally, the discrepancy between the strong intuition among practitioners that satisfaction has an obvious influence on productivity and low correlations for these elements of performance obtained in empirical studies has made this an appealing topic for researchers for decades (Judge et al., 2001). There are three mainstream hypotheses on the S-P nexus: (1) job satisfaction causes job performance; (2) job performance causes job satisfaction; (3) there are other complex relationships between the two including moderators, mediators or antecedent variables.

The first of these hypotheses again goes back to the Hawthorne studies and human relations movement, when the idea that improvement in employee morale leads to production improvement became widely accepted (Schwab & Cummings, 1970). Despite little supporting empirical evidence, the hypothesis that job attitudes affect employee behaviour became accepted as logically reasonable (Judge et al., 2001) and used as a common assumption in many studies. The second hypothesis reverses the cause and the effect, with Lawler and Porter (1967), for example, pointing out that rewards were not adequately considered in previous research, and it was therefore reasonable to assume that satisfaction follows the rewards produced by performance. Although there is some empirical evidence in favour of the second hypothesis (Judge et al., 2001), it is still insufficient to be convincing and has been criticised as containing a hidden and questionable presumption that performance and rewards are closely linked for individual workers (Fisher, 2003).

Because of the weak empirical evidence relating to the first two hypotheses, some researchers have turned to exploring common antecedent variables for satisfaction and performance in terms of mediators and moderators in the job S-P linkage (Judge et al., 2001; Schwab & Cummings, 1970). Some researchers such as Schwab and Cummings, 1970) argue that the unsatisfactory outcomes of S-P linkage research have been mainly caused by the ambiguity of definitions of job satisfaction. Although some measures of job satisfaction such as the Job Descriptive Index (Smith, 1969) and Minnesota Satisfaction Questionnaire (Weiss, Dawis, & England, 1967) have been developed, job satisfaction is still seen as a holistic concept in applications connecting satisfaction and job performance. It has been suggested that researchers should explore the relationship between specific attitude measures and specific job behaviours, rather than the link between general satisfaction and a specific behaviour (Fisher, 2003). Lai (2007), for example, divided the job satisfaction of dealers in the motor industry into social satisfaction and economic satisfaction, and found that noneconomic satisfaction was much more important than economic satisfaction in influencing performance. This dichotomy is also consistent with Brown's (2001) finding that economic satisfaction should be treated separately for analysis, since it is highly related to pay factors like pay equity.

However, some previous studies (Janssen and Van Yperen, 2004) fail to connect satisfaction with performance, while other studies (Lai, 2007; Nerkar et al., 1996) assume that all disaggregated satisfaction facets share common unidirectional relationships with performance; for instance, all satisfaction sub-dimensions lead to performance. Therefore, the vital unanswered question is whether it is possible that the low correlation observed in previous studies between overall satisfaction and performance was caused by different or even conflicting causal relationships between satisfaction sub-dimensions and performance. For example, economic satisfaction (satisfaction with pay) generated by receiving rewards is caused by performance rather than being a cause of performance, while some other satisfaction dimensions (such as satisfaction with co-workers and supervisors) may enhance performance.

Another explanation for unsatisfactory previous research results can also be attributed to changes in the conceptualisation of job performance. In early organisational studies such as the Hawthorne studies, job performance is considered to be virtually the same as task performance, defined as

> the proficiency with which incumbents perform activities that are formally recognized as part of their jobs; activities that contribute to the organization's technical core either directly by implementing a part of its technological process, or indirectly by providing it with needed materials or services. (Borman & Motowidlo, 1993a, p73)

In recent decades, another category of employee behaviour, known as organisational citizen behaviour (OCB), has been identified and accepted by both academics and practitioners. This assumes that job responsibilities, expressed active involvement in the organisation, and innovation for the benefit of the organisation take place even without reward expectations (Eisenberger et al., 1990). Job performance nowadays includes task performance, OCB and even counterproductive behaviours in some situations (Viswesvaran & Ones, 2000). As an early stage exploration, this study focuses on task performance (TP).

2.2 Conceptual model development

Many conceptual models describing job satisfaction and performance have been proposed, as presented in Figure 1 adapted from Judge, et al. (2001). The first three models assume there are causal relationships between job satisfaction and job performance. Model 4 and Model 5 assume there are antecedents or moderators affecting the S-P nexus. Model 6 is the null model that assuming there is no relationship.

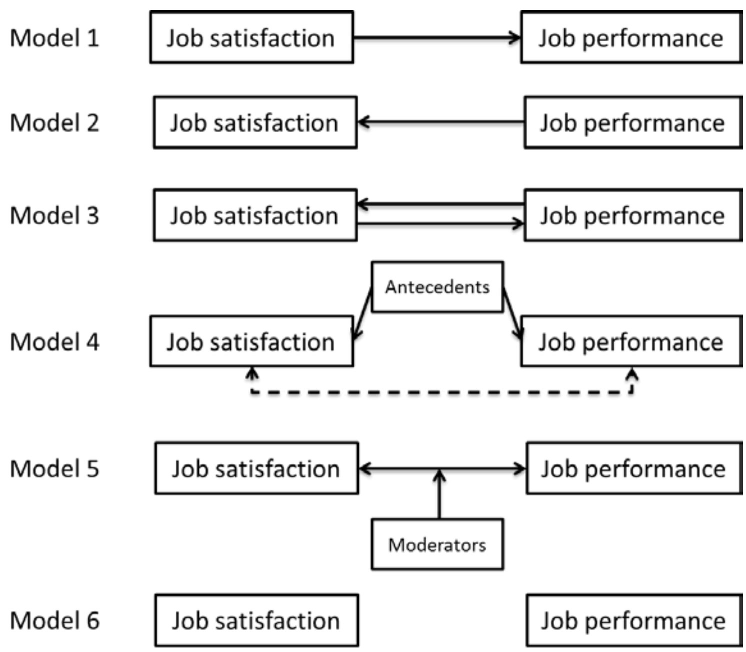


Figure 1: Main conceptual models of the S-P nexus

Following the majority of previous studies (Judge et al., 2001; Organ, 1988), this paper assumes there is a positive correlation between overall job satisfaction and job performance. In addition to the overall S-P nexus, a fine-grained hypothesized model is developed by using two broad dimensions of job satisfaction in terms of ES and PS. The theory of reciprocity and motivation theory are used to develop the conceptual model, as presented in Figure 2.

Figure 2: Proposed conceptual model in this study

3. Research method

3.1 Questionnaire survey

To explore the S-P nexus, related items of the questionnaire survey concerning interactions between person and environment are used, as presented in Table 1. Respondents are construction cost engineers also known as quantity surveyors. To measure job satisfaction, eight items as presented in Table 1 are used based on previous works of Smith (1969), Cotton and Tuttle (1986) and Xiong et al. (2014). Following previous works of Skitmore and Marston (1999) and Leung, Olomolaiye, Chong, and Lam (2005), five items such as "I estimate the budget of the project without overrunning" are used to measure task performance of those professionals.

Table 1: Measures of Job satisfaction

No.	Job satisfaction measures	1-not at all to 7 very intensive	Don't know
Q1	*Satisfaction with pay*	*1 2 3 4 5 6 7*	□
Q2	*Satisfaction with promotional opportunities*	*1 2 3 4 5 6 7*	□
Q3	*Satisfaction with organizational welfare*	*1 2 3 4 5 6 7*	□
Q4	*Satisfaction with work itself*	*1 2 3 4 5 6 7*	□
Q5	*Satisfaction with supervision*	*1 2 3 4 5 6 7*	□
Q6	*Satisfaction with co-workers*	*1 2 3 4 5 6 7*	□
Q7	*Satisfaction with workload*	*1 2 3 4 5 6 7*	□
Q8	*Satisfaction with current tasks*	*1 2 3 4 5 6 7*	□

Because of cultural and linguistic differences, the translation of questionnaires from English to Chinese needs be carried out with care. To keep sure of content validity, the translation and back translation technique (see detailed steps in Xiong, Skitmore, and Xia (2015)) was applied with assistance of four bilingual researchers.

3.2 Data collection and demographics

The snowball sampling technique is useful to gather sensitive information, especially in a situation where random sampling is not available. Snowball sampling allows researchers to access informants through contact information provided by other informants, and has been the most widely employed sampling method in many disciplines across the social sciences (Noy, 2008). Considering the study context, this technique is appropriate to this study. 285 complete responses among 310 returned ones were considered valid for further analysis in this study. The majority of respondents have a bachelor degree or higher education level. Respondents are almost evenly distributed across some characteristics, including gender (male/female), working city/state, company type (property developer/construction company/consulting company) and employment sector (public/private). To evaluate the internal consistency of the questionnaire items, Cronbach's alpha is calculated in SPSS 21.0, with the overall value equal to 0.868, indicating good consistency.

4. Result

4.1 Principal component analysis

The PCA confirms a two-dimensional structure of job satisfaction, with a 0.836 Kaiser-Mayer-Olkin measure of sampling adequacy higher than the a cut-off value of 0.5 and a highly significant $p<0.0001$ for Bartlett's test for sphericity indicating that the items are suitable for factor analyses. The solution with applying varimax rotation explains 65.7% variance of overall variance with component 1 and component 2 accounting for 50.5% and 15.2% respectively. Loadings with components, means, standard deviations and communities (h^2) of items are summarised in Table 2.

Table 2: Principal component analysis with varimax rotation

Items	Components		Item parameters		
	1	2	Mean	SD	h^2
Q1	*0.130*	*0.857*	*3.860*	*1.325*	*0.751*
Q2	*0.263*	*0.813*	*3.912*	*1.328*	*0.730*
Q3	*0.242*	*0.817*	*3.891*	*1.391*	*0.726*
Q4	*0.652*	*0.387*	*4.488*	*1.165*	*0.576*
Q5	*0.628*	*0.383*	*4.656*	*1.439*	*0.540*
Q6	*0.792*	*-0.087*	*5.193*	*1.163*	*0.635*
Q7	*0.680*	*0.347*	*4.284*	*1.327*	*0.583*
Q8	*0.797*	*0.287*	*4.442*	*1.254*	*0.717*

4.2 Correlation and regression analysis

To investigate the necessity to distinguish ES and PS, effects of sub-dimensional satisfaction on task performance are explored by applying regression analysis. Average values of ES, PS, and task performance are calculated. Overall satisfaction is attained by calculating the average of ES and PS with assuming equal weight. Correlations of these factors are firstly presented in Table 3. Regression analysis is firstly applied as Model A. If these two dimensions share consistency (e.g. Nerkar et al. (1996)), their effects on task performance should be consistent. However, it is found that only PS has a significant positive effect on task performance. Model B is then developed as conceptual model presented in Figure 2. The attained results are reasonable that PS positively affects task performance, and TP positively affects ES.

Table 3:Correlations between factors

Factors	A	B	C
A. task Performance	1		
B. ES_A	0.193**	1	
C. PS_A	0.344**	0.558**	1
D. overall satisfaction	0.296**	0.905**	0.858**

Note: **. Correlation is significant at the 0.01 level (2-tailed).

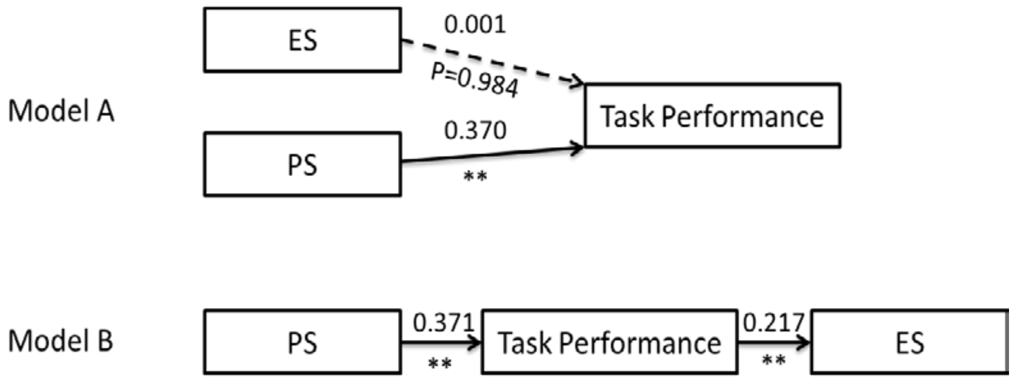
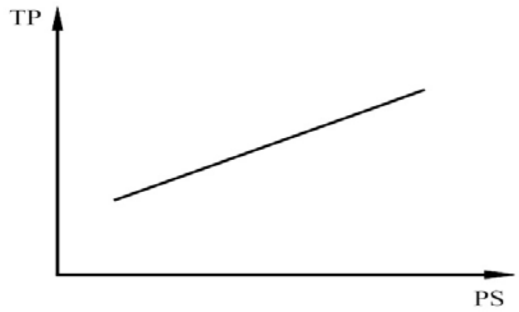
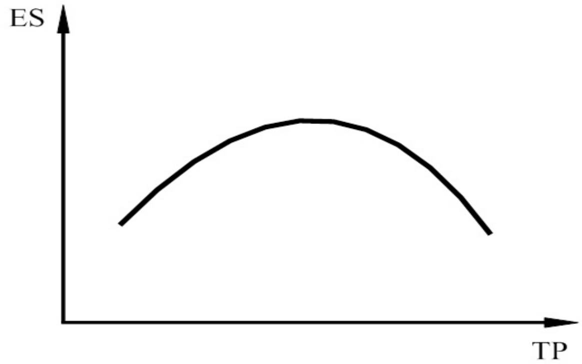


Figure 3: Model evaluations by regression analysis

4.3 The form of interaction

The above linear regression results reveal overall positive effects of PS on TP and TP on ES. It is found in studies of stress that although work stress has an overall negative effect on job performance, the relationship would be better to be descripted as n-shaped or inverted U-shaped form that there is a quadratic effect of stress on performance (Leung et al., 2005; Xiong et al., 2015). Considering similarity between stress and satisfaction, this study explores relationship form of two relationships in terms of PS-TP, TP-ES. Results are presented in Table 4.

Table 4: forms of effects

Relationships	Relationship form
PS-TP	
TP-ES	

5. Discussion and Conclusions

n previous studies on the nexus between job satisfaction and job performance, job satisfaction has been widely taken as a holistic term without investigating the internal dimensions. In the literature review, a two-dimensional structure of job satisfaction is proposed. As presented in Table 2, economic satisfaction (ES) and production-related satisfaction (PS) are different components. Similarly, job performance is a multi-attribute concept. This study focuses on task performance only.

To evaluate the validity of the proposed model in Figure 2, correlation and regression analyses are applied. Comparing the modelling results of Model A and Model B, it is necessary to distinguish ES and PS. Additionally, this study proposes a new model to describe relationships between the sub-dimensions of job satisfaction and performance. In addition to support from theories including reciprocity theory and motivation theory, this model is demonstrated as valid by empirical evidence gained from construction professionals in China.

In addition to overall positive linear effects of PS-TP and TP-ES as presented in Figure 3, it is found that n-shaped relationship would be better to describe the effect of TP on ES. Findings in this study would benefit further studies on the nexus between job satisfaction and performance.

There are a few limitations worth to be mentioned. Following the stimulus-organism-response paradigm in studying employee behaviour, antecedents of job satisfaction and performance include working environment factors like organizational support and individual characteristics (Xiong, 2015). Without considering these factors thoroughly, situations like Model 4 and Model 5 pointed by Judge et al. (2001) are needed to be further investigated in future research.

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Towards new shores in the Norwegian AEC-industry – A review of building process-related R&D initiatives and their impact

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Abstract

The overall and increasing awareness about the need to rethink traditional building processes has kicked-off a number of efforts in Norway. This conceptual paper presents a review of building process related R&D initiatives in the Norwegian AEC-industry. The paper reflects on the role of these initiatives as change drivers; in the transformation process from where the AEC-industry is today, towards new shores. The initiatives are many and there is a lack of holistic understanding of how the initiatives work (or not work) together in an ecosystem of change. The paper suggests a holistic framework for gaining better overview and understanding of the interrelationships between initiatives aiming to improve how we organize and execute building projects.

The framework contains two main dimensions. The first dimension is the definition of three levels of activity; the societal/authority level, the AEC-industry level, and the project level. The paper describes several examples of initiatives on each level. The second dimension is the identification of four groups of change drivers and measures; 1) game-changers, 2) top-down initiatives, 3) bottom-up initiatives and 4) incubators. These four groups are characterized by various degrees of being planned or random, and by having long-termed/global impact or short-termed/local impact perspectives. Strengths and weaknesses of the groups are discussed, as well as interrelationships across levels and interfaces. The paper applies a reflective approach, based on observations of practice in the Norwegian AEC-industry, through participation in workshops, discussions, and conferences. The discussions are furthermore based on reviews of key documents such as policy documents, strategies, and research proposals.

The increasing complexity and the rapid development on all levels in the AEC-industry calls for a more systematic, interdisciplinary, continuous and holistic competence and knowledge building. A better understanding of how the related R&D initiatives work, or counteract, can be helpful in optimizing their effect on the building processes.

Keywords: building process, change, holistic framework, R&D, overview.

1. Introduction

"I have yet to see any problem, however complicated, which, when looked at in the right way did not become still more complicated." Poul Anderson.

There seems to be a widespread consensus in the Norwegian AEC-industry (architecture, engineering, construction) about the urgent need for more research-based knowledge on how we should organize and execute our building projects. A number of initiatives with the aim to address this need have been kicked off during the last years.

This conceptual paper presents a review of these initiatives. The paper reflects on their role as change drivers in the transformation from where the AEC-industry is today, to where it should be, according to a number of national policies and strategies. The initiatives are many and there is a lack of holistic understanding of how the initiatives work (or not work) together in an ecosystem of change. The paper suggests a framework for gaining better overview and understanding of the driving forces of building process-related change and improvement in the AEC-industry. The framework is intended as a support for decision- and strategy makers, for funding institutions, and for research environments.

Firstly, the paper describes the backdrop which motivates the current building process-improvement efforts in the Norwegian AEC-industry. The paper briefly presents some theories, which have inspired the approach of the framework. The main part of the paper presents the review and related discussions of the current status in the AEC-industry, based on the application of the holistic framework. The paper concludes with a summary of trends and suggestions for further work.

2. Backdrop

Building, real estate, and infrastructure together represent the largest land-based industry in Norway when it comes to value creation. The sector consists of some few large enterprises and many SMEs. Approximately 320 000 workers in more than 85 000 enterprises are employed in the industry. Thus, directly or indirectly, the industry ensures economic growth and the income of a substantial part of Norwegian employees (Espelien, Theie and Bygballe, 2015). Simultaneously, the industry is responsible for creating and maintaining the built environment which affects us both as a society and as individuals.

In the last decades, groundbreaking innovations in means and modes of collaboration, enabling technologies, and standardization/industrialization of products and processes have unfolded. It is a paradox that the AEC-industry still underperforms when it comes to the quality of its end-products, innovation, and productivity. These aspects affect, in turn, value creation for the end-users and the society. The report of Egan (1998) still seems to be relevant in describing the AEC-industry as "adversarial", "ineffective", "fragmented", and "incapable of delivering for its clients". This is well illustrated in a quote from an American report, stating: "Construction projects frequently suffer from adversarial relationships, low rates of productivity, high rates of inefficiency and rework, frequent disputes, and lack of innovation, resulting in too many projects that cost too much and/or take too long to build. Also, projects continue to injure or kill too many workers, and owners are often disappointed with the quality of the end product" (Darrington et. al 2010). Key actors in the Norwegian AEC-industry pointed in 2014[1] to industry challenges such as:

- *Dysfunctional and fragmented industry:* The tender structure is competitive. There is a conflict-oriented mode materializing in disagreements and trials. There is a need for efforts and measures way beyond the ability of the individual actor;
- *Communication barriers and lack of trust:* There is a lack of transparency in work- and decision-making processes, as well as trust-based relationships and empowered employees;
- There is a need for collaborative efforts engaging and involving actors across the organizational barriers we traditionally face;
- *Short-term goals and focus on the "lowest bid":* Actors of the building process sub-optimize due to short-term focus on economy as decision criteria, rather than contract and order regimes that focuses on performance. There is a need to focus on long term goals, results/end products, user needs and value creation;
- *Increasing complexity:* The numbers of specialists, with different and often divergent needs and aims have increased and add complexity to the process. There is a need for cross-disciplinary approaches and multidisciplinary research activities;
- *Lack of implementation and adaption of projects to new technology and vice-versa:* The technology develops rapidly. This poses great challenges to the actors of the building process in adjusting and keeping up with the pace and the industry lacks trained personnel;
- *Lack of superior role models:* There are few locomotives of innovation within the industry, as it can be found in other successful industries (e.g. the offshore industry). There is a need for superior role models to push forward the innovation front.

This paints a rather gloomy picture of the AEC-industry. However, in several industry-wide discussions, participants emphasize that we should not disregard the stories of success and not forget to look critically on established industry "myths and truths". Yet the overall opinion of the AEC-industry seems to be that there is a need for change in how building projects are organized and executed, and that more R&D is urgently required. This need is further accentuated by:

- Societal challenges such as health and welfare, scarcity of resources, climate change, mitigation and adaptation;
- Urbanization, population growth and related productivity pressure;
- Increased globalization and international market competition, workforce migration;
- Changing markets and user needs, new legal requirements, and clients who are more demanding.

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[1] Identified in industry workshops and gatherings arranged by NTNU (2012-2013) and Bygg21.

Why does the AEC-industry underperform, in spite of all R&D-efforts and groundbreaking innovations, which obviously have enhanced great improvements in other industries? Past efforts show that there is no obvious or easy formula or recipe to success. A better understanding of the interrelationships between the drivers and measures that change how we organize and execute building projects can be helpful. In order to achieve such understanding, we need applicable tools and frameworks.

3. A holistic framework

3.1 Change one thing, change everything?

The current societal, economic and technological trends are requiring, driving and enabling change of practice, research and education across traditional disciplines and curricula. The AEC-industry can be said to be in a transition phase, on its way towards new shores. As a bi-product of this transition phase we see that the AEC-community face an increasing complexity which makes it highly challenging to address the various, partly conflicting, aims and values of all parties involved. The mix of uncertainty, uniqueness, interdependencies and unpredictable cause-effect relations create a context in which AEC-practitioners sometimes are managing mess rather than solving problems. Researchers such as Schön (1991) and Gibbons et al (1994) regards the traditions of Technical Rationality and Mode 1 knowledge production as insufficient in a real-world situation where many solutions cannot be found in a book or manual. Schön (1991) introduces Reflection-in-Action and Reflection-on-Action as fruitful approaches to better understanding how we learn, acquire and apply knowledge. Gibbons et al 1994) introduces Mode 2 knowledge production, which is transdisciplinary, transient, heterarchical and carried out in a context of application.

The awareness that many problems cannot be solved within a single tradition, organization, or on a single level in the AEC-industry, is increasing. This seems to have resulted in a shift from technology-biased focus and "silothinking" approaches, towards more integrated and holistic and interdisciplinary ways of thinking and working in the AEC-industry. There are a growing number of R&D initiatives which are looking at interfaces between entities and traditions, on value-creating synergies and integrated models, on life-cycle scenarios, on "soft" as well as "hard" skills and issues. One of these is consolidated in the CIB priority theme IDDS (Integrated Design and Delivery Systems) (Owen et al, 2010).

3.2 The framework, data and limitations

The idea behind the framework arises out of previous work with developing holistic approaches for better understanding complex phenomena in the AEC-industry (Moum, 2008). It is also based on reflective and explorative analyzes inspired by the thinking of researchers such as Schön (1991) and Gibbons et al (1994). The dimensions and elements of the framework will be explained and demonstrated throughout the review and the discussions which follow in the next section.

This paper is primarily based on observations of practice in the Norwegian AEC-industry, through participation in workshops, discussions, conferences, and on review of key documents such as policy documents, strategies and research proposals. The author has furthermore held key positions in some of the initiatives described. The framework idea and related overview/review is thus based on the reflections of the author, and on a Norwegian context. The paper presents examples of R&D activities, and not a complete summary of everything going on. In the further development of the framework, an extended review of supporting or challenging theories should be carried out, as the framework should be applied on similar situations in other countries. Through this conceptual paper, research fellows are invited to give their view on the framework and its usefulness. The framework and the related reflections are meant to kick off discussions and inspire further R&D activities in the field.

4. A multi-level review of the Status quo

The overall and increasing awareness about the need to rethink traditional building processes has kicked-off efforts on various levels. Three levels represent the first main dimension in the framework: 1) the societal/authority level, 2) the AEC-industry level and 3) the project level. In the following section, a brief overview of change-driving initiatives and measures related to each level is given.

4.1 Societal/authority level

"Buildings and infrastructure create great value and quality for its users and the society. They are flexible and use technology in smart ways. The construction industry contributes to solving social, health-related and environmental challenges in the society. The industry produces error-free, environmental-friendly and cost-efficient buildings and infrastructure, and improves the existing built environment. The construction sector is productive, innovative, competitive and strongly positioned on the global arena. The sector is effective, has a good reputation and it provides highly attractive work-places." (Ministry of Local Government and Regional Development, 2012. Authors translation).

This 2030-vision is stated in the White paper Good Buildings for a Better Society (2012), which was handed over to the Norwegian Parliament in 2012 by the Ministry of Local Government and Regional Development. The White paper is based on around 30 contributions from academia, organizations and companies/actors representing the entire value chain of the AEC-industry. As a result of the objectives and intentions described in this paper, a collaborative and interactive arena between the public authorities and the AEC-industry was established in 2013. This collaborative program is called Bygg21 (Construction 21), and is hosted by the Agency for Construction Quality (Direktoratet for Byggkvalitet/DiBK).

4.2 AEC-industry level

Bygg21 has developed an overall strategy for the AEC-industry (Bygg21, 2014), which addresses three main activity areas; 1) R&D and innovation, 2) education and 3) knowledge dissemination. Four building process-related focus-areas of R&D have been identified in this strategy; 1) Standardization and industrial design, 2) Value-creating collaboration, 3) KPIs and benchmarking, and 4) Simplification of laws and regulations.

The board of Bygg21 consists of people representing the CEO-level in leading Norwegian R&D- and AEC-companies. Bygg21 has initiated and partly also funded several ongoing activities on national level. One of these is the "Next step" project – a national guideline which organizes the building process in 8 key stages, from "cradle to grave" (from strategic definition to demolition). The guideline is a modified and Norway-tailored version of RIBAs plan of work[2], and shall contribute to an AEC-industry wide terminology and common understanding of the main stages of the building process. Another important activity is the so-called "performance benchmarking project", where the American Construction Industry Institute's 10-10 benchmarking system[3] is tested out by a number of companies in the Norwegian AEC industry.

In 2012, several key players in the AEC-industry formulated a collective call for more knowledge on building processes. NTNU carried out, on their assignment, a feasibility study on how to organize a national joint effort. This resulted in the establishment of Project Norway in 2014 – The Norwegian Centre of Project-Related Activity[4]. Project Norway includes a program dedicated to the AEC-industry and building process-related R&D (the BAE-program). Today, the program has around 15 partners including NTNU, SINTEF and BI Norwegian Business School. In its strategy, the program states that its partners shall actively contribute to initiating and stimulating experience exchange between R&D projects and activities. The program seeks furthermore to improve the framework conditions for process-related R&D and innovation (funding models, national policies etc.).

Other Norwegian AEC-networks, organizations and communities which have process-related R&D and innovation on their agenda is BuildingSMART Norway, Lean Construction Norway and the professional associations and organizations. Examples of thematic collaborative initiatives (stimulated by the authorities) are joint efforts with the aim to improve HSE (no mortal injuries on the construction site) or avoid AEC-industry criminality and "black" working. One of the latest initiatives on AEC-industry level is to develop a roadmap for a digital AEC-industry (the first gathering took place in October 2015, hosted by The Federation of Norwegian Construction Industries/BNL).

4.3 Project level

Throughout the last five years, a number of building-process related R&D projects have been established. Typically, these are so-called Innovation projects. Innovation Projects for the Industrial Sector are funded by User-driven Research based Innovation (BIA), a programme of

[2] http://www.ribaplanofwork.com/Download.aspx
[3] https://www.construction-institute.org/scriptcontent/10-10_promo.cfm
[4] http://www.prosjektnorge.no

The Research Council of Norway (RCN). The BIA programme aims to promote value creation in Norwegian trade and industry through research-based innovation in companies and the R&D groups with which they cooperate (RCN, 2015). Innovation Projects are owned by a company or organization, and they include research activities and knowledge development needed for implementing innovations and value-creating renewals. These projects call for a research methodology which enables a high degree of interaction between the industrial partners and the involved R&D environments. A successful implementation which enables a subsequently value-creating effect in the companies is crucial.

Table 1 shows ongoing Innovation projects (except BA2015, which is a consortium funded project). This funding model is dominating in the current Norwegian AEC-industry. The projects are commonly based on real-life demonstration projects and/or case-studies. Building projects are actively used as a living lab for collecting data, learning and testing out new solutions. The possibility of in-kind contribution instead of cash seems to lower the threshold for industry partner involvement. This might to some degree explain the dominance of this funding model within building process related R&D.

"Hot topics" are lean design and production, BIM, new collaborative models, value creation, efficiency, project management and the learning from other industries (such as oil and gas).

Table 1: Overview of ongoing R&D projects (Source: BAE-program)

Project	***Purpose***	***Periode***	***Project owner and partners***
OSCAR – Creating value for owner and user (innovation project)	*Focus on early stage planning and experiences from operation and use. Effectiveness.*	*2014-2017*	*Multiconsult AS (consultant company)*
SpeedUp (innovation project)	*50% shorter execution time. Eliminating time-thieves and making processes more efficient.*	*2014 - 2018*	*Reinertsen (consultant company, former contractor)*
SamBIM - BIM-driven collaboration in the building process. (innovation project)	*Develop BIM-driven processes and collaborative models that boost value creation.*	*2012-2016*	*Skanska Norway (contractor)*
HPWS - High Performance Work. (innovation project)	*Development of the Norwegian collaborative model for efficient production in periods with hired workforce.*	*2013-2017*	*Grande Entreprenør (contractor)*
INPRO - Integrated methodology for design management. (innovation project)	*Better understanding management of production based processes, based on involving planning (Involverende Planlegging).*	*2013-2017*	*Veidekke Entreprenør (contractor)*
BA2015	*Improve efficiency and sustainability of the AEC-industry. Focus on benchmarking (collaboration with CII in the USA), and demonstration projects.*	*2013 - 2015*	*Consortium-funded program with 18 partners from industry and academia. Project management by Metier, SINTEF and NTNU.*

5. Discussion

The multi-level status quo shows that there are many process-relevant R&D initiatives going on or on their way. How do they contribute to change and impact, across levels, actors and projects? To which degree are these initiatives drivers or measures for change – and what are their weaknesses? In order to discuss this, the following section explains the second dimension of the conceptual framework: the four groups of change-drivers and measures.

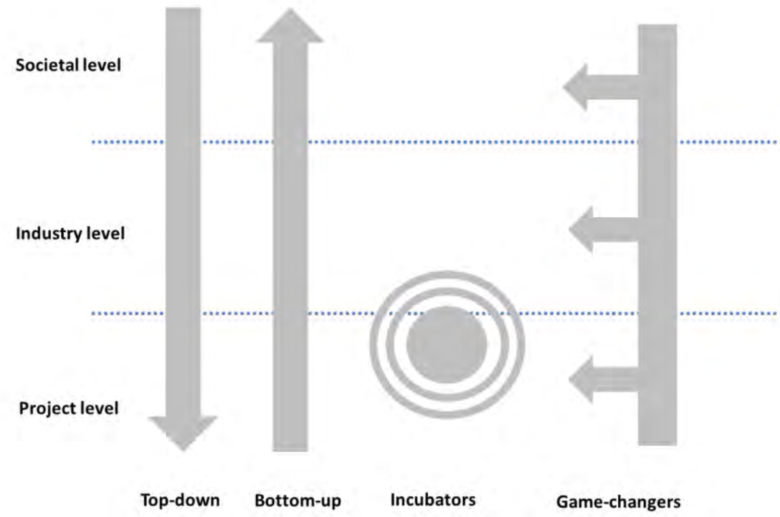

Figure 1: Change drivers

5.1 Game-changers

Game-changers, as we use the term in this paper, are people, products or processes with the power to change mindsets and how we live, collaborate and work. Enabling technologies are obvious examples of game-changers. The last few years have shown us how much Internet, new user-interfaces such as touch-screens, apps, and the social media can influence our daily work and social lives. Future powerful game-changers are expected to be, for instance, 3D printing, nano-technology and the Internet of Things. Non-technological examples of game-changers are political systems, market-mechanisms (global markets and competition) and environmental issues (e.g. earthquakes, global warming, and scarcity of resources).

Technological game-changers can trigger chaos or quantum leaps. They can enable improvement, new businesses, innovation and value creation, *if* we are able to see their possibilities and to implement them, modify them or adjust to them. They create possibilities and challenges on and across all levels. To be an early adapter or even creator of a game-changer, can create completely new business possibilities. Steve Jobs with his Apple-products is a much used example. It is, however, hard to predict what are actual game-changers and not only a dead-end development (the Kodak-effect) or a mayfly phenomenon. It can, on the one hand, be a cost- and time high risk-activity to hop-on an early stage development. As it can, on the other hand, be a risk not to participate. To make the right decision requires a good understanding of trends and market mechanisms.

In the AEC-industry, much focus has been put on implementing Building Information Modelling and the related standards and software-solutions. Already ten years ago BuildingSMART prophesized a paradigm shift in how we manage and handle information.

5.2 Top-down

Standards, laws and regulations are powerful examples of top-down change-drivers. Other examples are policies, strategies and charters. They are placed on the scale between compulsory and voluntary. Top-down initiatives are mostly strategic and goal-oriented, with a long-term view. They are often initiated by authorities or by the management level in companies and organizations. Thus their creators possess great authority and influence. A weakness of laws, regulations and standards, is that they can be conserving. They can thus hamper innovation and change if they do not match the societal development. In Norway, there is a tradition for involving citizens and employees in the process of establishing top-down initiatives (hearings, workshops etc.). Still, the weaknesses of measures such as strategies and policies, is related to ownership, alienation and commitment. One much used phrase is that "culture eats strategy for breakfast". Without people who are willing to commit, change or improve, it is hardly possible to realize strategies or goals (at least in our part of the world). Thus, many good plans and intentions remain in the management drawers, only to be mentioned in sales material and principal speeches.

Examples of top-down examples in the AEC-industry, apart from laws and regulations, are the governmental policy paper, the strategy of Bygg21 or the Project Norway-program, and the "Next step" initiative. In Norway, the public clients are important role models in the AEC-industry. Statsbygg did already in 2007 require the use of open BIM in their building projects – thus pushing the broad implementation of related technologies in the AEC-industry.

5.3 Bottom-up

"One-man" initiatives, based on personal engagement, belief and commitment are another powerful driver of change. This is particularly the case if the group or person is in the position to convince their companies or networks about the need to change or adapt to something new (for instance by being a project manager). Individuals or groups seem to be closer to the take-up of new ideas and ways of thinking than a big organization. Such initiatives might pop up and "grow" randomly. The management-level might not recognize or attend to them, and they might not be embedded in a strategy or directed towards a common long termed goal. Another weakness is the lack of robustness and the strong dependency on the initiators knowledge/competence and availability. Internal development projects within companies can also be regarded as a kind of "one-man-initiatives" in the AEC-industry, as they are mostly closed and decoupled from other similar activities in other companies.

An example of a bottom-up initiative is the implementation of lean principles in a Statsbygg project (Kunsthøyskolen i Bergen). The project manager is convinced of the usefulness of lean and is applying some of its tools and methods on the management of design and construction. Based on the experiences in this project (which, by the way, has got a lot of prices and awards for its innovative process approach), lean is now implemented in other Statsbygg projects (a shift from bottom-up to top-down).

5.4 Incubators

Incubators are collaborative "local" platforms or R&D projects where for instance research and industry partners join to find new solutions to identified problems (theoretically and/or practically). Such incubators are often closely linked to one single/some few companies' interests and business goals. They are temporary and involving a "closed" consortium of partners. Such projects can be important "low-threshold" incubators of change and improvement in the businesses involved. The strength of the incubators is that they are thematically focused arenas. It might be easier to commit and recruit partners to such initiatives than to permanent, thematically open "top-down" initiatives. Incubators might however have limited impact beyond the consortium and the life-time of the project. It is a risk that such projects can become separate silos of knowledge-development.

The innovation projects in Table 1 are examples of incubators. It is interesting to observe that most of these projects have very broad scopes, each of them aiming to address an array of the industry challenges.

5.5 The ecosystem of change drivers

How do these main groups of drivers and measures of change interact with each other? They are for instance characterized by various degrees of being planned or random, and long-termed or short-termed perspectives (Figure 2).

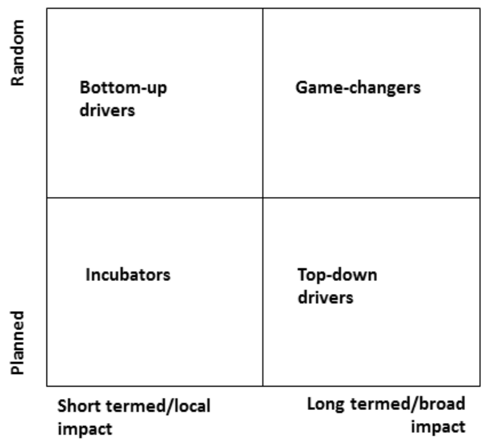

Figure 2: The conceptual framework

The interface between the "boxes" in Figure 2 is dynamic. Initiatives can initially be bottom-up driven, before they become an incubator, and/or integrated in a top-down strategy. Game-changers can inspire bottom-up or top-down initiatives. Incubators and bottom-up initiatives might catalyze new game-changers. The four groups of drivers impact on each-other. They work/play together in an eco-system, where the strengths lie in their additive impact, not in each single box. Game-changers without incubators or top-down/bottom-up initiatives would lack their instruments of implementation. Without game-changers, top-down or bottom-up initiatives would lack an important motivation. Incubators only would lead to a fragmented and unsystematic knowledge development. Top-down initiatives only might become conserving and not well rooted in real-life practice. Bottom-up initiatives only would lead to random and local change, without long-termed perspectives and goals.

The described initiatives did not emerge chronologically or develop step-by-step. They are rooted in a multi-level awareness-wave of the need to improve and change. There has also previously been carried out ambitious initiatives in Norway with the aim to improve processes. They mobilized a lot of partners and kicked-off many projects. Still, they did not have the impact hoped for after they were completed. Perhaps the Norwegian AEC-industry now, 10-15 years later, have reached the maturity, which is needed to improve how we organize and execute building projects.

6. Conclusions

The review in this paper indicates that there is a focus shift in the Norwegian AEC-industry and its process-related R&D:

- There is a growing awareness on all levels that process-improvement is needed in order to secure quality, productivity and competitiveness.
- More focus on life-cycle perspectives, the interfaces between people and process stages, and the need for interdisciplinary and holistic approaches.
- “Outside the box” thinking is increasingly called for. It is a paradox that many attempts of solving the problems are based on the same thinking that originally created them, and that an obvious solution to a problem within one area create new problems in other areas.
- There has been a shift from technology focus to people/culture focus (from "hard" to "soft" and qualitative/hard-to-measure issues).
- More focus on systematic and continuous learning and on the usefulness of looking to other countries and traditions (e.g. several Norwegian contractors have been hiring high-profiled Stanford researchers for implementing VDC).
- Process-Innovation is increasingly recognized and appreciated in the AEC-industry. In 2015 the AEC innovation price was awarded to a contractor for their effort on lean-based process-improvement.

The increasing complexity and the rapid development on all levels call for a more systematic, interdisciplinary, continuous and holistic competence and knowledge building. This greatly challenges the actors involved, due to capacity, openness, to balancing short- and long-termed goals and activities. Successful change and adjustment requires the ability to take risks, to prioritize, to understand possibilities, to understand what is possible to control and what should not be controlled, to adjust and modify. To bring good intentions and ambitions into action and effect will probably remain a challenging act.

This conceptual paper has presented a review of the current situation in the Norwegian AEC-industry, and suggested a holistic framework for better understanding the interdependencies between various drivers and measures of change. The next step for developing the framework would be to move towards theorizing and selecting relevant theoretical perspectives for understanding the phenomenon. The review indicate however that R&D initiatives, when working together in a balanced ecosystem, might guide the Norwegian AEC-industry towards new shores. On this voyage, a final reminder is appropriate: Change for a reason and not for the sake of change alone.

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Construction Camps in Building and Civil Engineering Construction

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Abstract

The establishment of construction camps needs to be addressed by contractors working outside of urban areas or in areas that are not readily accessible on a daily basis.

The establishment of construction camps is subject to legislation and international recommendations. However, construction camps, medical assistance and facilities, inter alia, living, sleeping, ablutions, cooking, washing and recreational, impact on labour relations, health, the environment, productivity and the achievement of quality. Given the aforementioned, the establishment of construction camps should form an integral part of any health and safety (H&S) programme, and be addressed in H&S specifications and H&S plans where applicable. South African literature pertaining to construction camp practices is perfunctory. To this end a descriptive survey was conducted among building and civil engineering contractors undertaking projects for the East Cape Department of Roads and Public Works (ECDRPW).

Findings include, inter alia: contractors provide spartan accommodation and sleeping facilities, rudimentary ablutions, minimal cooking and washing facilities; recreational facilities are marginal, and first aid constitutes medical assistance.

Conclusions include, *inter alia*: the conditions in construction camps are inadequate and could be enhanced; the providers of such camps are non-compliant and not committed to best practice, and the prevailing conditions are unlikely to complement workers' health and wellbeing, the environment, productivity, and the achievement of quality.

Recommendations include, *inter alia*, an industry standard should be evolved in terms of the types of construction camp accommodation and facilities, which should also be clearly identified during the early stages of projects, and during the 'tender documentation and procurement' stage.

Keywords: construction camps, living and ablution facilities

1. Introduction

The establishment of construction camps is subject to legislation and international recommendations. However, construction camps, medical assistance, and facilities, *inter alia*, living, sleeping, ablutions, cooking, washing and recreational, impact on labour relations, health, the environment, all affect productivity and the achievement of quality. Given the aforementioned, the establishment of construction camps should form an integral part of any health and safety (H&S) programme. Studies indicate that up to 30% of workers across construction organisations would be transient in nature and require rental and temporary accommodation (Chang-Richards *et al.,* 2014).

Construction work is tough, dirty and hazardous and involves high levels of manual and / or physical activity. Therefore, good welfare facilities not only improve workers' welfare, but enhance efficiency (ILO, 1995, Muiruri and Mulinge, 2014).

Transient construction sites, is where work is of short duration (up to a week) or completed over a number of locations. Work of longer duration may include working over continuous geographical areas, where major road works, cable laying contracts are examples cited by the Health and Safety Executive (HSE) (2011).

Given the abovementioned and the paucity of literature pertaining to the subject area, a study was conducted to determine practices relative to the accommodation of management, supervision, and workers working on construction projects in rural areas, and more specifically to determine mainstream construction camp practices.

2. Literature Review

South African literature pertaining to construction camp practices is perfunctory. Therefore, the literature was mostly sourced from international standards, guidelines, articles, and case studies. Construction occurs in mining and general industries within their general maintenance activities, so the literature is not only confined to infrastructure development.

2.1 The effect of camps on communities and construction workers

The Western Australia development boom over the past few years led to under-developed communities being overwhelmed with a new population that would arrive with new ventures. With such development come social and economic stresses. Local resources become stretched and result in local authorities being unable to meet such demands in terms of infrastructure, transportation, and even basic supplies. While this has advantages for the local community it could lead to shortages relative to accommodation, and workers having to walk distances to shops and for basic supplies not available where the site camps have been located (Mathiesen, 2003; McKenzie, 2015).

2.2 Standards

The European Bank for Reconstruction and Development (EBRD) and International Financial Corporation (IFC) (2009) refer to the ILO Workers' Housing Recommendation 115, which *inter alia*, states that it is generally not desirable that employers provide housing for their workers directly, and that they should seek alternatives. If there are no alternatives, employers should pay attention to workers' rights and housing standards. Housing standards should include special attention to: minimum space allocated per person; supply of potable water; adequate sewage and garbage disposal; adequate protection against heat, cold, damp, noise, fire, disease-carrying animals, and insects; adequate sanitary and washing facilities, ventilations, cooking and storage facilities, and natural and artificial lighting, and a minimum degree of privacy for individuals. Furthermore, where accommodations are provided for single workers, the following should be considered: a separate bed for each worker; separate gender accommodation; adequate sanitary conveniences, and common dining rooms, canteens, rest and recreation rooms and health facilities where otherwise not available in the community.

The International Labour Organization (ILO) (1992) states that suitable living accommodation should be made available for construction workers where work is undertaken in remote areas. Remote sites are noted as where adequate transportation between home and work is not available. The ILO note that genders should have separate facilities, such as sanitary, washing and sleeping facilities. Shelters, furthermore, should as far as practicable provide washing, eating facilities, and the storage of clothing where not available close by.

The ILO helpdesk has published a guideline as to how workers should be housed, and what could be taken into account. Minimum specifications and levels are provided. Workers housing should ensure that workers' are not affected by air pollution, surface run-off, sewage, or other waste. Provision of rest and recreation rooms, even health facilities should be available if not in the local community. Sleeping quarters should be between 7.5m^2 and 14.5m^2 where up to 4 persons share. Shifts should be separated so that workers are not disturbed. Aspects such as vermin, fire protection, emergency exits and planning, and regular inspections to ensure decent condition and that the premises are in a good state of repair (ILO, 1996).

A Danish study indicated that camps were created by the developers, were in remote areas around the construction site and lacked shops and welfare facilities. Workers could also use their own caravans, ablutions were shared and conditions were noted as poor. Communal areas were available, with a privately run canteen and a bar run by the occupants (Mathiesen, 2003). Maidment and Trotter (1967) define resilience from the perspective of risk as, "the capacity to foresee …" (pp23-24).

2.3 Long distance work commuting: fly-in fly-out (FIFO)

Western Australia has experienced heightened economic activity over the past few decades, resulting in a reduced unemployment rate and a high demand for labour. The results of the activity created the FIFO positions. The FIFO practice developed in the Gulf of Mexico, in the off-shore oil sector, and has since become pervasive across the mining world. The FIFO work-style that defined as "encompassing all those who travel to work, stay a pre-determined number of days ('roster') then return to a home location for a set break time." (McKenzie, 2010). Mathieson (2003) indicated that Danish workers had the option of staying on site, or commuting. The decision to stay on site is most often incentive related, and calculated accordingly. Nordic countries are further noted as having particular Regulations relative to travel allowances based on distance travelled, with Norway being most regulated.

2.4 Health issues, stress and working away from home

Increased stress related to working away from home has a number of possibly negative outcomes. Construction workers tend to work longer hours, drink more, do not exercise and eat badly. Loneliness is made worse where married employees are forced into a single-person status, which could stretch for years (Pearson and Broughton, 2015).

Mathieson (2003) reports that those in camps regard time off on-site as being still at work. Life on site covers three distinct areas, namely work, time off on-site (at the camp), and time off at home. The time between workdays is required for recuperation for the next day's work. Workers in camp describe a typical workday as work, meals, some television, time with fellow campers, and sleep. Washing, shopping, and contacting family are additional activities.

A number of studies regarding suicide among construction workers in the United Kingdom (UK) indicate that, while not unique to the UK, is reported as being due in part to the peripatetic nature of the workforce. Many construction workers are expected to work away from family and friends for weeks on end, often alone (Pearson and Broughton, 2015). All levels of construction workers are affected. Pearson and Broughton (2015) cite Mel Pritchard, a production leader for Mace, on the Heathrow Terminal 1 project, who has lived and worked abroad, who stated: "If you are on your own, it can be a miserable existence." Mathieson (2003) states that camp life is a lifestyle difficult to tackle, and the ability to withstand boredom, and resisting the temptation to have 'the bottle and get to bed on time'.

Higher levels of morbidity rates were noted where workers were on site, with the cardiovascular and digestive disorders prevalent from lack of rest, and respiratory and locomotor systems affected by general stress. Accident rates were also noted as higher risk among those at construction site camps (Mathieson, 2003).

2.5 Cultural issues

Cultural issues when working in different countries have an impact, for example those working in the Middle East work a six-day week, and according to Mel Pritchard, many do not make it and leave (Pearson and Broughton, 2015). McKenzie (2010) reports that many companies in the Western Australian mining sector are cognizant of the ripple effects of family breakdown caused by the FIFO form of work. As such employers provide wellness programmes, including counseling services to the employee and family. In stark contrast, in developing countries problems of low literacy resulting in poor communication, unregulated construction practices, extreme weather, and a general poor culture do not promote overall health and safety (H&S) standards (Muiruri and Mulinge, 2014).

2.6 The South African legislative framework

In terms of the South African Constitution, there are a number of rights that could be linked to the rights of workers in the context of this paper (Republic of South Africa (RSA), 1996). Section 24 states: "Everyone has a right to an environment that is not harmful to their health", and Section 27 (2) states that "Everyone has the right to have access to sufficient food and water."

Regulation 30(2) 'Construction Employees' Facilities' of the Construction Regulations (RSA, 2014) states: "A contractor must provide reasonable and suitable living accommodation for the workers at construction sites who are far removed from their homes and where adequate transportation between the site and their homes, or other suitable living accommodation, is not available." In theory and in practice, this aspect should be addressed in the H&S Specification and H&S Plan, which in turn requires that the client must ensure that there is adequate resourcing for this aspect when it is identified.

The Occupational Health and Safety Act (OHSA) No. 85 of 1993 requires employers to comply with the rights as stated in the Constitution, as they relate to employees. Employers have a further responsibility as it relates to those directly affected by activities and also are expected to ensure that all equipment and substances designed for use is safe and without risk to health (RSA, 1993a). While these duties apply to the working environment, in many cases accommodation could be adjacent, within or close to the construction works. Thus the line between being separated from the work place, and 'off-duty' could be deemed blurry at best.

Should a worker be injured from activities, equipment or substances on site, there is a strong likelihood of the Compensation Commissioner accepting a claim in terms of the Compensation for Occupational Injuries and Diseases Act (COIDA) (RSA, 1993b). Where a contractor provides transportation to and from site, the worker is deemed to be on site should there be an accident. South African media often reports high numbers of road traffic accidents among construction workers being transported on the back of light delivery vehicles, flat-bed or tip trucks, and motor vehicle accidents in the course of employment contribute approximately 40% of fatalities in construction. The result of excessive COIDA claims for such losses could result in the loading of COIDA premiums.

Smallwood and Wheeler (1998), state that the Facilities Regulations require a range of basic supplies for ablutions, that include soap, toilets, towels showers with hot and cold water. Potable water, separate dining facilities and adequate tables and chairs should be available.

2.7 South African literature

Only one previous study could be identified, conducted by Smallwood and Wheeler (1998). The study indicated that sleeping facilities were provided, and showers, wash hand basins and toilets available. Hand towels were not available and minimal availability of soap. Generally cooking facilities were available. Wash troughs were available for washing personal items and in almost 50% of cases, television, and other forms of recreational facilities were provided. The provision of first aid facilities with access to a doctor and hospital was apparent.

3. Research Findings

A descriptive survey was conducted among a convenience sample of building and civil and engineering contractors who are currently undertaking projects for the ECDRPW. The focus was on the accommodation of management, supervision, and workers working on construction projects in rural areas, and more specifically to determine mainstream construction camp practices. The questionnaires were disseminated by a Manager of the ECDRPW in the Alfred Nzo District, by Construction H&S Agents also working in the area, as well as the ECDRPW Construction H&S Manager for the province. The ECDRPW master H&S Specification used to guide construction H&S Agents and Designers, makes reference to the care of workers on site (Welfare), in that 'adequate toilets, clean, safe drinking water and decent shelter will be afforded workers at all times'. No further reference is made to actual accommodation standards or requirements.

A total of 22 responses were received and included in the analysis of the data. The mean age of respondents was 42.4 years, and 90.9% were male, and 9.1% female. The mean period worked in the construction sector was 17.4 years, and for current employer was 14.4 years. The respondents recorded a diverse range in terms of their level of education – thirteen in total. The highest percentage was 18.2% relative to each of Grade 9 and Grade 12.

27.3% respondents indicated they are building contractors, and 72.7% civil engineering contractors. A total of 68.4% respondents indicated they use construction camps, 10.5% provide such camps, and 21.1% do not use construction camps. In terms of the latter, due to space constraints a table cannot be presented. However, boarding houses, caravan parks, renting a house, and private accommodation were all identified relative to management, supervision, and workers. Bed & breakfasts were only identified relative to management and supervision.

Table 1 indicates the lowest, highest, and mean number of people staying in construction camps. Given the lowest, highest, and mean number per category, it is clear that in most cases, middle and site management are not accommodated on site, however supervisors and skilled, semi-skilled, and general workers are.

Table 1: Number of people staying in construction camps on site

Category	*Lowest*	*Highest*	*Mean No.*
Management:			
• *Middle*	*0*	*4*	*0.37*
• *Site*	*0*	*8*	*0.95*
Supervision	*0*	*12*	*3.68*
Workers:			
• *Skilled*	*1*	*20*	*5.95*
• *Semi-skilled*	*2*	*20*	*6.84*
• *General*	*0*	*50*	*10.11*

Table 2 indicates the extent to which management, supervision, and workers are accommodated on site. Only general workers (MS = 3.18) can be deemed to be accommodated frequently on site as the MS > 3.00. However, semi-skilled, and skilled workers have MSs marginally below 3.00, namely 2.95 and 2.86 respectively.

Table 2: Extent to which management, supervision, and workers are accommodated on site

Category	*Response (%)*						*MS*
	Unsure	*Never*	*Rarely*	*Some-times*	*Often*	*Always*	
Management:							
• *Middle*	*0.0*	*89.5*	*5.3*	*5.3*	*0.0*	*0.0*	*1.16*
• *Site*	*0.0*	*61.1*	*0.0*	*33.3*	*5.6*	*0.0*	*1.83*
Supervision	*0.0*	*38.1*	*28.6*	*33.3*	*0.0*	*0.0*	*1.95*
Workers:							
• *Skilled*	*4.5*	*31.8*	*22.7*	*0.0*	*9.1*	*31.8*	*2.86*
• *Semi-skilled*	*0.0*	*31.8*	*22.7*	*0.0*	*9.1*	*36.4*	*2.95*
• *General*	*0.0*	*31.8*	*0.0*	*22.7*	*9.1*	*36.4*	*3.18*

A total of 33.3% of respondents indicated that fenced-off compounds were ‘always’ provided for the construction camps, 4.8% ‘often’, 52.4% ‘sometimes’, 4.8% rarely, and 4.8% ‘never’. The resultant MS of 3.57 indicates that the practice is between sometimes to often / often. Ideally construction camps should be fenced off for security reasons.

Table 3 indicates the type of living quarters provided in the construction camps. Park homes and tents predominate with MSs of 2.67, and given that the MSs > 2.60 ≤ 3.40, the provision is between rarely to sometimes / sometimes. MSs > 1.80 ≤ 2.60 indicate the frequency is between never to rarely / rarely (pre-fabs), and MSs ≥ 1.00 ≤ 1.80 indicate the frequency is between never to rarely (converted containers and caravans).

Table 3: Types of living quarters provided in the construction camps

Category	*Response (%)*						*MS*	*Rank*
	Unsure	*Never*	*Rarely*	*Some times*	*Often*	*Always*		
Park homes	*0.0*	*33.3*	*4.8*	*38.1*	*9.5*	*14.3*	*2.67*	*1*
Tents	*0.0*	*19.0*	*38.1*	*19.0*	*4.8*	*19.0*	*2.67*	*2*
Pre-fabs	*0.0*	*42.9*	*4.8*	*42.9*	*4.8*	*4.8*	*2.24*	*3*
Converted containers	*0.0*	*57.1*	*28.6*	*9.5*	*4.8*	*0.0*	*1.62*	*4*
Caravans	*0.0*	*76.2*	*0.0*	*23.8*	*0.0*	*0.0*	*1.48*	*5*

The facilities provided by the contractors in the construction camps can best be described as limited (Table 4). Not a single MS is > 3.00, which indicates that the provision of the facilities is infrequent as opposed to frequent. A mean MS was computed for the six categories of facilities: sleeping (1.54); ablutions (1.78); cooking (1.50); washing (1.09); recreational (1.17), and medical aid (1.21).

The highest MS relative to each of the six categories is: sleeping - bed (2.18); ablutions – toilets (2.82); cooking – stove (1.77); washing – outsourced (1.18); recreational – radio (1.50), and medical aid – first aid room (1.50).

Table 4: Types of facilities provided in the construction camps

Category	*Response (%)*						*MS*	*Rank*
	Unsure	*Never*	*Rarely*	*Some-times*	*Often*	*Always*		
Sleeping facilities:								
• *Bed*	*0.0*	*59.1*	*4.5*	*13.6*	*4.5*	*18.2*	*2.18*	*1*
• *Bed linen*	*0.0*	*68.2*	*4.5*	*13.6*	*0.0*	*13.6*	*1.86*	*2*
• *Fans*	*0.0*	*63.6*	*0.0*	*31.8*	*0.0*	*4.5*	*1.82*	*3*
• *Pillow(s)*	*0.0*	*77.3*	*4.5*	*4.5*	*0.0*	*13.6*	*1.68*	*4*
• *Mosquito nets*	*0.0*	*81.8*	*0.0*	*13.6*	*0.0*	*4.5*	*1.45*	*5*
• *Bunk*	*0.0*	*81.8*	*4.5*	*4.5*	*4.5*	*4.5*	*1.45*	*6*
• *Heaters*	*0.0*	*90.9*	*4.5*	*0.0*	*0.0*	*4.5*	*1.23*	*7*
• *Stretcher*	*0.0*	*95.5*	*0.0*	*0.0*	*0.0*	*4.5*	*1.18*	*8*

• *Sleeping bag*	*0.0*	*95.5*	*4.5*	*0.0*	*0.0*	*0.0*	*1.05*	*9*
• *Mean*							*1.54*	
Ablutions:								
• *Toilets*	*0.0*	*40.9*	*9.1*	*9.1*	*9.1*	*31.8*	*2.82*	*1*
• *Showers*	*0.0*	*72.7*	*0.0*	*4.5*	*0.0*	*22.7*	*2.00*	*2*
• *Soap*	*0.0*	*81.8*	*0.0*	*0.0*	*0.0*	*18.2*	*1.73*	*3*
• *Wash hand basins*	*0.0*	*86.4*	*0.0*	*0.0*	*0.0*	*13.6*	*1.55*	*4*
• *Towels*	*0.0*	*90.9*	*0.0*	*0.0*	*0.0*	*9.1*	*1.36*	*5*
• *Urinals*	*0.0*	*90.9*	*4.5*	*0.0*	*0.0*	*4.5*	*1.23*	*6*
• *Mean*							*1.78*	
Cooking facilities:								
• *Stove*	*0.0*	*77.3*	*0.0*	*4.5*	*4.5*	*13.6*	*1.77*	*1*
• *Fridge*	*0.0*	*77.3*	*0.0*	*9.1*	*0.0*	*13.6*	*1.73*	*2*
• *Microwave*	*0.0*	*77.3*	*0.0*	*9.1*	*0.0*	*13.6*	*1.73*	*3*
• *Sink*	*0.0*	*81.8*	*0.0*	*4.5*	*4.5*	*9.1*	*1.59*	*4*
• *Canteen*	*0.0*	*90.9*	*4.5*	*0.0*	*4.5*	*0.0*	*1.18*	*5*
• *Outsourced*	*0.0*	*100.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.00*	*6*
• *Mean*							*1.50*	
Washing facilities:								
• *Outsourced*	*0.0*	*95.5*	*0.0*	*0.0*	*0.0*	*4.5*	*1.18*	*1*
• *Wash trough*	*0.0*	*95.5*	*0.0*	*4.5*	*0.0*	*0.0*	*1.09*	*2*
• *Washing machine*	*0.0*	*95.5*	*4.5*	*0.0*	*0.0*	*0.0*	*1.05*	*3*
• *Tumble dryer*	*0.0*	*95.5*	*4.5*	*0.0*	*0.0*	*0.0*	*1.05*	*4*
• *Mean*							*1.09*	
Recreational facilities:								
• *Radio*	*0.0*	*81.8*	*0.0*	*9.1*	*4.5*	*4.5*	*1.50*	*1*
• *TV*	*0.0*	*90.9*	*0.0*	*0.0*	*4.5*	*4.5*	*1.32*	*2*
• *CD / DVD player*	*0.0*	*90.9*	*4.5*	*0.0*	*0.0*	*4.5*	*1.23*	*3*
• *Satellite TV*	*0.0*	*90.9*	*4.5*	*0.0*	*0.0*	*4.5*	*1.23*	*4*
• *Pool*	*0.0*	*95.5*	*0.0*	*4.5*	*0.0*	*0.0*	*1.09*	*5*
• *Darts*	*0.0*	*100.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.00*	*6*
• *Drafts*	*0.0*	*100.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.00*	*7*
• *Keerum*	*0.0*	*100.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.00*	*8*

• *Mean*							*1.17*	
Medical aid facilities:								
• *First aid room*	*0.0*	*85.0*	*0.0*	*5.0*	*0.0*	*10.0*	*1.50*	*1*
• *Clinic*	*0.0*	*95.2*	*0.0*	*0.0*	*0.0*	*4.8*	*1.19*	*2*
• *Occupational health nurse*	*0.0*	*95.0*	*0.0*	*0.0*	*5.0*	*0.0*	*1.15*	*3*
• *Paramedic*	*0.0*	*95.2*	*0.0*	*4.8*	*0.0*	*0.0*	*1.10*	*4*
• *Medical doctor*	*0.0*	*95.2*	*0.0*	*4.8*	*0.0*	*0.0*	*1.10*	*5*
• *Mean*							*1.21*	

Respondents were requested to provide comments in general regarding construction camps. A total of thirteen comments were received, which equates to an average of 0.59 per respondent. The responses recorded verbatim include: “They are not safe as they are supposed to be”; “Camps are in bad condition”; “Not safe at all”; “We rarely use construction camps as we found local people come and make trouble and things / equipment etc. go missing. We opted to find renting spaces for our staff”; “These camps are in bad condition” (3 No.); “Our camps are in very bad condition and need attention”; “Our camps are in very bad condition and need attention so that they can be in a good state by complying to OHS Act”; “Cultural observances compromise PPE compliance”; “It is our company policy to make use of private accommodation for all staff”; “Occupational Hygiene needs to improve”, and “Condition of the camps are very poor.”

4. Discussion

Although the area in which most of the participants were noted as working could be deemed rural in nature, with very scant if any supply of running water, electricity, or community resources, the Constitution, OHSA, and the Construction Regulations dictate the rights of workers, and that workers are kept well relative to the working environment. Despite the legal requirements, the level of compliance on the contracts can only be deemed poor to appalling. Given that middle and site management are not accommodated on site, and that supervisors and skilled, semi-skilled, and general workers are, indicates that the former are averse to construction camps. A range of living quarters are provided in the construction camps i.e. no standard type is adopted. The sleeping, ablution, cooking, washing, recreation, and medical aid facilities are virtually non-existent.

5. Conclusions and Recommendations

The finding that middle and site management are not accommodated on site, that supervisors are to a degree, and skilled, semi-skilled, and general workers are to a greater extent, and the ‘negative’ general comments received relative to construction camps leads to the conclusion that the level of employees in the hierarchy influences the standard of accommodation and that there is recognition that the conditions of construction camps are not ideal. A further conclusion is that contractors and the client are not committed to the health and wellbeing of their workers and in fact are non-compliant. The range of living quarters provided in the construction camps leads to the conclusion that no industry standard exists.

In terms of recommendations, the EC DRPW should be made aware of the findings of the research, as the client in this case. However, the results are equally important to other clients and employers, who are likely to require their workers to work in remote areas for extended periods. The level of employees in the hierarchy should not influence the standard of accommodation i.e. it should be appropriate, adequate, and decent. Ideally an industry standard should be evolved in terms of the types of construction camp accommodation and sleeping, ablution, cooking, washing, recreation, and medical aid facilities. Furthermore, temporary accommodation and facilities requirements should be clearly identified during the early stages of projects, namely 'project initiation and briefing' and 'concept and feasibility'. During the 'tender documentation and procurement' stage, tender documentation, and especially the H&S Specification, which details the client's H&S requirements, and the Bills of Quantities, should be explicit as opposed to implicit in terms of the requirements and facilitate adequate financial provision therefore. The latter will ensure that the 'playing fields are level', and that contractors making adequate financial provision for H&S will not compromise their chance of winning a bid. Community engagement and participation using social facilitators could enhance the level and standard of accommodation and general facilities, emergency, and general local facilities noted.

Voluntary (built environment and related) associations, and statutory built environment councils should be made aware of the issues relative to construction camps, the need for legal compliance, and also what constitutes 'appropriate, adequate, and decent', with a view to promoting 'better practice' construction camps.

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A heritage park as a form of communication

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Abstract

This article was devoted to research on methods of architectural and urban past commutation towards widespread public, in a scope of wooden and timber-framing vernacular architecture in central European region. It was crucial to determine whether a museum in a form of a heritage park (open-air museum) is still informative and appealing to local society and tourists. On the other hand contemporary commercial approach was discussed, which assumes re-use of old historical building by introduction of new functions (i.e. hotels) and adjustment of structure to nowadays needs. The elaboration is addressed to all: historians, architects, engineers, designers, museum workers, as well as governments and cultural institutions, focused on methods of preservation and popularisation of knowledge on vernacular architecture. Research was carried out on literature and case studies with use of: analysis, synthesis and critical overview. Conclusions present compare synthesis of both aforementioned solutions and an effort to formulate guidelines for the future. Also an attempt was taken to describe the most proper way of cultural education in vernacular architectural and urban heritage, with the highest respect towards original values and minimum loss to the historical verity or knowledge.

Keywords: A heritage park, communication of heritage, adaptation, re-use of architecture

1. Introduction

Architectural and urban heritage is a valid factor in development and transformation of ongoing city and rural planning. Based on long-term experience of past designers and builders, it may also serve as a set of guidelines and inspiration for contemporary movements in architecture (i.e. regional, sustainable, ecological, etc.). It is also a vast database of solutions responding to the human needs, climate requirements and proper building infill into a land or city scape. As Midura (1999) states, it stands as a witness of chosen societies groups' culture, as well as sanctuary of disappearing human natural environment. Important to the scientist and professionals, architectural and urban heritage is most of all, an observer to the history of residents living in a certain region or country at a given time. Their customs, everyday habits, religious believes and overall culture – in many cases already gone today – is reflected in a function, structure and architecture of their buildings.

Contemporarily there are two different methods for vernacular architecture re-use and exhibition. One – a Heritage Park – can be considered today as traditional method itself, while the other – refurbishment and adaptation to nowadays need – may seem innovative, but in some cases destructive for old substance. Worthwhile is the analysis of both cases, in order to find out which treatment will serve better presentation of past customs towards widespread public.

1.1 Scope and method

Central European region – similarly to Scandinavian area – offers expressive examples of vernacular architecture, especially in a range of wooden and timber-framing structures. Therefore, a large number of heritage parks were established in selected localization, starting from turn of XIX and XX century. Soon, a newer process became common, which was a growing interest of private investors' sector in adaptation of historical buildings for new purposes. Thus, both phenomena were included in the scope of presented study.

Research was carried out on: site, through literature and by interviews. The case studies as representative as possible (on site), were carefully selected in the central European area: Bucharest (Romania), Oliwa (Poland) and Seifhennersdorf (Germany). During buildings examination process (which was conducted on urban: arrangements, layouts, cross sections and elevations), there were used – analysis: graphical, comparative, critical and synthesis (for conclusion elaboration). The study focused mainly on how much of original substance was kept during regeneration process, what was preserved, what demolished and which method was used. These researches were preceded with literature studies, complemented by interviews and talks, carried out by authors with building owners and experts. The later turned out to be crucial in understanding of a process of old structures adjustment to contemporary users' needs, safety regulations, fire protection issues and many others.

2. Traditional Heritage Park

Especially vernacular architecture, as the one serving all basic human needs and purposes, is most informative of all for scientists and researches as well as for contemporary communities. Related mostly to the wooden and timber-framed village landscape, may be inaccessible to the wider public, due to a large spread of buildings at a certain regions. Moreover preservation of vernacular monuments may be impossible in their original environment (Midura 1999).

In XIX century village lifestyle started to transform, due to technological change in: tools, farming methods and overall living situation. In order to save disappearing buildings and barns, Artur Hazelius, who already took part in organization of previous national displays at worldwide exhibitions, started to gather monuments, creating in 1873 beginnings of Swedish ethnographical collections (Nor. *Skandinavisk-etnografiska samlingen*). In 1880 they have been transformed in Nordic Museum (Nor. *Nordiska Museum*). His next activities lead in 1891 to collection of historic houses and barns on Djůgarden Island and initiating new form of gathering and presenting of historical village buildings and items – on an open air. This exposition type became a model for emerging at the turn of XIX and XX century open-air museums (Nor. *Nordiska museet, Skansen*), i.e. already in 1881 new facility was opened near Oslo. (fig. 1) (Szolginia 1992) Interest in folk art and collecting of monumental building, intensively evolved at the beginning of XX century, thus in 1914 in Europe 104 *Skansen* museums were established (including 81 in Norway and Sweden). (Szolginia 1992), (Trocka-Leszczyńska 2001) Complexes of this type created in other countries, i.e. Germany (Germ. *Freiluftmuseum*. *Freilichtmuseum*) – forming a sort of a *heritage parks* – were popularized, as a method of presenting past architecture and achievements to the society and tourists. Such model of exhibition enabled visitors to analyse and compere buildings from different regions in a few hours, as the scientific researcher would do even during a life-time study. Arranged in increasingly innovative way heritage parks became very popular, and this process was intensified after WWII, when UNESCO and ICOM got involved between years 1956-1958. Only then, governments included open-air displays in official policies and scientific guidelines were established. Nowadays also in Poland there are about 60 of these museums, while in Europe their number reaches about 2000 complexes. (Błaszczyk 1972), (Czajkowski 1981), (Czajkowski 1984), (Midura 1999), (Sieraczkiewicz Święch 1999), (Trocka-Leszczyńska 2001)

Figure 1: First on the World open-air museum (1881 r.) in Oslo – contains 158 buildings dated back to XIII–XIX century. (Photograph E. Trocka-Leszczyńska)

2.1 Exhibition features

The concept of open-air museum assumes display of vernacular architecture objects from one or few selected ethnographic regions, according to a specific scientific plan. However, museums formula evolves in a spontaneous manner and each unit may differ. Among the obvious: cottages, farms, household equipment, there are many other categories of buildings or facilities displayed, like – industrial objects, i.e. mills (wind, water, lumber) – sacral, i.e. churches of diverse religions, campaniles – public use: schools, administration buildings or inns. (fig. 2) There are two types of an open-air museum display arrangement: park-like – where pieces of exhibition are placed loosely among tall trees and an exact re-creation of an original settlement structure. While, depending on a number of presented regions, heritage parks can be divided into: central – with large exhibitions from few provinces, and local – devoted to a certain smaller part of a country (occasionally in theirs place of origin). Czajkowski (1981) goes further and proposes subdivisions into: central, "supraregional" (original expression), regional, local, however he notices that practical use of this typology is difficult. (Błaszczyk 1972), (Czajkowski 1981), (Midura 1999), (Organization 1970), (Sieraczkiewicz Święch 1999)

Despite exposition model used, chosen items must be original and unique representatives of province tradition and culture. They should reflect skills and knowledge of builders or craftsmen of certain area, and usually show architectural preferences of local community. It should be pointed out, that: small architecture objects, furnishing and equipment, from given time and region, are one of the most important elements in display at heritage park. Museums of this type can offer presentations in expanded versions – be connected to i.e.: technical exhibitions, craftsmen workshops, folk culture displays, fishery collections, etc. Moreover there is a tendency to use types of plants characteristic for elaborated region, or even connecting architectural exhibits to museums of agriculture. (Czajkowski 1981), (Midura 1999), (Organization 1970), (Sieraczkiewicz Święch 1999), (Błaszczyk 1972)

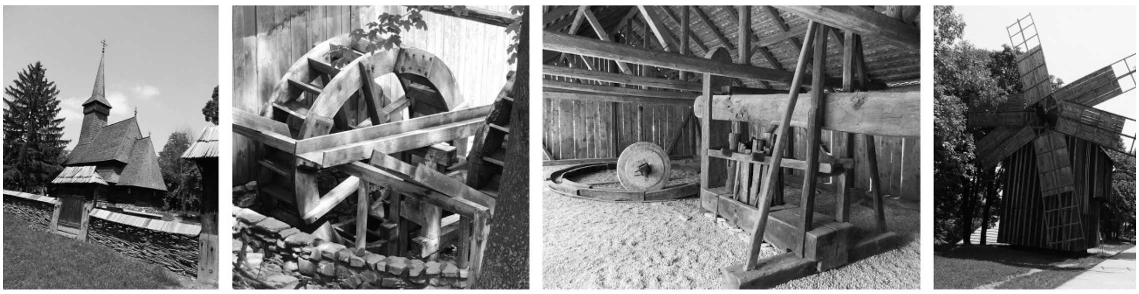

Figure 2: A public use and industrial buildings in Village Museum in Bucharest, Muzeul National al Satului 'Dimitrie Gusti'. (Photograph J. Jablonska)

2.2 Case study

Due to its scale and profile an exceptional example of such solution is "Muzeul National al Satului 'Dimitrie Gusti'" – so called 'Village Museum', located in Bucharest, Romania. The initial idea came from prof. Romulus Vuia in 1929, when he settled two peasants' houses near the city. Further on prof. Dmitri Gusti with large groups of students stared vast sociological studies, summarised by exhibition. It was containing reconstructions of parts of village buildings. (Focsa 1970) In 1936 the full village museum was created on the basis of royal decree and it collects 50 vernacular, wooden buildings on 30 acres of land. They origin from different regions of the country: Transilvania, Banat, Muntenia, Oltenia, Dobrogea or adjacent Moldova and can be dated back to the XVIII century. The exposition of carefully preserved wooden buildings contains: dwellings, logs, barns, churches, mills, gates, fences and is complemented by agricultural equipment. The arrangement of objects and elements of landscape, create illusion of a functioning village, which is strengthened by fully furnished interiors and presence of farm animals. Selection of houses aims at presentation of different functional and spatial solution depending on a regional culture, traditions, customs, climate, types of settlement units and houses, means of transport, geology, economy and other conditions as well as various structure organization and building methods. It is also crucial, that depending on a region, exhibition shows varied occupation, i.e.: shepherding form mountain region, agriculture, livestock or orchard in Podkarpacie area and agriculture in flat regions. Aforementioned diversity is expressed in architectural forms and building functional program, use of certain building materials, treatment of wood, solution of construction, connections and joints. Also types of decoration and colour are strongly exposed in this museum. (Fig. 2) (Focsa 1970), (Information 2012), (Information 2014), (Popoiu 2008)

Figure 3: Village Musem in Bucharest, Muzeul National al Satului 'Dimitrie Gusti', from left: general view, House form Moiseni, House form Moiseni – window frame detail (Photograph J. Jablonska)

Among others "Muzeul National al Satului 'Dimitrie Gusti'" presents interesting example of wooden house form Moiseni (from 1870), raised on rectangular plan (fig. 3). The simple program of function reflects in a spatial argument of interior, consistent of: porch, entrance hall, pantry and multi-use, large room. The usual wall structure was formed form three large oak logs, crossed at the corners of the house. High-picked, hipped roof was covered by wooden shingle. As an exterior decoration served carvings in wood, i.e.: handrails of the porch and window frames (fig. 3). Also highly intriguing is the house form Salciua, raised in 1815. Rectangular plan consentient of two interiors – larger serving as living room and smaller called entry room – is shaded by a deep porch, decorated with wooden, arched arcades. All covered by a very high hipped roof made from grain straw. The supporting structure of walls in prepared from several wooden logs, crossed at the corner of the building. (Information 2012) These examples illustrate very well a fact, that in traditional heritage park, a lot of attention is sacrificed into most true re-creation of past living conditions.

3. Contemporary past-presentation possibilities

Aforementioned heritage park model with all sub-types is understood as one group of possibilities for outdoor legacy preserving and communication of folk architecture to the widespread public. The other, more contemporary, is based on commercial approach. Good example of such solution would be complexes "Dwór Oliwski", Gdańsk in Poland (fig. 4) or „Windmühle Seifhennersdorf", Seifhennersdorf, in Germany (fig. 5 and 6). In both cases, historical vernacular architecture was used to create hotels. Though aiming at gathering income, their owners managed to preserve and expose heritage values of re-used buildings and sites. After proper conservation works existing historical architecture, was blended with new structures, enabling introducing contemporary functions, i.e.: hotel, gastronomy, workshops and other services. Also completely new buildings were erected, in form and styles harmonious to the heritage requirements, allowing fulfilment of a whole program for nowadays customers' needs. (Jabłońska 2011), (Trocka-Leszczyńska and Jabłońska 2014)

3.1 Case study

"Dwór Oliwski" (fig. 4) (implementation between 2002-2009 by Anna Brzozowska-Baran – architect and owner) is a contemporary hotel complex surrounded by greenery area. Its structure was based on buildings connected to bygone manor house and facilities, dating back to XVIII and XIX century. 70 rooms are complemented by: restaurant, tearoom, bar, wine cellar, conference rooms and SPA with pool. There are several objects creating whole spatial arrangement and these are: the traditional polish court from XVIII (founded on spot of previous summer mansion from XVI century) – lately extended, the old granary and two reconstructed buildings – a barn and a stable (connected together with an extension). Both new buildings were erected at the beginning of XXI century, according to the patterns from turn of the XVIII and XIX century. (Jabłońska 2011)

Figure 4: Buildings from complex „ Dwór Oliwski", in Poland
(fot. Artur Andrzej, licence: CC BY-SA 3.0, https://pl.wikipedia.org/wiki/Hotele_w_Gda%C5%84sku#/media/File:Gda%C5%84sk_ulica_Bytowska_4_i_staw.JPG, accessed on: 2015.11.26)

The idea assumed: preservation of traditional courtyard spatial agreement, protection and re-creation of as many traditional architectural forms as possible, inspiration by historical XVII century buildings still present in the surroundings, use of old-fashioned materials, conservational restauration of details (like painted or sculptured celling, banisters, doors), harmonization with context, nearby parks and greenery system. Due to such approach, visitors may get acquainted with many vernacular forms of architecture, like: wooden timber-framing (so called Prussian wall), mansard gables, dormers, traditional ceramic tiles or –reconstructed on the barn and the stable roof covered by thatch of reeds. (Jabłońska 2011)

„Windmühle Seifhennersdorf" in Germany (designed by Architekturbüro Gustavs + Lungwitz Dresden) (fig. 5, 6) also serves a hotel function, but what is interesting it was adjusted for training centre of people with different disabilities. Apart from rooms, it contains: a restaurant, workshops and a regional house. Overall complex is a blend of old and new architecture, where contemporary forms were strictly inspired by tradition. Visitors can admire – wooden: walls' overlay, timber-frame structures and foot bridges, traditional high-pitched roofs, doors, windows, dormers and old-style materials (also: stone, ceramics). New forms, like: full-wall glazing or solar-panels, were composed in a harmonious way, enriching historic landscape. The terrain agreement could not be re-created, for it was adjusted for wheelchairs movement. However a significant number of tall trees preserved, harmonizes well with complex historic character. The interior of restaurant is full of by-gone architectural details, while rooms, workshops and toilets have modest up-to-date design, so they will be as safe and comfortable as possible for their users. (Trocka-Leszczyńska Jabłońska 2014)

Figure 5: Buildings from complex „Windmühle Seifhennersdorf", Seifhennersdorf, in Germany. (Photograph E. Trocka-Leszczynska)

Figure 6: Buildings from complex „Windmühle Seifhennersdorf", Seifhennersdorf, in Germany. (Photograph E. Trocka-Leszczynska)

4. Discussion

The first approach allows for preserving all original assumptions of the vernacular architecture and urban structure, and usually is very appealing to the visitors. It is much more understandable than texts or illustration found in books (Błaszczyk 1972) or Internet. However in open air-museum buildings become exhibits, which cannot be touched or used by visitors. Kept in their basic form, they communicate knowledge but interaction of guests is limited. Moreover visited exclusively at a certain situations, become an isolated "islands" in the urban structures and social awareness.

It must also be stressed that open-air museums deal with a lot of expensive problems, like fire-protection (need for sprinkle and fire-alarms) for whole complexes or security from thieves. These issues were not handled in the past, when vernacular buildings were originally erected. Facing discovered problems a lot of heritage parks were forced to implement different additional services aiming at raising money for building maintenance. (Piasecka-Wilczyńska 1995) Usually these are: educational and craft workshops, expertise and conservation services, carpentry workshops (old patterns of furniture) inns, restaurants, shops, cultural festivals, family events organization, etc. And as Lasowa (1995) stresses they all must be carried out without the loss of quality of main museums' activity. Sometimes there is a need of erecting additional buildings (in authority of museum or local town or village), like: gastronomy points, hotels and motels. (Lasowa 1995) Thus, a threat exists that o lot of monuments will not be preserved at all, due to high maintains costs.

The second solution, allows historical complexes to become alive and vibrant places of present-day human activities, with all required service function already build-in the complex. The architecture and urban fabric can be experienced by users on daily basis, allowing them to really "touch" history of past generation. However, the original structure and spatial arrangement of the buildings must be adjusted to the contemporary requirements, even if there are taken into consideration only: technical conditions, fire safety and sanitary reasons. Therefore, valid parts of original communication are irrevocably lost and knowledge becomes limited (i.e. need for additional evacuation staircases, introduction of elevators, additional sanitary rooms).

In advantage, re-used building substance becomes an attraction that interests clients and draws money. Thus, money can be earned, without the need of sub-funding from governments and institutions. At the same time, problems of: fire-protection solutions, monitoring and burglar prevention, have to be obligatory solved in all nowadays design. These seem like obvious benefits, when economy and functionality come together in one venture. However among disadvantages, on the contrary towards heritage park arrangement, furnishing form epoch is rear and equipment seldom. Also there is no possibility for re-creation of climate and character of bygone days (animals, plants, and arraignments) and todays' needs and requirements may turn out to be more important than preservation and conservational issues.

5. Comparison

As a summary of aforementioned considerations, a table was prepared devoted towards advantages and disadvantages of both presented methods of preservation, allowing simple and clear comparisons. Few criteria were established, basing on general role of past communication towards widespread public, these were: knowledge communication, educational value, preservation and conservational value, harmonization with urban structure of settlement unit, simplicity of introduction of nowadays safety conditions, people-architecture interaction, and attractiveness. A three step grading system was adopted: high – medium – low, however grades were shortly explained in brackets. This clarification was necessary, due to some subjectiveness of evaluation, which could not be omitted.

Table 1: A comparisons of advantages and disadvantages of heritage parks and contemporary adaptation of historic buildings. (elaboration J. Jablonska)

Future	***A heritage park (an open-air museum)***	***Adaptation of historic structure to nowadays, commercial functions***
Knowledge communication	*high*	*medium (changes introduced)*
Education value	*high*	*medium (changes introduced)*
Preservation and conservational value	*high*	*medium (changes introduced)*
Harmonization with urban structure of settlement unit	*low (an island form)*	*high (blended)*
Simplicity of introduction of nowadays safety conditions	*low to medium (a lot of objects, need for money submission)*	*high (need for fulfilment of conservation guidelines)*
People-architecture interaction	*medium*	*high*
Attractiveness	*medium*	*high (possibility to stay in historical building)*

6. Conclusions

This study may serve all subjects engaged in historic building preservation. Case study supported by presented literature research, will assist acknowledging both open-air museum and reuse of historic building structure, as well as learning about different approaches and existing implementation. Aforementioned comparison should reinforce the decision making process on selection for the suitable way of historic building treatment. Studies may be continued at the basis of included material.

As it was clearly proved both methods for vernacular buildings preservation and treatment are connected to positives and negatives, which may affect decision making process of governments and cultural institutions. It is obvious that museums, and in this case open-air museums, are necessary for preserving past and communicating it to widespread public and future generations. At the same time commercial approach, assuming refurbishment of old structures with their adaptation to nowadays needs, can become rescue for many buildings which cannot be overtaken by public programs. The private investor sector should be encouraged to seek attractive solutions on the basis of amazing vernacular architecture of central Europe, of course until the preservation and conservation will be respected. We hope, that by such approach a lot of precious wooden and timber-frame structures will be saved and will have chance to become a vibrant places, where past can be not only studied, but experienced. Moreover, historic buildings will be treated as a valid and equal element of urban fabric in contemporary cities.

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Work environment and communication of posted workers on a Swedish construction project

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Abstract

Procurement of foreign labour in Sweden has changed the once homogenous society to be a more multicultural. Influx of posted workers in Sweden is mainly due to shortage of skilled workers in certain trade and the ageing local workforce. However, this multicultural workforce in the local construction scenario is creating new problems. The main problem is poor health and safety knowledge and the difficulty to communicate when common language and common working culture is lacking. This communication difficulty together with poor health and safety knowledge contribute to the stigma that posted workers contribute to a poor health and safety at the workplace. Since this scenario will unlikely change, it is important that we gauge health and safety knowledge of posted workers and overcome communication barriers in order to have an insight of how to manage the problem.

Therefore, this study was aimed at examining the work environment and communication of posted workers (in this case, posted subcontractors) faced by main contractor on a construction project. The objectives were i) to analyse the recorded incidents concerning posted workers ii) to assess the work environment of posted workers and ii) to examine the communication between the main contractor and the posted subcontractors. A case study was adopted to achieve these objectives. Results demonstrated that despite a few barriers, the work environment functioned very well during the project execution due to the effective role of the Health and Safety Coordinator. Moreover, only 28 incidents were reported from June 2012 until June 2015 and of this only 4 cases involved posted subcontractors while 18 cases involved local subcontractors and 6 cases involved main contractor. The barriers identified were i) communication difficulties due language barrier which could easily results in misunderstandings, and ii) cultural differences regarding safety and health at work. No conclusions can be drawn whether or not posted workers caused more accidents compared with local workers.

Keywords: posted workers, health and safety, construction; multicultural communication

1. Introduction

With the expansion of the European Union and various new schemes providing opportunities to move across member states to work, the number of foreign workers have grown tremendously. Dramatic shifts of labour process in the construction industry can be observed when many labourers move from Eastern to Western Europe (Agapiou, 2005). According to a report by the labour organisation, 20 percent of the labour force comprises posted workers employed in the construction sector. Construction companies typically have large variations in employment and need different opportunities to generate resources for building projects. Generally, companies use mainly their own resources, but lately had begun to subcontract work packages, procured staff and in recent years also contracted personnel to cope with workload peaks and special solutions. The shortage of skilled labour and the ageing workforce in the construction industry are additional reasons for companies to look for workforce abroad

While foreign workers may bring much needed skills and meet labour demands in the industry, the existence of irregular workforce can have an impact on labour market conditions, public finances and health and safety measures (Nurul Azita Salleh, et al 2012). The use of foreign labour at construction sites has been identified as one of the major issues confronting employers and unions. Key issues include their health and safety knowledge, language of communication and working culture. Therefore, this study was aimed to examine the work environment and communication of posted workers (in this case posted subcontractors) faced by main contractor on a construction project. The objectives were i) to analyse recorded incidents concerning posted workers ii) to assess work environment of posted workers and ii) to examine the communication between the main contractor and the posted subcontractors. The paper will present discussions on posted workers in Sweden, the multicultural communication barriers, research method and findings.

2. Posted workers in Sweden

Posting of workers to Sweden is a topical and controversial issue. The Swedish Work Environment (SWEA) defined posted employee as a person who is sent by his or her employer to work in another country for a limited period. The employee shall provide cross border services. For the duration of the work, the employee is subject to certain provisions in the host country's legislation or collective bargaining agreements. Posted workers are guaranteed certain level of protection in accordance with provisions in the Posting of Workers Directive (Directive 1996/711). Some important areas covered by posted workers' rights are: working environment, minimum wages and holiday pay, regulations on working hours, workplace discrimination and parental leave. These rules will reflect the standards of local workers. This step will eliminate "social dumping" where foreign service providers can undercut local service providers because their labour standards are lower. In July 2013, SWEA has taken the initiative to impose a record on all posted workers, allowing the possibility to gain statistics on the exact number of posted workers in the country. From the posting records for the second half of 2013, approximately 2,800 posted workers work in the construction sector. This figure represents approximately 1.3 percent of the total number of construction workers in the country (Sveriges Byggindustrier

2013). There are three ways of how posted workers get engaged in Sweden, namely: i) when their company won a bid ii) hiring of individuals through outsourcing companies and iii) self-employment with F-tax. The record also revealed that most posted workers comes from Poland (more than 1200 workers), Lithuania (more than 600 workers), Denmark (around 600 workers) Germany, Latvia Finland, Slovenia and Ireland (below 400 workers). While Sweden used statutory means to ensure that the core employment conditions stipulated by the Directive are applied to posted workers, the tradition for statutory minimum wages is not applicable. Here, the foreign suppliers, by means of union pressure, enter collective agreement with the Union. The union for construction workers is 'Byggnads' the powerful union with more than 100,000 members. The critique here is whether the free movement of labour market can tolerate equality of arms for trade unions seeking to combat wage shopping on the part of employers.

Studies of the impact of the construction labour movement have suggested that foreign labour have high risk of occupational accidents compared with local workers (Agapiou, 2005; Rowlands, 2005). With low wages, foreign workers are willing to work in hazardous conditions and generally take jobs that are temporary, require less skill and are largely unattractive to local labour forces (Robert, 2004; Rowlands, 2005). Language diversity becomes a barrier in communication on site which often results in unsafe behaviours. This problem is evident in a study performed by Trajkobski & Loosemore (2006) where nearly half of the respondents admitted to have misunderstood work-based instructions as a result of their poor command of the native language while 67 percent acknowledge that they had made a mistake at some point as a result of this handicap. Lack of knowledge in the existing situation of foreign construction workers in Sweden, the scale and implications of their health and safety problems make it difficult to accurately demonstrate the extent of the problem.

3. Multicultural communication

Culture differences have a big influence on the performance of construction industry (Ambos and Schlegelmilch 2008). The management style in the west is different from that in the east: Swedish management style is approachable and open, while, the East European managers are highly hierarchical and dictatorial. For managers with low multi-lingual skills Loosemore and Lee (2002) claimed that this often meant that early warnings of foreseeable problems would not be forthcoming and that operatives would be more likely to ignore the problems or will tackle them independently without consulting the managers first. The consequences of mismanaging cultural diversity are serious and include increased stress among the workforce, confusion, frustration and conflict which translates into lower morale, productivity, quality problems and higher accident rates (Loosemore and Lee 2002).

Today, many different nationalities can be found on construction project sites and when they meet, all differences between them can potentially lead to misunderstanding. Many languages spoken on site and the use of English as the main medium of communication is confined to a relatively small group that can speak it fluently (Loosemore and Lee 2002). Examples of issues arising from this cross-cultural misunderstandings are: instructions would have to be issued repeatedly and that they had to be reinforced by especially close supervision; a lack of a common language is a significant source of frustration that reduces their effectiveness and productivity on site and it can lead to health and safety problems. In the construction industry in Australia, language factor had contributed towards high accidents rate (86 percent) due to foreign workers using a language other than English at the work place. Thus the challenges of converting health and safety systems to accommodate this multicultural workforce need to be addressed seriously (Trajkovski and Loosemore's 2006). In Sweden, posted workers from the Nordic countries are able to communicate using the local language thus minimising these barriers.

4. Research Method

To achieve the research aim, a case study which had posted subcontractors and local subcontractors on the project was chosen. This allowed possible access to information from both parties and the management. Once this project was identified, document analysis was conducted to gather data on the health and safety performance of workers on the project. The documents were mostly confidential, internal documents. The materials presented in this paper are with permission from the organisation concerned. The information gathered were from the digital database Construction Industry Information System (BIA) that was linked to the company. The categories of information extracted were types of accidents, causes of accidents, notes and reports on incidences.

The next phase was gathering information on health and safety experience of posted subcontractors on site. This was achieved through two sets of interviews. The first interview was an open interview (Interview A) involved the project management team to capture and examined i) health and safety of posted subcontractors and ii) communication with posted subcontractors. This was performed through face-to-face interviews with six persons from the main contractor. They were the production manager who also qualified as a safety coordinator (M1), two project supervisors (M2, M3), one main safety representative (M4), one logistic coordinator who is also qualified safety coordinator (M5) and one project safety coordinator (M6). The second interview (Interview B) was a semi-structured interview involved posted subcontractors. Since this study was performed at the end of the project, all posted workers had left the country. Therefore, ten posted subcontractors were contacted by email informing them about the aim of the study and the intended questions. Only four posted subcontractors responded and they were from Chez Republic (P1), Denmark (P2), Eastland (P3) and Lithuanian (P4). Although the sample size was small, reliability of the results were secured by critically examining all information obtained from the management side and posted subcontractors.

Notes are made after each interview. Transcripts are read through and notes made, throughout the reading, on general themes within the transcripts. From the reading, as many headings as necessary are written down to describe all aspects of the content. The 'headings' or 'category system' should account for almost all of the interview data. The method used to categorise and codify the interview transcripts was developed out of the literature on content analysis and out of other sources concerned with the analysis of qualitative data (Bryman 1988).

5. Results

Case study – Project KKH

Project KKH located in Malmö city centre started from June 2012 and was completed in May 2015. The project comprised the construction of a six sub-projects: a concert hall, a congress hall, a hotel, two apartment buildings and an office building. Each sub-project is managed by a project team. Common functions such as logistics coordination as well as health and safety are planned at the main level. Since the construction area is very limited, meticulous planning was required for logistics demanding high cooperation between the various sub-projects. A total of 1.6 million work hours were recorded for the entire project. Project KKH has a strict policy about personal protective equipment (PPE) that must be borne by all on site at all times. The compulsory five PPEs are safety helmet, safety shoes, safety glasses, high visibility jackets and safety gloves. The project has a strong health and safety organisation led by the main safety coordinator, main safety representative, safety representatives from each sub-project and managers with health and safety competence.

Posted workers on project KKH.

Of 4341 total workers registered with the project until 31 Maj 2015, 436 were posted workers. On average almost 350 workers were on site daily and the most 600 workers and only 70 were directly employed by the main contractor. Most of the posted workers were from Poland, Latvia, Lithuanian, Germany, Denmark and Czech Republic. Table 1 shows the distribution of posted workers on the project.

Table 1: Distribution of posted subcontractors according to trade at project KKH

COUNTRY	***TYPE OF WORK (number of workers in parentheses)***
Denmark	*Telephony (2), Blinds and curtains (6), Crane operator (3), Floor layer (27), Installation of concrete elements (9), Design Engineer (1)*
Estonia	*Production and assembly of steel and glass profiles (13)*
Finland	*Ventilation Work (3)*
Italy	*Bathroom modules(20)*
Latvia	*Frame mounting (57)*
Lithuanian	*Steel Designer and frame mounting (56)*
The Netherlands	*Floor layers (natural stone)*
Poland	*Framing contractor: Design and manufacture of precast element (13), Stone layer (7), Ventilation Work (9), Formwork, Concrete work, groundwork, wall, mounting plaster walls, steel construction (135)*

All workers including posted workers must undergo safety introduction before starting work on the project. For posted workers, the safety introduction was conducted in English or the native language. The main contractors have their own staff who are fluent in Germany and Polish but for other languages, the management sought help among the posted workers. The main reason for engaging posted workers on this project were either cost issue or skill shortage. In terms of cost, many Eastern European subcontractors quoted significantly lower price than the corresponding Swedish subcontractors. Even with additional cost for training posted workers in occupational health and safety, their quotation is still much lower. For this project, the main contractor engaged posted workers for concreting buildings due to shortage of local concretors. Additionally, posted subcontractors are also employed for certain specialist work. For example subcontractors from Czech Republic are competent in producing and assembling facade elements while those from Germany subcontractors specialise in design and construction of the concert hall.

Recorded incidents on project KKH

From the start of construction in June 2012 until 30 June 2015, a total of 28 cases of incidents (all workers) were reported and notably only 3 cases with absence from work. The distribution of accidents at project KKH (with absent from work in parenthesis) were as follows: main contractor – 9 (0); local subcontractor – 16 (2); and posted subcontractor – 3 (1). From the reported incidents, 16 were categorised as self-inflicted, meaning that injury was caused by improper use of equipment or facilities, incorrect working method, insufficient knowledge, carelessness or stress. Three incidents occurred because of both self-inflicted and technical deficiency, e.g. meaning lack of protective device or equipment, lack of supervision or control, disarray at the workplace or poor housekeeping and incorrect work performance or workmanship. Five incidents were caused by technical defects. Lastly, four incidents were caused due to negligence of co-workers which included lack of communication between the workers, incomplete work instructions and faulty methods.

Further examination of how the foreign workers contributed to the project statistic is necessary. The list below presents the cases involving posted workers (first three) while the fourth involved a foreign worker that was employed by a local subcontractor. Analysis of the underlying causes revealed that most the incidences were due to negligence, poor knowledge, stress, lack of working instruction, faulty equipment and poor supervision.

1. A posted worker used an unauthorised ladder during assembly of facade elements. When the worker climbed down the ladder it began to slide, causing to him to fall. The employee landed badly and broke one foot and a finger. However, no sick leave was taken, and instead alternative duties were allocated to him.
2. A posted worker was working on the roof top when a power cable reel came rolling down. The worker managed to catch the cable reel from falling down from the roof, but in doing so broke his little finger. No sick leave was taken.
3. A posted crane operator raised a hoisting drum without communicating with the ground crew and had no insight where to place the load. The operator lowered the drum too fast and hit a local worker in the head.

4. A foreign worker (not posted but employed by a local subcontractor) with very limited knowledge of Swedish and English illegally borrowed a rolling scaffold during cleaning work. The worker drove the scaffolding along a vent pipe while standing on the scaffold. His action caused the scaffolding to overturn and he fell about 2 meters down to the floor. He broke his wrist and ankle and was on sick leave for more than 14 days.

Results from interview A

How was the overall health and safety experience at project KKH?

In general, everyone agreed that there was good working environment and safety on project KKH. They stated that health and safety was always high on the company's agenda throughout the project. This was mainly due to the main contractor's strong health and safety organisation. On this project, the role of the safety coordinator was not borne by the project manager. Instead this role was allocated to an individual whose duty was solely to manage health and safety on the project. Generally, it is usual for project managers to have two roles both, i.e. as managers and safety coordinators. Separating the roles had worked well due to non-conflicting interests of the health and safety against productivity. When asked about the health and safety of posted workers, respondents claimed that posted workers standard of health and safety is much lower than the main contractor. The main hurdle is the communication difficulty which hindered progress of the project. These different standards resulted problems during the project as what is acceptable with one party was not so with the other. Respondent M6 agreed that was not easy to get everyone on board working with the company's work environment policies and their own workers were no different. However, all respondents agreed that the posted subcontractors were keen to work with the management and comply with the company's health and safety practices. There was not one particular trade group that caused more accidents than the other. However, respondent M3 claimed that certain posted workers performed work unsafely. Respondent M6 believed that it was luck that no serious incidents occurred on the project. In one incident, when the posted worker injured and broke his foot, report was made only after a week. Hence, it was not impossible if incidences involving posted workers (especially when they work late evenings and on weekends) went unreported. The management were aware of this possibility but found it difficult to overcome the issue especially when it involved working outside the ordinary working time (after 07.00 – 16.00; Monday till Friday). Even though the company is successful in educating its own workers (who were directly employed) to have high regard for health and safety, the same cannot be applied to local and posted subcontractors. The latter complained that the pressure on health and safety was costing them time and money. Many of the subcontractors' workers were having difficulty adapting at work and not used to the strong emphasis on health and safety at work.

How was the health and safety of posted subcontractors and their workers?

All respondents agreed that posted subcontractors were not at the front-end of health and safety compared with the main contractor. The subcontractors had a lot to learn about working safely and paying attention to risks. Majority agreed that the working culture among posted workers is prioritising productivity more than health and safety. They only performed safety precaution when required. Respondent M3 observed that apart from compulsory PPE, foreign workers never took extra initiatives regarding health and safety. For example during welding work on a higher storey, it was recommended to mark the floor below to notify of the activity above. None of the subcontractors took this extra initiative. Respondent M5 claimed that posted subcontractors had different levels of risk tolerance in comparison with local workers. Even though posted workers are required to abide by safety rules, they lacked planning and control capabilities. For example, they knowingly placed materials in spaces that should be free and unblocked. Both respondent M2 and M3 noticed that subcontractors in general and posted subcontractors specifically abide by safety rules to please the management and avoid being reprimanded or penalised. For example, in one case, workers from Lithuanian kept repeating the same mistakes such as using unapproved ladders, incomplete PPE, using safety and lifting equipment that were not inspected. The penalty were reminders and fines. On the contrary, the main contractor's own worker had to be sent home for using unapproved ladders after several warnings. The same rule were not applied to the subcontractors mainly because handling these issues took a lot of time and energy. Nevertheless, the management admitted that they must continue to champion for safer work environment. The respondents noticed that there was a positive difference in the understanding of health and safety among posted subcontractors upon completion of the contract. They had begun to embrace the company's health and safety rules and regulations and understood the reasons to observe them. The company was proud of this outcome and would continue to improve it.

How did the communication work between the posted subcontractors and main contractor?

Overall, communication worked fairly well. It was difficult in the beginning but it got better as the project progressed and the management learned how to manage this hurdle. Having at least one person in the group that could communicate either in English or Swedish was important to ensure safe work environment. Sometimes the respondents resorted to using hand movements or demonstration to get things done. In certain complicated and critical situations, the company was lucky to have one of the local subcontractor's worker who could speak Russian and managed to help out. One of the project supervisors spoke Polish and German, making communication with the respective subcontractors much easier and smoother. There was no problem communicating with the Danes. In the case for respondent M4, there was never a direct communication between him and posted workers. He usually conveyed his instructions through project supervisors who would then discuss them with the project manager. According to respondent M4 when the project manager was involved, posted workers took matters seriously. The disadvantage was that the chain of communication was long and time wasting. Additionally, respondent M4 felt intimidated using his broken English when communicating with foreign workers. Yet, communicating with posted subcontractors who spoke good English, made the job easier for respondent M5. This was evident with the subcontractor from Czech Republic where they performed well in the project. Unfortunately, in some subcontractor groups, only the group leaders can speak fairly good English. In such situation, all instructions or corrective measures had to be conveyed to the group leader and the management team had no idea what the group leader actually said to their workers. This sometimes led to situations where subcontractors kept repeating the same mistakes and no corrective measures were performed. A lot of time was wasted with fussing about performing the corrective measures. This is a common scenario every morning. As the project progressed, respondent M1 had learned how to communicate with limited English to the posted subcontractors. Whenever he needed to inform them about corrective measures, he ensured that then group leader informed all of his workers and not just the one involved with the corrective measures. This was successful in getting them to perform.

Results from interview B

How important was a safe and healthy work environment for you?

All four respondents agreed that safety and a good working environment are very important. Respondent P1 explained that since he was responsible for his workers, he had to prioritise their safety. Respondent P2 emphasised that both physical and psychological work is very important for himself and his colleagues. Together they worked constantly to create a good and safe working environment. For respondent P3 many factors were vital in ensuring the safety of the working environment including actions such as putting up barriers, signs, warning signs, light signals, etc. as he discovered how much they really needed to make a workplace safe. According to respondent P4, the main contractor achieved good working environment on project KKH due to regular control on health and safety.

How was your health and safety experience on project KKH?

Overall all four respondents agreed that they had very good experience and witnessed how safety was made a priority at project KKH. However, respondent P1 claimed that foreign subcontractors had stringent rules compared to local subcontractors when it came to health and safety issues. According to respondent P1, to ensure his own skilled workers to understand the importance of these issues, they had to keep a higher level of safety standard than the local subcontractors and this was the greatest difficulty. For respondents P2 and P4, the difficulty had been the obligation to wear PPE all the time regardless of the task performed. Respondent P2 would have preferred if the management had been more flexible as their work entailed a lot of working on the knees and the safety helmet contributed to an increased load on the neck. Similarly, the requirement of wearing gloves posed problems as it was difficult to use the fingers when working with bonding of wood flooring. His workers were photographed on several occasions for not wearing gloves or helmet while working. He felt that the management should have taken a more diplomatic approach and reminded his workers instead of photographing the offence as evidence. Respondent P3 emphasised that all safety restrictions and safe work could sometime lead to retaliation. He confessed that there was no strong distinction between the standards of safety at the Swedish construction sites to his home country but better implementation in Sweden.

How did the communication work between you (or your workers) with the main contractor?

Surprisingly, the respondents did not see language as a barrier. Mainly, English was used among all posted subcontractors except for the German and Danish subcontractors. Respondents P1, P3 and P4 used English to communicate. They admitted that while there were some mistakes when communicating, they were resolved quickly. They could make themselves understood well enough to exchange the amount of information that was required and necessary. Both management and subcontractors appreciated the open dialogue based on trust between them. They believed that their language skills were sufficient to perform their tasks. Everyone agreed that that it was very important to have good commination to ensure the smooth running of the project.

6. Analysis and discussions

Working with posted workers posed many challenges for the main contractor and its own workers. It is clear the foreign workers on the project lack health and safety knowledge and have higher risk tolerance in comparison with local workers. This concurs with studies performed by the SWEA (2012), Bergsten et al. (2014) and Jonsson and Larsson (2013) that there are a number of difficulties linked to the current global and free labour movement. People with a foreign background have a 36 percent higher chance of being involved in an accident than a person with Swedish background (SWEA 2014). The risk is also evident when people with different cultural backgrounds work together. The probability of an accident occurring has substantially been linked to linguistic misunderstandings and cultural differences at the workplace, which are different from what the foreign workers are accustomed to (Allwood 1985). In Australia, Loosemore and Andonakis (2007) discovered that the existing language problem among foreign workers usually affect compliance with health and safety, thus, effecting the implementation of healthier and safer work environment. Accidents have also been linked to outdated regulations: The Work Environment Act was written in the 1970s, a time before the EU's single market was established and when foreign companies on the Swedish workplaces was unusual. Today, many foreign workers see the free labour movement in the EU as an opportunity to earn better living outside their homeland (Jonsson and Larsson 2013) and construction is among the attractive trades. Construction workers often come from Eastern Europe, where wages are lower, social security is inferior or non-existent and unemployment has periodically been high. Posted workers were procured based on price and labour shortage. Nonetheless, their presence often create resentment from the local Union (Byggnads) as they not only for their poor health and safety knowledge but also the collective agreement with foreign workers working conditions and wages (Jonsson and Larsson 2013).

Results from interview A showed that there were divided opinions on how well communication worked with posted workers. Majority of respondents from the management team felt that their English skills were sufficient for satisfactory communication with the posted subcontractors. A few respondents had communication difficulties with posted workers. Certain respondents stated that since their language skills was limited, they had chosen not to communicate directly with the posted subcontractors. Another concern was that usually, the posted supervisory person was the only one who spoke English. Several respondents felt that this lead to the long chain of communication (Figure 1) which was troubling, and that information got lost in the trail. The long communication chain was time-consuming and problematic and can lead to security risk in emergency situations (Gustafsson and Hansson 2005).

Posted worker $\Longleftrightarrow$ Posted worker supervisor $\Longleftrightarrow$ Swedish supervisor $\Longleftrightarrow$ Swedish Manager

On the contrary, the posted subcontractors' response reflect a different picture. They claimed that communication worked well and there had not been any major misunderstandings despite the language barrier and their English skills were sufficient to get the work done. In cases where communications had worked well, it was often because the posted workers were fluent in English. There was also the contradiction of stricter rules when breaching the health and safety rules and regulation. The management team claimed (from interview A) that they impose stricter rules to their own workers i.e. like sending them home after several warnings. In a conflicting claim made by posted subcontractors (interview B), they felt that the main contractor had stringent rules imposed on them compared to local subcontractors i.e. photographed their worker when they failed to use full PPE.

7. Conclusions

The objectives of the study are i) to analyse recorded incidents concerning posted workers ii) to assess work environment of posted workers and ii) to examine the communication between the main contractor and the posted subcontractors. The objectives were achieved as follows: *objective i)* there is no evident linking foreign workers to occupational accidents. On the contrary, project KKH incident records showed the opposite; *objective ii)* the work environment with posted subcontractors are satisfactory. However, the posted subcontractors lack sufficient knowledge and understanding to be able to work safely which can be problematic. The main contractor had to put in extra time and resources to resolves these problems; objective iii) communication difficulties based on lack of language skills could easily lead to misunderstandings, cultural work differences in safety and work environment compounded job safety problems, and the presence of foreign workers from different countries (sharing no common language at the work site) accentuated job safety problems in the industry. Suggestions from this study are i) increase more simple and clear aids to communicate in multicultural workplace e.g. more visual communication, ii) clear emphasis on the contract on the requirement for language competence and health and safety competence when procuring posted workers iii) education about cultural differences must be performed; and iv) improve English and other common foreign language proficiencies of local workers. The over-reliance on labour-only subcontracting and more importantly, the use of foreign workers is a scenario that will be common in construction projects. Thus, the Swedish construction industry must embrace, accept and adjust to having a multicultural workforce.

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Part II: Constructing Commitment and acknowledging human experiences

3. Health and Safety
4. Organisations, Knowledge and Communications
5. Projects, Procurement and Performance
6. Users, Clients and Stakeholder Engagement

TAMPERE UNIVERSITY OF TECHNOLOGY

Revisiting the Relationship between Physical Strain and Task Productivity

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Abstract

Identifying human factors and job characteristics affecting performance is crucial for a sustainable management of the workforce in a labor-intensive industry, such as the construction industry. At the individual worker level, physiological status and environmental stressors are reported to influence workforce performance. Previous exploratory research reported a U-shaped curve between physical strain and productivity at the group level. This paper revisits those exploratory findings to validate the U-curve relationship between physical strain and productivity at the group level. It also evaluates the relationship at the individual level while controlling for personal demographic information and heat stress. This study builds upon the previous study by expanding the original dataset and conducting an identical experimental protocol. The subjects wore sensors to monitor their heart rate, which indirectly measured their physical strain. Cameras were used to record experimental activities. The correlations between physical strain and productivity were analyzed at both the individual and group levels. We divided each subject's four-hour experimental data into 5-minute intervals, assigned time variables, and generated panel data sets for each subject. Then, the time effect on the subjects was observed to reflect the effect of time on physical strain and productivity. To conduct the panel data regression analysis, individual physical differences such as age, gender and body mass index were defined as control variables; physical strain and time effect were set as independent variables; and productivity was defined as a dependent variable. Random-effect models of panel data analysis were used to investigate the relationship. Based on the above statistical analysis, we observed the U-curve relationship between physical strain and task-level productivity both in the group and individual level as the construction laborers' job characteristics. This research finding demonstrates how physical strain in a laborer involved in construction work is correlated to task productivity.

Keywords: Occupational Health and Safety, Labor Productivity, Work Physiology, Labor and Personal Issues, Human Resource Management

1. Introduction

Taylor (1911) initiated the modern journey into management theories. Still, the application of Taylor's findings, aka Taylorism has shown many shortcomings due to some of its assumptions. Whereas its major issues have been overcome by human relations and lean concepts, Taylor's premise is still powerful for its implied argument for sustainability that encompasses human resources, and provides a good introduction to this paper.

> We can see our forests vanishing, our water-powers going to waste, our soil being carried by floods into the sea; and the end of our coal and our iron is in sight. But our larger wastes of human effort, which go on every day through such of our acts as are blundering, ill-directed, or inefficient, [...] are less visible, less tangible, and are but vaguely appreciated. We can see and feel the waste of material things. Awkward, inefficient, or ill-directed movements of men, however, leave nothing visible or tangible behind them. Their appreciation calls for [...] an effort of the imagination. (Taylor, 1911, pp.iii).

When it comes to workforce, the construction industry in the United States is struggling with high fatalities and injury rates (CPWR 2013). Construction workers are suffering from several health issues such as obesity, cardiovascular diseases, and musculoskeletal disorders (BLS 2012). Workers' poor health conditions cause higher rates of presenteeism and absenteeism (Swanson et al. 2011), which eventually lead to labor productivity losses. Job characteristics in construction may be the reason why the construction labor productivity is stagnant or even decreasing compared to manufacturing over the past decades. Thus, identifying the human factors and job characteristics affecting construction labor performance is crucial for a sustainable management of the workforce in such a labor-intensive industry (Gatti et al. 2012).

The influence of physical strain on the productivity of construction workers was recently explored by Gatti et al. (2014) who performed a study to identify the relationship between physical strain and performance in the construction workforce by using wearable physiological status monitor (PSM) technology. Relying on literature using heart rate as a reliable indicator of physical strain level (Kirk & Sullman 2011; Ainslie et al. 2003), Gatti et al. (2014) reported a U-shaped curve between physical strain and productivity at the group level based on experiments with 9 subjects of age between 19 and 23. Results of this exploratory study were well discussed but carried limited external validity due to the small subject sample, and the narrow range of the subject ages. For the same limitations, individual factors, such as age, gender, body mass index (BMI), height, and weight could not be statistically controlled in the analysis of the relationship between physical strain and productivity. Also, Gatti et al (2014) did not evaluate if productivity would reduce according to an increase in their physiological strain or if their physiological strain would increase according to the effort input to increase productivity. Thus, this paper sought to revisit the U-curve found by Gatti et al. (2014) by investigating the causality between physiological strain and productivity. To this end, panel data were produced by reflecting the time variable in each subject data, and 5-minute interval panel data were produced.

2. Methods

2.1 Participants

Gatti et al. (2014) conducted 9 experiments with subjects with an age range from 19 to 23. We collected data from additional 11 experiments with an age range from 23 to 33. All subjects were recruited among university students and were instructed to perform simulated construction activities that did not require previous field experience. The participant sample is assumed to represent the population of workers entering the industry as apprentices. The study was approved by the Institutional Review Board (IRB) of the University of Washington.

2.2 Equipment and Experiment Protocol

All the procedures of the experiment followed the protocol of the initial exploratory study, and were conducted in the same lab using the same physical layout. The detailed protocol is described in Gatti et al. (2014), and only briefly described in this paper. Subjects simulated the construction task of installing a raised deck made of concrete pavers weighing 7kg on adjustable plastic supports. The distance from the storage area to the floor installation area was 2.2 meters. After completing the installation of a rectangular-shaped floor (seven rows by three concrete pavers), subjects moved on to an adjacent floor installation area. This task was repeated during four working periods consisting of approximately 50 minutes each with 10-minute breaks. The same instrumentation, the BioHarness BT (Zephyr Performance System, Annapolis, MD, USA) was used to collect heart rates. This device weighs 35g without fabric chest belt, and it collects electrocardiogram (ECG), breathing rate, skin temperature and 3-axial accelerometer data. As part of the approved IRB protocol, we monitored subject overexertion in real time using transmission of live data to the laboratory computer through a radio signal communication rather than logging data inside of the device's memory. Researchers monitored heart rate on the computer screen during the entire experiment. A heat-stress meter (Sper Scientific, Scottsdale, AZ, USA) measured wet-bulb globe temperature as the index of indoor heat-stress level. Figure 1 shows the devices that were used during the assigned raised concrete deck installation activity.

Figure 1. Experimental setting and equipment

The experiment participants were provided bottled water to rehydrate. This allowed assuming that the hydration status was maintained at a normal level homogenously among all participants, so that a participant's hydration level did not critically influenced her heart rate.

2.3 Heart Rate Index

The relative heart rate (RHR) was estimated as an indicator for assessing physical strain introduced by Rodahl (1989):

$RHR[\%] = (HR - HR_{rest})/(HR_{max} - HR_{rest}) \times 100$,

where 'HRmax' is predicted maximum heart rate and 'HRrest' is measured average heart rate while sitting on a chair for 15 minutes. Using RHR instead of absolute heart rate values allowed to normalize the individual characteristic such as the subject's age and resting heart rate.

There are several formulas to calculate the maximum heart rate. This study adapted the equation used in Gatti et al. (2014) introduced by Tanaka et al. (2001):

$HR_{max} = 208 - 0.7 \times Age$, where 'Age' is the age of subject.

2.4 Research Hypothesis

Since the study design does not provide production goals in the assigned time of the task, the subjects work at their own pace. This potentially means the productivity in time t is positively related with productivity in time t + Δt at the individual level. Between individuals, more productive workers will remain more productive than low-productive workers based on author's observations while monitoring experiments.

Research Hypothesis 1: This study hypothesizes that the worker's current production rate affects next production rate positively.

If the individual characteristics were not taken into account in the relationship between physical strain and productivity, the direction of the relationship is positive as found by Gatti et al. (2014). However, when we consider the individual factors such as age, gender and BMI by controlling for them in the regression model, the direction of the relationship could be linearly negative as discussed by other studies (Åstrand et al. 2003; Bernold & AbouRizk 2010). Thus, when the physical strain (i.e., RHR) increases, the productivity will be decreasing linearly.

Research Hypothesis 2: The direction of the relationship between individual physical strain at time t and productivity at time t + Δt is linearly negative while controlling for the effect of individual factors.

Gatti et al (2014) found that the scatter plot of physical strain versus productivity fits a convex parabolic regression model. However, based on the literature that discussed negative effect of physical strain on productivity (Åstrand et al. 2003; Bernold & AbouRizk 2010), we could hypothesize that the quadratic relationship between physical strain and productivity can be a concave parabolic shape (i.e. inverted U-shape) while controlling for individual factor variables. Thus, the productivity will increase with increasing RHR at certain points; however, the productivity will decrease when the worker has an overexertion status by exceeding an RHR turning point level.

Research Hypothesis 3: At the group level, the quadratic relationship between physical strain at time t and productivity at time t + Δt is a concave parabolic shape while controlling for individual factor variables.

2.5 Description of Variables

Based on the description on the research hypothesis of this study, the dependent variable is the productivity at the task level of construction activity. Since the data come from a panel data set including time factor, we lead the dependent variable by one 5-min period. The independent variables are RHR, and productivity is measured over the 5-min period.

Additionally, variations of circadian rhythms affect the physical strain of workers (Åstrand 2003; Folkard 2003). Thus, a categorical variable was added to control for the start time of each experiment: morning (before noon), afternoon (noon to 6 pm), and evening (after 6pm).

Table 1. Definition of variables

Variables	*Variable code*	*Description*	*Hypothesis*
Productivity in next 5 minutes	*LEADPRO*	*The explanatory variable collected every 5 minutes, which affects the productivity of the next 5 minutes (longitudinal) than the productivity during the same time period (cross-sectional).*	*Dependent variable*
Productivity in current 5 minutes	*PRO*	*The unit productivity measure by the number of panels installed was divided by 5 minutes. The unit of this variable is concrete panels installed per minute.*	+
Relative heart rate	*RHR*	*The normalized indicator of physical strain level was measured by heart rate, taking into account age and heart rate at rest.*	-
Squared relative heart	*RHRSQ*	*A squared term of relative heart rate was used for the quadratic regression model.*	-
Subject age	*AGE*	*The younger subject would be more productive than older subject while working in the labor-intensive task.*	*Control variable*
Gender of subject	*MALE*	*The male subject can be more productive in the given concrete-paver-installation activity (Female=0, Male =1).*	*Control variable*
Body mass index	*BMI*	*High obesity level or low body mass index can influence productivity level.*	*Control variable*
Resting heart rate	*HRINR*	*The index of physiological status measured by heart rate at rest.*	*Control variable*
Time for conducting experiment	*MORN, AFTER, EVEN*	*Dummy variable; the evening (omitted coefficient) is the baseline of the analysis. EVEN is the reference dummy variable in the regression model.*	*Control variable*

2.6 Data Analysis

Experiments were assigned a session code (e.g. A.M.4) for data analysis following the same convention as Gatti et al (2014). Data for two of the 2014 experiments were lost due to a technical failure (i.e. J.F.4 and U.M.4). After integrating data collected in 2010 and 2014, we had 20 experiments available for analysis. The Pearson product-moment correlation coefficient is used for individual level of correlation between physiological strain and productivity. The group level of distribution of the data points is analyzed by scatter plot with linear and quadratic fit lines. For each experimental session, time-series data were generated in 5-minute intervals for average heart rate and unit productivity resulting in multiple observations for each experimental session. Each time interval includes cross-sectional data for each subject's individual characteristics that can influence productivity, such as age, gender, BMI, resting heart rate, and time for conducting the experiment (Table 1). All subject time series and cross-sectional data were integrated on the panel dataset. Due to some missing data on specific subjects, the panel data is unbalanced, but there were no time gaps because the missing data was observed at the beginning of the experiment (i.e. the ECG patch of wearable sensor was not wet enough to transmit an ECG signal to the sensor module before the subjects were made sweaty by physical activity) or at the end of the experiment (i.e. the case where a subject elected to stop the experiment earlier than four hours of working). Heart rate outliers were detected and removed using the Grubbs test on an individual level. Removed heart rate values were counted as missing values and replaced with neighboring preceding non-missing values.

This study aimed at studying how the influence of physical strain measured by heart rate on productivity would change over time, so panel data analysis was employed. A random effects (RE) model was used rather than a fixed effects (FE) model because each subject's individual characteristics data were collected and used to estimate their effects on the dependent variable. The data analysis was conducted using STATA13 (College Station, TX, USA: StataCorp LP).

Muscle types and environmental conditions are known to affect heart rate. Since the subjects followed the same experimental protocol, it is reasonable to assume all the participants mostly used the same muscle types, and the unobserved effect of muscle type use had no relationship with the explanatory variable. We also controlled the effects of the observed difference of individual characteristics (i.e. age, gender, BMI, and resting heart rate) on their productivity. Moreover, for all the test participants, consumption of food and caffeinated beverages and smoking were banned 2-hour before the experiment.

3. Results

Demographic information of the 2010 and 2014 samples is summarized in Table 2 after excluding sessions with lost data (i.e. J.F.4 and U.M.4). With a 99% confidence level, there is not statistic difference in average age in subject and indoor WBGT measured by heat stress monitor between the 2010 and 2014 experiments. However, the range of subject ages is much wider for the 2014 group (SD=3.1) than for the 2010 group (SD=1.7). This was intended to overcome one of the stated limitations of the study by Gatti et al (2014) based on the 2010 sample. Thus, age was also included as control variables in the panel data analysis. The indoor wet-bulb globe temperatures (WBGT), measured at the time and day that the subjects conducted a task, were not significantly different. The indoor WBGT temperature measured are not varied between subjects as well as between data collected in 2010 and 2014. Thus, the variable of heat stress level eventually was removed from the regression model analysis. Last, a greater sample of people is expected to show a wider range of anthropometric measurements such as weight and height. Thus, this factor should be statistically controlled in the regression model for analyzing the relationship between physical strain and productivity model.

Table 2: Demographic information of subjects and indoor heat stress index

Variable	*Data Collection in 2010 (n=9)*	*Data Collection in 2014 (n=11)*	*p*
Age (years)	*20.7 (1.7)*	*25.5(3.1)*	*<.001*
Height (cm)	*173.3(5.3)*	*174.5(14.3)*	*.810*
Weight (kg)	*68.5(5.9)*	*68.0 (17.0)*	*.932*
BMI	*22.8(1.5)*	*22.1 (3.4)*	*.055*
Indoor WBGT (°C)	*14.1(1.1)*	*13.9(.9)*	*<.001*

One of the 2010 subjects participated twice in the experiment similarly to two 2014 subjects. Since the objective of this study is to understand the relationship between physical strain level measured by heart rate and productivity while controlling for effects from other factors, such as age, gender, and BMI, etc., we treated each experimental observation as a separate data point, which also increased the statistical power.

In the result of the correlation coefficient analysis with x-axis for RHR and y-axis for productivity, most subjects presented moderate and strong positive correlation relationship (Table 3). If the heart rate is an effective predictor of physical strain, the physical strain is positively correlated with task level of productivity in the concrete paver installation activity.

Table 3: Correlation coefficient between relative heart rate and productivity

Correlation coefficient	*-0.5 <= r <-0.2*	*-0.2 <= r <0*	*0< r <=0.2*	*0.2<r <=0.5*	*0.5<r <=0.8*
Direction and strength of correlation	*Moderately negative*	*Weakly negative*	*Weakly positive*	*Moderately positive*	*Strongly positive*
Subject	*(Q.F.4)*	*(D.F.4), (I.M.2), (L.M.4)*	*(F.F.4), (U.M.4)*	*(A.M.4), (B.M.4), (G.M.2), (K.M.4), (M.M.4), (T.M.4)*	*(C.M.4), (H.M.2), (E.F.4), (N.F.4), (O.M.4), (P.F.4), (R.M.4), (S.M.4)*

In Figure 2, the group-level scatter plot between RHR and productivity confirms the u-curve trend that was observed by Gatti et al (2014). Except for apparent outliers (i.e., subject in the right bottom in the plot), the observed data is clustered in three individual groups. In the first group, the subjects were productive while maintaining low RHR. In the second group, the subjects achieved low productivity while maintaining an average level of RHR. In the last group, the subjects were highly productive, but the physical strain level was also high based on the measured relative heart rate.

Before performing the panel data analysis, we looked at multicollinearity among the dependent variable and independent variables. After performing the variance inflation factors (VIF) measurement test with the dependent and independent variables except for the square term of relative heart rate, we found that none of the VIF values of variables exceeded 10, which indicates no multicollinearity among the variables (O'Brien 2007).

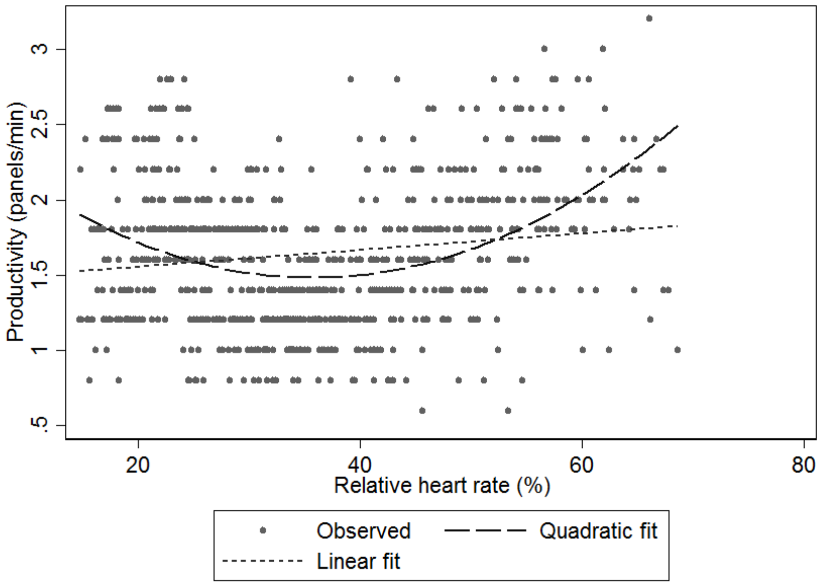

Figure 2. Scatter plot relative heart rate vs. productivity (time interval 5 min)

The results of panel analysis for RE models are summarized in Table 4. We initially analyzed data both with the RE model and FE model. Since there are no omitted time-invariant explanatory variables in the RE model while the FE model omitted control variables in the analysis, the RE model is better than the FE model (Allison 2009). Due to the omitted variables in the FE model, the Hausman test choosing between the FE model and RE model was not applicable. Also, the effects of time-invariant variables were estimated with small standard errors of the estimates; thus the RE model is appropriate to the collected data set.

The effect of explanatory variables on the dependent variable is identically applied to 'between groups' and 'within group' in the RE panel data regression model. In the RE model, the group variable is defined as the subject. Model 1 in Table 4 tested Research Hypothesis 1, that the subject's current production rate linearly affects positively the production rate in the next period. Therefore, assuming Subjects A and B had the same control variables (e.g., the same age, sex, BMI, resting HR, conducting task in the similar workday such as morning hour), if subject A was over-producing Subject B by 1 panel/minute at current time (t), it was found with 95% confidence level that Subject A would also over-produce Subject B by 0.8 panels/minute in the next 5 minutes ($p<0.01$). Model 2 in Table 4 tested Research Hypothesis 2, that the relationship between physical strain and productivity is linearly negative at the group level.

Since we confirmed the statistically significant effect of current productivity (i.e., Productivity t) to the next productivity rate (i.e., Productivity t+1), the variable PRO was also included in the model ($p<0.01$). A linear relationship between RHR and productivity was presumed in the hypothesis, but there was no significant linear effect of RHR variable on the dependent variable with 95% confidence level. The final Model 3 (i.e., Full model) tested Research Hypothesis 3, that the RHR variable is nonlinearly related to the dependent variable at the group level. We also added a PRO variable in Model 3 since the significant effect of it is estimated in Model 1 ($p<0.01$). Based on the analysis of Model 3, the coefficient of RHRSQ is a positive value ($p<0.05$), and the coefficient of RHR is negative ($p<0.05$), so the shape of the quadratic graph is a U-shape. The turning point of the U-shape is 30%, estimated at the coefficient on RHR over twice the absolute value of the coefficient on RHRSQ (i.e., $|-.012/(2\times.0002)|$). So, the turning point in the model where individual factors were controlled was lower than the turning point of scatter plot (i.e., around 40%) in Figure 2. Therefore, the result of analysis was unlike the Research Hypothesis3—workers' productivity will increase up to a certain level of RHR, and when RHR continuously increases over a certain turning point, productivity will decrease. Productivity keeps decreasing until the RHR of workers reached 30%, and when RHR has increased over 30%, productivity will increase along the U- shape curve with a 95% confidence level when the effect of other variables, including PRO, are constant.

Table 4: Panel data analyses

	Model 1	*Model 2*	*Model 3*
Variables	*LEADPRO*	*LEADPRO*	*LEADPRO*
Control Variables			
AGE	*.017**** *(.005)*	*.017**** *(.005)*	*.013**** *(.005)*
MALE	*.028* *(.026)*	*.028* *(.026)*	*.038* *(.026)*
BMI	*-.009*** *(.004)*	*-.009** *(.005)*	*-.009*** *(.005)*
HRINR	*-.003**** *(.001)*	*-.003*** *(.001)*	*-.003** *(.001)*
MORN	*-.114**** *(.036)*	*-.113**** *(.036)*	*-.095*** *(.036)*
AFTER	*-.118**** *(.040)*	*-.117**** *(.040)*	*-.067** *(.043)*
Explanatory Variables			
PRO	*.799**** *(.023)*	*.798**** *(.024)*	*.785**** *(.024)*
RHR		*.0001* *(.0001)*	*-.012*** *(.005)*
RHRSQ			*.0002*** *(.0001)*
N. of observations	*739*	*739*	*739*
Number of groups	*20*	*20*	*20*
F test	*1782.24****	*1779.90****	*1796.16****
R-squared (overall)	*.7091*	*.7092*	*.7113*

*Note 1. Significant levels; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.*
Note 2. Standard errors in parentheses.

4. Discussion

The results of our data analysis led to a failure to reject the null hypothesis for research hypotheses 2 and 3. Therefore, we could not accept these research hypotheses on the relationship between physical strain (i.e., RHR) and productivity. On the other hand, we were able to reject the null hypothesis for research hypothesis 1. Therefore, we found that the prior productivity positively related with the following productivity in a 5-minute interval.

Taylor (1911) introduced scientific management by investigating the current production rate as a decreasing function of fatigue, in his time and motion observation studies. The recent development of precise and wearable sensors to monitor the physiological status of workers allows for a simpler and more scientific data collection and analysis for reevaluate Taylor's findings. The current study hypothesized that increasing physical strain will have a correlation with a significant decrease in future productivity from a certain inflection point (concave parabolic shape). However, the result was found to be the opposite (e.g., convex U-shape) suggesting that the higher physiological strain/cost was the result of higher production output. As an explanation of these results, we can envision that a subject who put more effort (higher strain) at the current time point would be more productive at the current time (cross-sectional) as found by Gatti et al (20104). However, a 5-minute lag does not seem enough to observe the expected negative relationship with increasing physical strain and decreasing production rate. The ongoing continuation of this study is expected to complement human scientific management by considering a control production schedule that reflects the expected time for production decreases based on the real-time physical strain of workers who perform repetitive construction activities. Thus, this study will predict and quantify the concept of human durability defined by Taylor—'The current rate of activity in a given muscle group is a decreasing unit of fatigue in that group' (March & Simon p.17) —to generalize it among the current construction workers in the apprenticeship level population aged from 19 to 29.

The heart rate index has a limitation to be used as a single index to measure workers' physical strain. Rather than physical strain, heart rate should be used as an index to measure physical workload objectively, or as a physiological cost, meaning how much physical effort was put in for a worker to conduct a task. Therefore, when the relationship between heart rate and productivity is positive, it should be interpreted that productivity is improved as long as the worker invests more physiological cost. In addition to this, any follow-up study should involve a task longer than 4 hours, and analyze how the efficiency of productivity (output) decreases in proportion to physical cost (input). In the U-shape that was drawn from this study, when data is added with RHR, which is measured higher than the observed level due to the 4-hour work period, the relationship between physical strain and productivity in the quadratic term can turn into a third-order term. That is, if RHR increases and stays at an excessive level, productivity can decrease again.

This study has found that individual workers' physical characteristics or other psychological factors influence their physiological strain or productivity. Therefore, follow-up research is needed to see what factors are involved in the process of physiological strain influencing productivity. Also, follow-up research should be done to figure out if there is any group of people that fails to fit themselves to the task given in terms of physiological aspects and how to train them to be a group of people that can adapt themselves to it properly. About the range of this training, it can be done with an on-the-job site, but it needs to be extended to change the workers' life quality and attitude, even off-duty as well. The following studies should involve additional explanatory variables about emotional and mental activities.

In this study, individual factors were control variables, as was presumed in the beginning, and coefficient and p-value of the model were not discussed. However, the effect of age and BMI on productivity was found to be significant. Therefore, the following experiments and studies should put these factors into consideration. Especially, the effect of time of experiment on dependent variables was significant.

5. Conclusions

By using panel data analyses, we found the U-curve relationship between physical strain and task- level productivity both in the group and on an individual level, as the construction laborers' job characteristics. This trend was found identically, regardless of the difference of physical characteristics among individuals. From a management perspective, there are many other factors influencing the worker's performance; for instance, social support, mental stress motivation and engagement, and so forth. However, when it comes to the construction industry, we believe that physical strain plays a significant role that has been somehow ignored by previous research on labor performance. Physical strain should be monitored by project and safety managers to sustainably manage construction workers so that they can achieve optimal performance. Therefore, to plan work assignments, it is needed to consider the characteristics of change in workers' physiological strain. We proposed the heart rate or relative heart rate needs to be understood as how much physical effort the subject consumed for production. Thus, the physiological cost significantly affects task productivity, and the efficiency of investing physiological effect on productivity is changing by time. This proposition should be studied with further investigations about the worker who has lower efficiency on their productivity per their physiological cost input. This contributes to managing the unveiled issues in the construction companies' organizational level to foster the low-performance of employees to maintain their careers more sustainably.

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Empowerment in construction: a qualitative analysis of subcontractors' quality assurance

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Abstract

Employee involvement has been a focus of attention for many years in various guises, such as participative decision-making and participative management, but more recently it has been extended through the concept of empowerment. Employee empowerment means that management provides employees with the tools and authority required to continuously improve their performance. Empowerment leads to better utilization of skills and innovative capabilities. Once empowerment is attained, the individual worker becomes an integral part of the project organization and will be willing to commit himself to project goals. Workers can offer different perspectives than foremen, and they may be able to offer a creative solution not otherwise considered. However, construction as a project-based industry characterized by variation and contract orientation sets challenges for empowerment.

The purpose of this study was set to determine how subcontracted employees are empowered during the preparation and implementation phases of quality assurance. In this study, we investigate how employees are empowered in quality assurance and how well the information of quality standards is getting to employees.

A qualitative approach was chosen to assess the empowerment practices in quality operations among subcontractors. The data is based on a set of 20 semi-structured interviews in the Helsinki metropolitan area with Finnish and Estonian speaking workers and supervisors.

The findings of the study indicate that subcontracted workers are often neglected in the quality assurance process by their nearest supervisors. Workers are not involved in formal planning of tasks or self-inspection in quality assurance. They need to recall spoken information, since written documents are not on hand. Further, workers rarely cited any particular quality standards during the interviews and perceived quality as 'the same as always' or 'what looks good'.

Keywords: employee empowerment, quality, quality assurance, subcontracting

1. Introduction

Definitions of empowerment abound (Honold, 1997). Conger and Kanungo (1988) argue that empowerment is often seen as a synonym for sharing power. In fact, in empowerment, power is shared to subordinates. To decide and act as empowered subordinates, the workforce needs the knowledge, skills, authority and desire to take responsibility (Juran and De Feo, 2010). The authors emphasize that empowering the workforce will lead to a culture of high performance or what is often called a quality culture. Empowerment has been collectively defined as: The process of giving employees the authority to take decisions, relating to their work processes and functions, and within the limits provided by management, but requiring them to assume full responsibility and risk for their actions (Holt et al., 2000). The authors add that empowerment is employees' perception that they believe in and control what happens to their work processes, and that they are capable of controlling those processes efficiently and effectively.

Empowerment is distinctively conceptualized as a structural concept and as a psychological concept. As a structural concept, empowerment is deeply rooted in job design and occurs through objective and formal organizational changes that grant individuals greater latitude to make decisions and exert influence regarding their work (Liden and Arad, 1996). The psychological perspective, on the other hand, proposes that empowerment is a constellation of experienced cognitions. Psychologically empowered individuals and teams 'see themselves as having freedom and discretion, as having a personal connection to the organization, as confident about their abilities, and as able to make a difference in the system in which they are embedded' (Tuuli and Rowlinson, 2010).

Many aspects of present construction management structures foster the lowering of individuals' feelings of self-efficacy and of belonging to the company and also to the project. Construction as a project based industry with changing teams and leaders sets barriers for strategic workforce empowerment (Greasley, 2005). That is, features of bureaucratic and authoritarian management systems breed powerlessness resulting from dependency, poor communication systems and poor recognition or reward structures (Greasley et al., 2003). Especially construction contractors are blamed to be too cost and revenue oriented. An excessive body of research argues that more attention should be paid to quality (e.g. Zantanidis and Tsiotras, 1998) and partnering (e.g. Wong and Fung, 1999; Särkilahti, 1995) because main contractors often outsource construction work to subcontractors and suppliers. High quality relationships with subcontractors benefit the performance of main contractors (Kale and Arditi, 2001). Subcontractors should be regarded as partners and provided all available information and steering possible (Haupt and Whiteman, 2004). Contract orientation in the industry has led to a situation where risk is allocated 'elsewhere'. Construction is also characterized by disputes and litigation of past problems and there are little resources for developing new strategies for improved performance (Holt, 2000).

People and processes are highly related. Every individual has the potential to improve not only one's own processes but others as well. Imperfect empowerment is unsuccessful because poor performance of one hampers the improvement of others (Nesan and Holt, 1999; cited by Holt

2000), especially in project environment where processes are highly connected to one another. Therefore, the concept of empowerment should be extended to project supply chains, not limited to organizational boundaries (Dainty et al., 2002).

Empowerment requires a holistic approach in reorganizing the way the business thinks and every individual in the organization should be part of it (Holt, 2000). The main benefits of employee empowerment are enhanced morale, more productivity, healthier coworker relationships, and creative thinking (Tuuli and Rowlinson, 2010; Mullins and Peacock, 1991). Involving employees in decisions that directly affect their jobs while also empowering employees to be more autonomous, greatly improves company morale at large. When employees are given independence and expected to be more self-sufficient, they eventually become more efficient as they learn to navigate their responsibilities with minimal interference. This allows foremen to allocate more resources to their other responsibilities and decreases micromanagement that minimizes productivity. Employee empowerment also fosters better relationships between employees and with their foremen, as employees who are given more independence tend to form better working relationships. Employees can offer different perspectives than foremen and they may be able to offer a creative solution not otherwise considered.

Empowerment is seen as an important characteristic of quality improvement (Juran and De Feo, 2000). Formal quality assurance procedures increase productivity in construction because they lead to more systematic overall management of work. Thus the management of resources, information, organization structure and people are enhanced leading to better utilization of site-based resources (Langford et al., 2000).

Construction can be characterized as a fragmented project industry, meaning that each project is unique in various degrees. Therefore, the construction industry lacks standardization. Attempts to standardize processes encounter obstacles in an environment where subcontracting prevails and project teams change. However, many processes (tasks) are recurrent from project to project, especially in industrialized housing construction, setting a fruitful soil for standardization. In the current study, the authors show that steering and monitoring practices of subcontracted work are emphasized by variation. In quality operations, it is essential that employees carrying out the work are fully aware of the quality standards set by the customer and designers. Furthermore, the project's management team should systematically run the quality assurance procedures that the subcontractor follows.

A cultural and behavioural shift in the mind-set of all participants in the construction process (Kanji and Wong, 1998), especially top or senior management, is necessary if the construction industry is to improve its performance and competitiveness. Participation in decision making (PDM) means that both supervisors and subordinates mutually have influence in organizations (Deming, 1982). Since the 1990s, the literature has emphasized e.g. Total Quality Management (TQM) and Lean to answer mainly the poor efficiency of construction. Both aim at satisfying the customer’s needs in an effective manner and feature workforce empowerment.

This paper describes the design and implementation of steering and controlling of subcontracted work. The data for this study were collected using semi-structured interviews in housing construction sites in the Helsinki metropolitan area in Finland. The present study fills a gap in the literature by systematically investigating the employee empowerment practises in quality operations, particularly in the involvement in task preparation and self-inspection. Furthermore, this paper discusses potential ways to increase employee empowerment.

2. Empowerment in Construction

In Finland, construction experienced a major change in production technology in the 1960s when industrialization started the still on-going urbanization, which affected the demand of affordable housing. Off-site building technology made it possible to build housing fast and cost-effectively compared to traditional bricks and mortar technology. Particularly prefabricated concrete units led to new demands for the management of construction. For example, the structural engineering of prefabricated concrete units started to require specialization. The Design-Bid-Build delivery is the traditional and still the most widely used delivery method in Finland in terms of the number of projects. In terms of contract sums, the most widely used delivery methods are forms of Construction management (CM). Therefore, the development of procurement and cooperation are important for construction companies since contractors' procurement accounts for 60–90 percent of their turnover and subcontracted works constitute over 50 percent of total works.

Furthermore, new project delivery models, such as Construction management (CM), caused fragmentation leading to the rise of subcontracting. Procurement and dealing with numerous parties started to play a larger role adding complexity to projects. In quality operations, subcontracted contractors are steered via separate contractual arrangements requiring subcontractors' own supervision of work. This partly outsources quality management to the subcontractor.

Wong and Fung (1999) argued that there are three reasons for subcontracting. First, the subcontractor is specialized and possesses certain skills. Secondly, the main contractor's skills are insufficient in a particular area. Thirdly, there are possibilities for cost savings as the main contractor is relieved from maintaining the in-house capability for the subcontracted work. Therefore, subcontractors should be seen as a strategic resource for main contractors (Kale and Arditi, 2001). Specializing and subcontracting seem to be a permanent phenomenon because technology is in a continuous progress increasing fragmentation.

Improvements in technology and the fragmentation of project management are not the only challenges human resources management faces in construction in the 2010s. A wide range of people with different backgrounds work in the construction sector, such as unskilled workmen, highly educated managers, and foreigners. Individuals coming from different working cultures need to work together and understand each other in a changing project-based environment. These different groups have both common and separate objectives that overlap but often they also are different. Further, on an individual level, objectives differ on how work is carried out (Loosemore et al., 2003).

Empowerment is the process of enabling workers to set their own work-related goals, make decisions, and solve problems within their sphere of responsibility and authority. Therefore empowering can be both simple and complex at the same time (Pheng and May, 1997). It is simple in that foremen need to stop 'bossing' people around and let them do their jobs. It is complex in that foremen and workers typically are not trained to do that and may therefore require training to facilitate the process of empowerment. This process of change is especially difficult in the competitive environment in which construction takes place and where the bottom line is still the primary motivation of construction companies.

Participative management is an important criterion in the implementation of TQM (e.g. Ho et al., 2000; Yong and Wilkinson, 2001). One of the important concepts of TQM is employee involvement and empowerment (Haupt and Whiteman, 2004). In the TQM initiative, workers are encouraged to use their expertise and knowledge to suggest methods for improvements in their work areas. These suggestions could be related to improvements in the job or the product. This is in contrast to conventional quality assurance practices where managers and foremen take all decisions and workers just follow them to accomplish their jobs.

Most of today's quality problems in construction do not have a technical origin but are rather a result of the motivations and attitudes of both managers and workers towards their work (Atkinson, 1997; Bennett, 2000) and thus constitute the main challenge and opportunity in project management. The attitudes of individuals towards work are developed through the influences of the organisational systems within which they function. Hierarchical management structures, top-down information systems and adversarial contracts are all integral parts of the operational framework of the construction industry and each has substantial negative consequences on the social and cultural aspects of the industry. For instance, Haupt and Whiteman (2004) used a survey to assess the most important factors underlying unsuccessful attempts to implement TQM. The authors identified subcontractors' reluctance to co-operate and low bid subcontracting among the most important factors for poor implementation of TQM.

Empowerment approaches aim at enhancing responsibility, increasing authority, and making jobs challenging and interesting to workers, based on their abilities and the needs of the project. This means that managers and foremen provide workers with the tools required to continuously improve their work and performance. From the employees' viewpoint, the nearest supervisor has a strong influence on how empowerment can be implemented (Greasley et al., 2005). Empowerment also means that all workers feel that they have the responsibility and authority to participate in planning, controlling and decision making in their own work. According to Juran and De Feo (2010), workers need to have common goals with the organization and particularly an understanding of other stakeholders and customers' needs. This shared agenda is linked to the need to feel that the work has a meaning, which leads to engagement. Empowerment increases trust and commitment in the workplace (Dainty et al., 2002).

Juran and De Feo (2010) argue that open communication is vital in building workforce empowerment and engagement. Workers need to be encouraged to use their existing knowledge and skills fully, as well as develop new skills. They need procedures to help them to do their job, rather than to be told how to do it. Foremen have to define quality goals clearly, for instance through structured checklists, and to empower workers to check their own work and sign off on correctly completed work. Workers are able to make day-to-day decisions correctly only if their needs for information are fulfilled. Juran and De Feo add that what was before thought to be 'not relevant information' is nowadays relevant. Subcontractors' workforce is easily neglected in the sharing of information because there are numerous steps from the customer to the subcontracted worker in information distribution (Figure 1). The effective management of the information flow sets a major cornerstone, not only for empowerment, but also for successful project execution. Therefore, contractors should consider subcontractors as partners, and managers should consult employees before making decisions affecting them (Kathuria and Davis, 2000). Further, Wong and Fung (1999) suggest that subcontractors should take part in the site's quality teams to improve performance and co-operation. Expanding the use of building information modelling (BIM) helps knowledge sharing and the communication relationships in projects. BIM has thus far mainly been used as a tool for designers but it has lately been extended to other processes of construction projects, such as construction management.

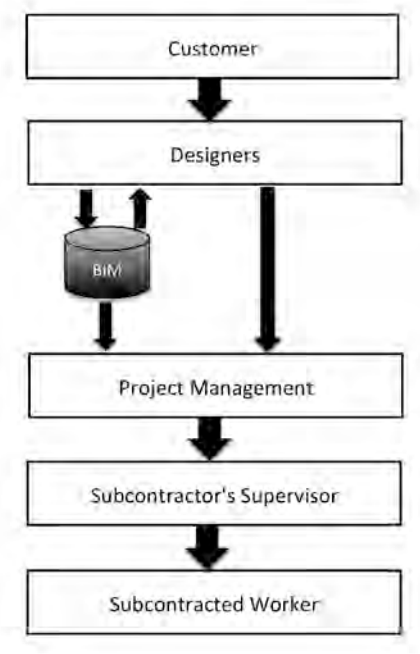

Figure 1: Information distribution from designers to a subcontracted worker

Unfortunately, there are many barriers to the empowerment of workers. There is still a widespread belief among managers that to empower workers is to lose one's own power and authority (Pheng and May, 1997). Empowerment also requires the management to take risks by turning over some control of the works to the workers (Ambad and Bahron, 2012). The management must appreciate that relinquishing control to the effective and skilled workers will result in a more productive organization with better teamwork and faster problem resolution. On the other hand, workers might be reluctant to take more responsibility for their work and quality assurance.

Project managers also encounter challenges in managing the empowerment of individuals or sub-teams outside their organization (Dainty et al., 2002). They need to make decisions concerning HRM under the pressure coming from the wider organization and the ongoing project (Loosemore et al., 2003). The implementation of HRM procedures and an empowerment policy encounters numerous difficulties because teams and leaders change from project to project. Every project is steered by its own management team, which is far from senior management by both its mentality and physical location (Greasley et al., 2005). Further, project objectives are short-term and company strategy is long-term. These two worlds conflict, for example, in staff training, which may not be beneficial for a project but for an organization in the long run.

3. Methodology and Data

The data for this study was collected in June 2015 in co-operation with four large Finnish main contractors. Subcontractors' supervisors and employees were interviewed in 5 new-built housing construction projects located in the Helsinki metropolitan area. The selected contractors were participating in a research project aimed at gaining better quality and performance through applying effective leadership tools for project management especially during the implementation phase. The selection of applicable projects followed the research projects' initial selection of case projects. Therefore, the selected projects are not a pure cross-section of on-going housing construction projects because in the cases, management personnel had received training and encouragement to enhance leadership practices on site. However, employee empowerment was not a topic of the received training and therefore, from the view of this paper, generalization of the results faces no hindrances arising from the selection of the surveyed projects.

Semi-structured interviews were chosen to allow a deeper insight into the quality assurance practices that the sites have applied in the steering of subcontracted work. The issues discussed concerned three main topics: task preparation, knowledge of quality specifications, and quality assurance. A pre-defined structure of questions was used in each interview, including follow-up questions when appropriate to complement answers. The interviews were conducted by two researchers so that one asked the questions and discussed the topics, and the other researcher simultaneously took notes. The duration of the interviews varied between 10 to 20 minutes and workers assigned to same tasks (max. 2 persons) were interviewed at once. The specific environment for the interviews was either the Project Management's office or on the site where the workers were working at the time.

Only Finnish speaking Finns and Estonians were included in the sample. A total of 20 interviews were conducted and documented with 26 participants (Table 1). The selection of respondents was made in co-operation with each project manager in advance or ad-hoc at the site, and the response rate reached 90 percent. However, taking into account these two different methods of selection, calculating an exact response rate rests solely on the ad-hoc selection, in which one group of electricians and one group of fitters of prefabricated units declined to take part in the study.

Table 1: Overview of the interviews

		Count	Percent
Position			
	Supervisor	6	23.1%
	Employee	20	76.9%
	TOTAL	26	
Trade/profession			
	Carpentry	6	23.1%
	Electricity	5	19.2%
	Plumbing or ventilation	4	15.4%
	Masonry	4	15.4%
	Plastering	2	7.7%
	Painting	2	7.7%
	Finishing	1	3.8%
	Handyman	2	7.7%
	TOTAL	26	
Nationality			
	Finnish	20	76.9%
	Estonian	6	23.1%
	TOTAL	26	

23.1 percent of the respondents were subcontractors' supervisors and the rest, 76.9 percent, were employees. The interviews represent a large variety of professions, including carpentry, electricity, plumbing or ventilation, and masonry. The qualitative data collected with the interviews were analysed to form a general impression of quality assurance practices, and partly transformed to quantitative data to present results in a condensed form.

4. Results: Empowerment in Subcontracted Work

On the workers' level, empowerment is not currently widely in use (Table 2). During the preparation phase of work, only 23.1 percent of workers had participated in a task specific starting meeting. During the starting meeting, the subcontractor and the project manager discuss the timetable and resources, quality requirements, and quality assurance etc. specific to the work. According to the interviews, typically a supervisor attends the meeting without workers, and in the cases when workers are involved, they are self-employed workers or 'heads of workers'. Task schemes are documents that are drawn up to prepare tasks for successful procurement and implementation. Only one worker had seen a task scheme for the current work, which indicates that task schemes are not in use at all or the information is not distributed to workers. Work was mostly guided on a day-to-day basis by supervisors.

Table 2: Documented employee empowerment practices

	Employee involvement			
	Yes count	Yes percent	No count	Total count
Task preparation knowledge of task specific quality requirements				
Orientation to site	26	100.0%	0	26
Official task specific starting meeting	6	23.1%	20	26
Documented task scheme	1	3.8%	25	26
Site specific standards and tolerances written down	0	0.0%	26	26
Quality supervision				
Documented self-inspection of the first section of tasks	1	3.8%	25	26
Drown stages of tasks self-inspected and documented[a]	3	11.5%	17	26
Tasks' documented self-inspection in the end or in stages	4	15.4%	22	26

Note a: Self-inspection of drown stages was not relevant in 6 cases, such as plastering.

Workers and their supervisors regarded quality typically as 'what looks good' or 'same as always', and no site specific written quality requirements were handed over to workers, as shown in Table 2. Tasks are recurrent from project to project especially in housing construction with little variation and the subcontractors had often co-operated with the main contractors in the past. Site-specific quality standards or tolerances did not exist or at least they were not written down and handed to the subcontractors. However, work was often guided by quality standards and working instructions coming from material suppliers.

In quality supervision, the project management team typically inspects the required first section with the subcontractor's supervisor possibly in co-operation with the customer's project representative or designer for preferred visual and functional outcome. Often self-inspection for a task is initially required by the project management, but rarely implemented. Self-inspection is understood almost solely as a supervisor's task, since only one worker executed documented self-inspection of the first section (Table 2). Drown stages were self-documented by 11.5 percent of the workers and the end of work by 15.4 percent. The documents were typically photographs and/or checklists.

5. Discussion and Conclusions

This paper argues that a greater emphasis should be laid on employee involvement and empowerment to increase productivity and quality in construction. The nature of project management in the industry changed already in the 20th century due to contract orientation, subcontracting, fragmentation, and complexity. The industry has put effort into increasing co-operation and decreasing confronting objectives via project management models, such as alliancing and IPD. Empowerment is embedded in mainstream management theories like TQM and Lean that have been applied by the industry. Important elements of TQM and Lean are training, development, and empowerment of employees. The principles of TQM should be applied beyond management levels and include workers on construction sites. Workers must be empowered, involved and trained in problem solving and quality assurance. However, main contractors' project management lacks a holistic approach to the development of empowerment, and subcontractors and their workers are often not considered to belong in projects' core organization. The benefits of empowerment are immense: a higher degree of morale, healthier co-worker relationships, enhanced productivity and innovativeness (Tuuli and Rowlinson, 2010).

The current study found that workers are not systematically involved in task preparation. A vast majority does not participate in the starting meetings of tasks, where information of how the work is carried out is discussed without go-betweens. Further, employees do not receive documents of specific quality requirements and task schemes, which raise knowledge of, not only the current task, but also preceding and subsequent tasks. The findings clearly indicate that there is a lack of understanding of how people-related issues may influence quality management systems within construction sites. Ironically, researchers have identified quality as being the most significant provider of competitive advantage (e.g. Zantanidis and Tsiotras, 1998). The obsession with the bottom line and viewing quality as merely an overhead might be contributory to this attitude. The exclusion of employees from quality assurance and quality improvement is a serious problem not only in Finland but also elsewhere (Haupt and Whiteman, 2004). Construction companies and main contractors clearly have not bought into this finding in their daily operations on site.

In Finnish housing construction, quality varies only limitedly, since it is strictly regulated by the National Building Code. A generally acknowledged mode for good building practise (e.g. tolerances for each task) is typically cited in contracts. In principle, common targets set a fruitful soil for the development of the standardization of quality processes. However, customer requirements steer quality from project to project, and therefore quality requirements should be cleared for workers. As presented in the results section above, subcontractors work with a ‘same as always’ and ‘what looks good’ mentality without specific project based quality standards.

For successful empowerment, all information should be shared with employees and there is no irrelevant information (Juran and De Feo 2000). Supervisors are not always present when workers make day-to-day decisions. Spoken information is useful but not always accessible and employees may change during construction work. To improve effective information distribution and to allow empowerment, more effort should be put into sharing information with workers. However, one should carefully consider the means of sharing written information so that workers can adapt it, meaning short and illustrative task schemes and a 'talk trough' of documents.

Another important finding was that subcontractors rarely systematically conduct documented self-inspection of quality, which is often initially required by project management. Moreover, workers are not empowered to self-inspection of their work. The nearest supervisor has a great influence over the success of empowerment (Greasley et al., 2005). Overall, the results of this paper indicate that empowerment is tackled by employees' nearest supervisors affected by the industry's prevailing culture of not supporting empowerment outside the core organization of projects.

Systematic quality assurance procedures lead to better utilization of site based resources (Langford et al., 2000). There is potential to increase empowerment in quality assurance, as the results show. Future research is needed to increase understanding of empowerment in subcontracted work.

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Emotional Intelligence: A Conceptual Model for Managing Productivity, Creativity and Performance

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Abstract

Analysis of the UK construction industry over the last 100 years has evidenced a number of performance-related issues; from productivity, through to quality, process management and challenges relating to innovation. Seminal literature and influential reports have directly garnered evidence from other sectors, citing specific exemplars of success which could quite easily be adopted for immediate impact. A recurrent theme from this literature suggests that 'soft skills' within organisations are increasingly being linked to performance improvement and profitability. These soft skills include "Emotional Intelligence" (EI), the underlying principle of which helps guide thinking and behaviour. This research examines the impact and pervasiveness of emotional intelligence in the UK construction industry, using construction project managers as the main sample set for investigation.

The research methodological approach adopted used literature from Construction and Applied Psychology to distil EI themes into a cogent set of priorities. The results help inform the next stage of this work, which engaged an explicit mixed methods approach as the primary data collection tool. Inferential analysis from 68 respondents helped to develop a conceptual engagement model for managing productivity, creativity and performance (with a construction setting).

Research findings identified a significant absence and understanding of EI in the sector. The conceptual model presented highlights a series of push-pull forces, which when combined together with different management tools (and the concepts of EI) can help increase productivity, creativity and performance. The conceptual model is considered beneficial across academia, training organisations, professional institutions and commercial organisations. Whilst this relatively small sample set is considered homogenous and 'representative', future work will include factors relating to scale, organisational maturity, and hierarchical trajectories.

Keywords: Project Management; Emotional Intelligence; Conceptual Model; Learning; Skills; Training.

1. Introduction

The construction industry has been criticised for its performance compared to other industrial sectors (Banwell, 1964; Latham, 1994; Egan, 1998). From a construction education and training perspective, emphasis has tended to focus upon "process" and "product"; and more recently, "environment" (Love and Wood, 2011). The increasing demands faced by project managers often resonate with understanding the need to increase the probability of project success. Process has historically been the focus of improvements across projects – the concepts and approaches of which are well-represented in various Project Management (PM) literature. However, whilst understanding process can assist in monitoring, correcting and reporting (on progress etc.), it is equally important to understand the underpinning 'glue'; as more often than not, this is reliant on people to ensure that success [process] is delivered. The importance of people [engaged in the process] is therefore exceptionally important, as this includes many issues, from initial recruitment, through to engagement, communication, motivation etc. Rothwell (1998), for example, identified the need to develop both 'hard' and 'soft' skills in construction graduates. However, sector-specific skills and the development of intellectual capital [in construction literature] seem to be somewhat underrepresented in extant literature. Acknowledging this paucity, there is an exigent need to understand the precise roles, traits and behaviours that form theses core skills sets (e.g. motivation, communication, conflict management, intuition etc.). These issues are examined in this paper, using the role of a project manager as the primary research lens.

2. Emotional Intelligence

Organisations often have to balance a range of skills and competence in order to meet business goals as "companies which are adept at using their skill base effectively are able to use and reuse…. these skills many times" (Andrews, 1987; Mintzberg and Quinn, 1991); Given this, over the last two decades in particular, various concepts on emotional intelligence (EI) have been published. The prominence and associated success of EI is now starting to be examined within the construction sector. EI is considered by some as a subset of Social Intelligence (Thorndike, 1904). It is comprised of four interrelated cognitive abilities which Salovey and Mayer (1990) summarise as:

- The ability to reason about a particular type of information;
- The ability to perceive accurately, appraise and express emotion;
- The ability to access or generate feelings when facilitating thought;
- The ability to understand emotion and emotional knowledge and to regulate emotions to promote emotional and intellectual growth.

3. Emotional Intelligence and the Project Manager

The role of a project manager is often demanding, complex and varied; the typical roles and traits of which are highlighted in the Project Management Body of Knowledge (PMBOK) Guide (PMI 2013). Thomas and Mengel (2008) highlight the importance of aligning learning to role complexity, and also competence to project management descriptors. Similarly, the need to focus on people management over "tools and techniques" was recognised by Ives (2005) and Winter et al. (2006). In addition, the influence of both internal and external environments when managing complex projects is also acknowledged, as the unpredictability (of events) often increases the complex nature of decision making particularly when multiple unknowns (variables) are present. This unpredictability places increased demands on the project manager beyond the typical process driven planning, managing and execution of tasks found within the taught linear skills documented in established text. Given this requirement for dealing with 'unknowns', within complex/chaotic environments, it requires personal attributes of: self-reference, an ability to thrive on change, to make informed decisions on the "fly", whilst also maintaining a motivated and focused team. Interpersonal skills are an important part of this, as recognised by the Project Management Institute (PMI, 2013); however, the methods to develop these within project managers are somewhat nondescript - in effect silent. Why is this void present when the criticality of these skills is openly acknowledged? This is especially so, as it is seen across other industries, that the engagement of soft skills can generate positive outcomes; where for example, the attributes of EI in chaotic/fluid environments have been applied successfully (Goleman (1996); Salovey and Grewel, 2005). Thus, whilst it is important to lead, guide, direct, motivate and steer the team through challenges [to deliver a specific goal], it is also important to appreciate the impact of EI on that process – especially to appreciate the impact this may have on project success. This poses a question: should EI be introduced to construction professionals so that an appreciation of interpersonal skills is understood, thereby facilitating an holistic approach to project delivery? Mayer and Salovey's (1997), definition of EI is particularly useful here, namely the ability to identify, understand, process and influence one's own emotions and those of others to guide feeling, thinking and actions present a clear direct path between the daily actions of the project manager and emotional intelligence.

4. Emotional Intelligence, Leadership and Project Teams

The Leadership within construction is ostensibly found in two main areas, charismatic and transformational (Love and Wood 2011). Bass, (1999), links transformational leadership with emotional intelligence; where, process was highlighted as the main focus across construction in improving effectiveness. EI however, is an essential method of expanding the model to further improve the probability of project success. Currently a project manager's EI abilities are not generally evaluated or assessed prior to appointment. The psychological attributes of project managers are however very important – and some would argue misunderstood. These include the process skills that assist in how "problems" are overcome, which reflects the thinking (and subsequently the behaviour) of the project manager. The PM's behaviour therefore has a direct correlation with leadership, the style adopted, impact across the team, and success of the project. Research by Leban and Zulauf (2004) support these findings specifically with reference to EI and its impact on leadership behaviour. The significance of 'good' leadership is especially important in complex projects, but more applied engagement is needed where cultural differences within the team are readily evident. The project manager's awareness of these social differences is paramount as this can influence thinking and behaviour (Goleman, 2001).

5. Research Methodology

This research stems from the need to gain understanding on why the construction industry fails to perform as effectively as other industrial sectors. The engagement of "soft skills" across other industrial sectors has generated positive results and associated increases in profitability. The engagement of "soft skills" within construction is loosely acknowledged within domain literature and this research aims to generate further understanding on how EI impacts on project management across the UK construction industry. Literature from the fields of Construction and Applied Psychology was first used to determine and distil EI themes into a cogent set of priorities. The results from this helped inform the next stage of this work, which engaged an explicit mixed methods approach as the primary data collection tool. To obtain appropriate data for this research, an on-line survey forum was deployed. The questionnaire was designed based on the findings from the literature review and associated priorities. This assessed the candidates' capacity to:

a. recognise their own emotions and those of others;

b. understand how best to motivate themselves;

c. become close to others;

d. manage their own feelings and those of others.

The questions were grouped in to three categories including the respondent's background, performance and leadership together with training and understanding of EI. The influencing factors for considering the research design included, but were not limited to:

(i) Being able to assess the present levels of emotional intelligence within a known sample size and background. An objective assessment promoting detached data.

(ii) Use of numeric data to link emotional intelligence with project success.

(iii) Highlight the nature and size of relationships between variables.

(iv) Engage statistics using closed questions and a five point Likert scale.

(v) Use of a finite timeframe.

(vi) The accessibility of primary data/methods of obtaining the data.

Data was gained from two industrial sectors (undertaking the same function). This promoted a more robust probability sample. The sample was determined by means of assessing the following criteria:

1. Is the sample appropriate to the objectives?

2. Is there sufficient time to capture data from the sample?

3. Is access to the sample possible?

4. Is the sample as good as possible?

The following steps were followed in compiling the primary data and concomitant analysis.

1. Sample Selection

2. Developing the questionnaire and piloting

3. Mode of delivery

4. Data collection

5. Response rate

6. Data & Discussion

An analytical survey was used to establish relationships and associations. These relate to defined attribute and objects introduced within the questionnaire. An example being the awareness of a project manager's EI and its relationship with general motivation on a given project. Inferential analysis from 68 respondents helped to develop a conceptual engagement model for managing productivity, creativity and performance (with a construction setting). Respondents were reviewed in terms of time spent within the construction sector and how long they held their current post/role. These were then reviewed against the perceived levels of EI. Research findings noted that there was a negative relationship r -0.19 (-1.188) from a sample of 68 or a degree of freedom at 66. The negative relationship communicates that as one variable increases (experience) the other decreases (EI). Whilst the demands from tomorrow's graduates highlight the increasing need on both hard and soft skills (Rothwell 1998), the legacy from both academia and commerce as reflected in this regard, suggests that EI is absent throughout, with younger professionals holding greater appreciation than experienced respondents. There is unfamiliarity surrounding EI, and whilst this may simply be a misunderstanding surrounding terminology, the data supports that it does however exists nonetheless.

This paper also examined how emotional intelligence affected a project manager's leadership and overall performance on projects. The data conveys 52% of the sample was not familiar with EI and a further 25% were a little familiar. The statistical significance of the levels of EI and the link with formal training surrounding EI suggests a slight positive relationship or p = 0.01 having a degree of freedom df of 63 and a two tail significance of 0.47. If the relationship p was 1.00 then a perfect association would be achieved. The upper and lower boundaries are +/- 1.00. As the correlation promotes 0.01, then this is close to a zero score. A zero score indicates that the sample are randomly scattered around any straight line drawn through the data. This suggests that EI has no effect on the samples leadership style and subsequently, project performance. Care is necessary here and is highlighted in the research by Crawford et al. (2006). Projects can be successful on process alone, specifically on low value/simplistic projects. 62% of the survey was completed by project managers who manage projects with values less than £1m. The importance of EI and transformational management increases in influence on complex projects. Love and Wood (2011), Mullar and Turner (2010), Turner and Mullar (2005), Zhang and Fan (2013), discuss the link between EI capabilities and project success with transformational leadership being highlighted as an influencing factor is steering the team through the changes and challenges faced.

The research confirms an insignificant relationship (0.47) between EI techniques engaged during projects and the formal training of the respondents thereby supporting current literature. Time Quality Cost (TQC) was used as a measure of success by 89% of the sample. Care on what this suggests needs to be taken as TQC is the outputs rather than how they were achieved. Given this, the data is clear in its assessment of EI and correlation with experience. A negative relationship exists, which suggests that 'soft' skills are not readily engaged. The research equally notes the absence of EI across CPD events and postgraduate education. There is an expectation that EI goes some considerable way to bridge the gap in knowledge and move towards a more holistic approach to project management. Only by adopting each and all avenues of improving project success will the performance levels within the construction sector be aligned with other industries. As the complexity of the project increases, the abilities and characteristics of the project manager becomes more influential over the teams, their performance and ultimately project success.

Clarke (2010), studied EI and its correlation with the behaviour of the project manager. Significant associations were found between teamwork and managing conflict, empathy and how this facilitated thinking and furthermore transformational leadership dynamics. The survey promoted data that initially failed to support this. EI was largely unknown. How the team was treated was regarded as significant by the data and influential in addressing motivation (95% - Q12/5). Whilst the treatment of the team is recognised in terms of the effect on motivation, the tools and behaviours employed by the project manager in influencing the magnitude of such motivation was not overtly appreciated or understood. Frequent interactions of a social nature positively influence performance (Ashmanasy and Dars, 2005). Whilst the lack of understanding surrounding EI was found within this study, a very high percentage (95%) confirmed that how they treated/managed/manipulated the team, directly influenced motivation.

The psychological aspects of a project manager need to be embraced and exploited in order to manage, motivate and drive the team. This self-awareness encapsulates social awareness and social management skills. Both link with EI but differ in that it does not manage "one's own and other's feeling to achieve a desired outcome." Ostensibly this may be considered to be manipulation however people tend to resist this. The perception of being a good manager may relate to the team members who believe that they are not being manipulated, are being listened to and wish to be associated with the team who delivers on a common goal. The challenge on most construction projects is the manner in which the team is created. Often teams are brought together based on their ability to provide a competitive quotation. A number of subcontractors often merge to create the 'construction team'. These subcontractors will invariably have their own identities, goals, objectives and drivers. The PM will therefore have to pull the group together to form an 'effective team' having its own identity and super-ordinate goal.

How team members behave with each other can directly influence how they perform within a project setting. The need to alter management style throughout the project, (Frame, 1987) shape the performance of the team. The ability to listen, learn, negotiate, analyse, persuade, influence and adapt are all flexible or persuasive attributes. Complex projects and how levels of emotional intelligence determine success levels on projects have been highlighted (Zhang and Fan, 2013). The next phase, team emotional intelligence is acknowledged. The Conceptual Skills Model, Figure 1, summarises the skills that influence one's own and other's emotions. Both process and people-centred management techniques need to be embraced. The Model reinforces the importance of motivation and the need to widen the project managers understanding beyond process. Engagement of different management tools to increase productivity, creativity and performance has a vastness that falls beyond the scope of this research. Process, EI and different management styles all combine and change throughout each project. The benefits experienced and lessons learned as suggested by Nonaka, (1994) are constantly being reviewed so that organisational knowledge continually evolves.

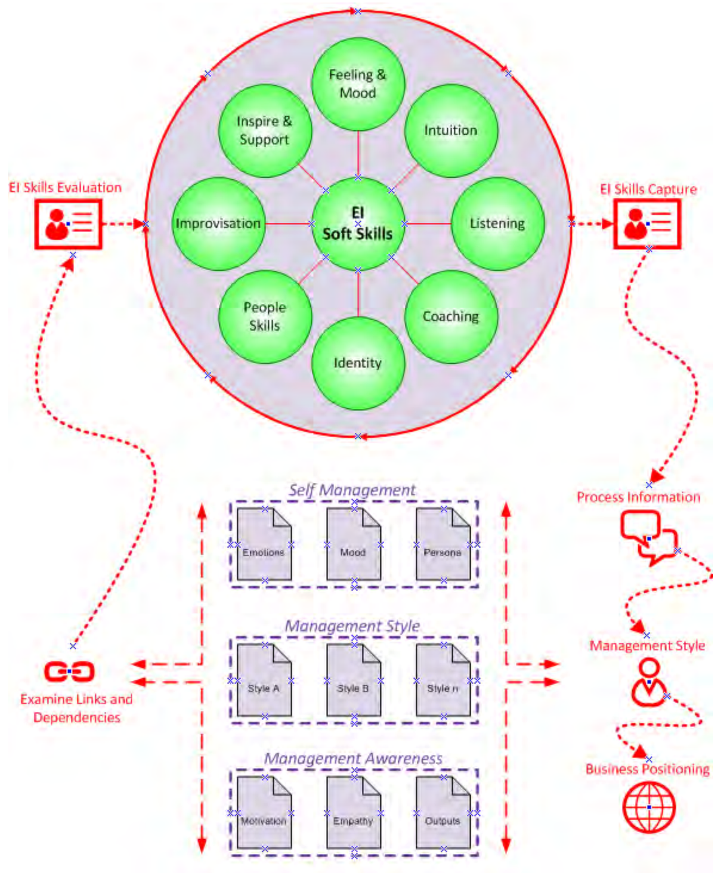

Figure 1. Soft Management Conceptual Skills Model

7. Conclusions

This research highlighted the need to engage 'soft skills' within organisations, particularly "Emotional Intelligence". The premise of which was that this understanding will help guide thinking and behaviour – leading to increased performance and project success. Given this, a Conceptual Skills Model for managing productivity, creativity and performance with a construction setting was developed from 68 respondents. This model helps identify how one manages one's own emotions, and how this impacts on the decisions taken and the effects of others. These "resilience factors" are essential for project managers. Whilst time, quality and cost elements continue to be used as indicator of project success, the foresight, consideration, objectivity, direction, support and leadership that the project manager eludes are not explicitly measured. Only the success/failures of the project manager's actions may be felt (albeit through the ubiquitous time, quality and cost assessments).

The 'Conceptual Skills Model' for Project Management aims to stimulate discussion within the world of project management on how improvements are able to be made with the associated increases in performance. The importance of these skills should not be underestimated. They have a proven benefit within other industrial sectors. The engagement of EI within the construction sector will, by default, need to engage and promote a step change. Arguably the need for such change, was highlighted as early as Banwell (1964), or indeed the Tavistock Institute (1966), reflecting the magnitude of the challenges faced. Critical reflection is therefore needed, not only to engage with areas that historically have been associated with other industrial sectors, but to begin to realise the true potential of these within the construction industry. The tacit skills of tomorrow's project managers need to embrace these findings. Similarly, process has consistently been the lens by which construction aimed to narrow performance gaps with other sectors. The research confirms the correlation between low value projects, the reliance on process and its relationship with successful outcomes. Furthermore the absence of EI within construction project managers is still evident.

Greater focus on the PM's ability to listen, learn, reflect, negotiate, analyse, persuade and influence the project team is therefore needed. This needs increased momentum, especially on challenging complex projects. The Conceptual Skills Model presents a clear 'interpersonal skills' definition, along with drivers and dependencies. This model offers stakeholders a conceptual stepwise solution. Whilst limited to the domain identified, additional work is now needed to expand the model, to encompass further 'soft skills' in order to create clear indicators of 'success'.

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Creativity and the Construction Project Manager: An Exploratory Study

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Abstract

This research examines how a special class of project managers – Creative Construction Project Managers (CCPMs) – are able to balance the inherent tension between pace, efficiency, productivity and quality to consistently achieve creative outcomes. This paper examines the cognition and action of CCPMs in response to the challenge posed by (1) the social needs of designers and other project stakeholders (2) a collaborative creative process and (3) the environmental press factors affecting designer's ability to be creative. A soft system methodology has been applied, whereby the challenge of creativity is considered a largely soft, fuzzy, wicked 'problem situation' – defined in the perceptions of project stakeholders; with CCPMs asked to describe their thinking and action in response to similar problem situations – and in doing so construct an approximation of their internal 'purposeful action model': their frame of reference when considering what action may be appropriate. The findings of this research draw parallels with previous research models, but are ultimately presented as an independent purposeful action model - focused on the specific challenges faced by project managers working on construction design projects. The proposed CCPM purposeful action model is recommended for application as a complementary overlay to project management best practice.

Keywords: Creativity, construction project manager, soft systems methodology

1. Introduction

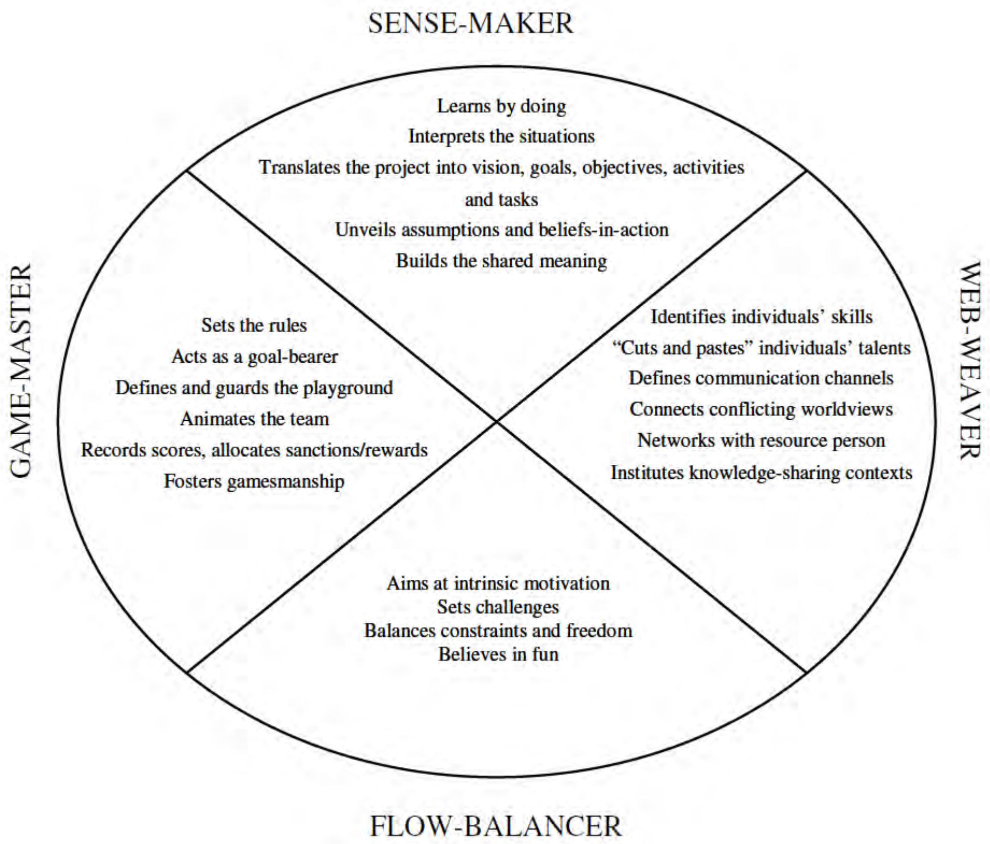
One of the most widely cited definitions of 'successful' project management is in taking appropriate action to balance conflicting objectives. When questioned on their function, most construction project managers – let's call them project management professionals (PMPs) - will tell you that they deliver projects 'on time, on budget and to the client's quality aspirations'. This comfortable mantra, is a poor reflection of the complex factors at play in building projects.

Anecdotal evidence suggests that PMP's rigid application of best practice methodologies has a tendency to introduce social disharmony and in doing so undermines the fertile environment needed for creativity to flourish. However, a different class of project manager also exists – referred to in this study as Creative Construction Project Managers (CCPMs). These CCPMs build happy and motivated teams, who consistently achieve creative outcomes. Due to the nature of the outcome, this approach may be considered as mitigating the 'problem situation' of creativity.

This research was borne out of a desire to uncover and document the approach of CCPMs in a format which PMPs would be likely to engage with; and in doing so build support for a paradigm shift in the dichotomisation of project objectives and the prioritisation of hard issues in mainstream project management practice (Lewis, Welsh, Dehler and Green, 2002; Gustavsson and Hallin, 2014).

One of the most significant challenges in this regard is the resistance of 'soft issues' to definition and 'engineering' in pursuit of an optimal, prescriptive response. Soft systems methodology offers a means of conceptualising the problem, as a 'problem situation' and engineering a solution, through the use of analogy through reference to 'purposeful action models'.

This research was inspired by Simon's exploratory study into creative project manager cognition and action. The model put forward in his 2006 journal article has been considered a purposeful action



model (see figure 1), which this research has sought to emulate.

Figure 1: Simon's model of creative project manager activities/actions

This research responds directly to Simon's call for further "direct observations and qualitative accounts of creative project manager (CPM) action, intuitive decision-making and rationale" (2006, p.125); recognising that Simon's model was not originally derived from, nor evaluated against project managers operating in the construction industry.

Throughout this paper, the term 'Creative Project Manager' ("CPM") has been used to describe the actions of project managers action as described in Simon's purposeful action model (2006) or as described in other academic literature; the term 'Creative Construction Project Manager' ("CCPM") has been used to describe the espoused action of the research population: Project managers whose projects have received peer recognition, awards or publication in the construction and architectural press.

2. Defining Creativity

Creativity is a highly subjective notion: What may be considered creative by one person may not be by another; creativity may be applied to any problem solving situation, not just the design of a product (Lindeman, 2010 in Taura and Nagai, 2011). The ambiguity of the term is reflected in the diversity of its definitions within the literature. Such varied definitions may be classified according to the perspective as to *where* creativity exists.

In 1961, Rhodes established four perspectives by which to locate creativity (in Lauer, 1994): Creativity in outcomes (product), as an attribute of people (person), as a type of cognitive process and as the conditions which facilitates creativity (press). In 2010, Gero identified seven perspectives and three strands of scientific creative research: cognitive behaviour, design process and interactions (in Taura and Nagai, 2011).

Since it was first published Rhodes 4-P's model has been cited in various seminal works on creativity. It is therefore perhaps unsurprising that parallels can be drawn between Rhodes' and Gero's definitions of creativity – as shown in table 1.

Table 1: Locating and defining creativity (adapted from Rhodes, 1961 in Lauer, 1994; Gero, 2010 in Taura and Nagai, 2011)

Academic field	*Perspective*	*Creativity existing…*	*Strand of research*
Psychology	Product	….in the design ….in the assessor of the design	
	Person	….in the designer	Cognitive behaviour
Psychology (Sociology)	Process	….in the design process	Design process (interactions)
Sociology	Press	….in the interaction between user & designer ….in the society in which the design sits ….in the interaction of all of the above	Interaction
	Rhodes (1961)	Gero (2010)	

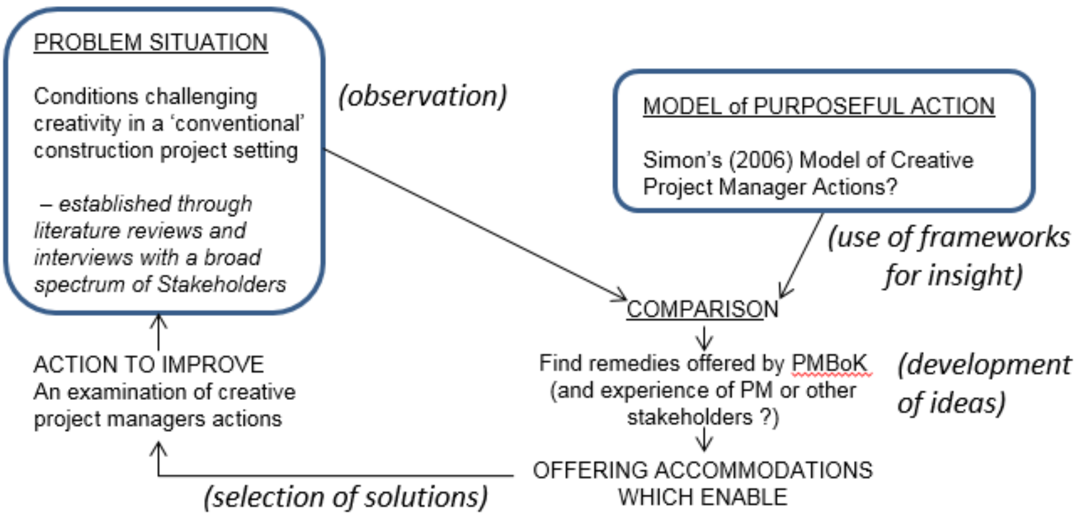
The comparison of Gero's and Rhodes' model demonstrates the integrity of Rhodes model and its continuing applicability as a framework for conceptualising creativity and focusing research. Gero's model is, however, useful in recognising the growing interest of research in collaborative design process, in favour of extended discussions of creative products or individuals.

This research is fundamentally concerned with building a holistic understanding of creativity; adopting a systems view of creativity which recognises the inter-dependencies between climatic, and cultural conditions, and the cognitive process and performance of creative individuals and teams. In the context of the CCPMs, we are concerned with the creative process of actualisation and not the creativity of building design.

3. The Methodology

A soft system methodology has been applied, whereby the challenge of creativity is considered a largely soft, fuzzy, wicked 'problem situation' – defined in the perceptions of project stakeholders.

Soft System Methodologies offer a means of "rationalising the cognitive process of addressing 'wicked', soft or fuzzy problems – defined as ill-defined problems which are messy… and whose solutions are not true or false, but better or worse" (Stanford Design School, 2014). In this context, problem-solving is an iterative process of examining aggregate stakeholder perceptions of the problems, taking action to improve, assessing the impact on the problem situation, and repeating the process. By doing so the 'problem solver' is, over time, able to engineer their thinking about a problem, building up an internal 'purposeful action model' based on actions which have helped to



improve the problem situation (see figure 2).

Figure 2: Soft systems and design thinking methodologies for problem finding and solving represented under an appreciative systems analogy (adopted from Checkland et al, 1999)

The problem situation has been initially been constructed from both academic literature and anecdotal evidence; this has then been briefly validated through discussions with construction industry professionals: stakeholders on award-winning projects.

Two rounds of semi-structured ethnographic interviews were held: The first sought to test and supplement the CCPM's perceptions of the problem situation. In the second round the CCPMs were asked to explain their actions in response to the problem situation. Three interviews were conducted in each round. The respondents were asked to reference their experiences on real projects of architectural merit on which they served as project managers. The findings of this research have been analysed in the context of Simon's (2006) creative project manager (CPM) purposeful action model.

A soft systems methodology has ultimately offered a framework for exploring Creative Construction Project Managers in a project context; but has also enabled the logic behind the action taken to be interpreted, and an approximation of the frame, or purposeful action model, informing CCPMs action to be constructed.

4. Discussion of Results

The matrix summarised in table 2 compares the key outcomes of the research findings against Simon's (2006) CPM purposeful action model. The results are discussed within the framework of the defined subsections within Simon's model and contrasted to four new core themes: (1) personal and professional relations (2) visioning (3) sense-making (4) guarding the design team and process derived from the second round of interviews.

Table 2: Research findings overview: matrix comparing research findings with Simon's (2006) model

	WEB WEAVING	Identifies individuals skills	Cuts and pastes individuals talents	Defines communication channels	Connects conflicting worldviews	Networks with resource person	Institutes knowledge-sharing contexts	**SENSE-MAKER**	Learns by doing	Interprets the situation	Translates the project into visions, goals, objectives…	… activities and tasks	Unveils assumptions and beliefs in action	Builds the shared meaning	**GAME-MASTER**	Sets the rules	Acts as a goal-bearer	Defines and guards the playground	Animates the team	Records scores, allocates sanctions	Fosters gamesmanship	**FLOW-BALANCER**	Aims at intrinisic motivation	Sets challenges	Balances constraints and freedom	Believes in fun
PERSONAL and PROFESSIONAL RELATIONS																										
Build personal relationships with Client																										
Build personal relationships with influential design team members																										
Channel or redirect people with a negative outlook																			✔							
Maintain personal relationships on an equal footing					✔																✔		✔			
VISIONING																										
Establish the project brief through conversation with Client											✔															
Build Team						✔																	✔			
Soft influence over brief implementation											✔															
Build design team ownership of project plan					✔						✔					✔										
Build respect and understanding of [concessions needed for] a creative design process																		✔			✔					
SENSE MAKING																										
Embeds themselves within the design team									✔									✔			✔					
Interpret, communicate and represent the design frame					✔					✔			✔	✔			✔		✔	✔	✔					
Interpret and relate design issues back to goals and objectives					✔					✔			✔	✔			✔									
Build support for creative ideas or solutions of merit																			✔	✔	✔					
Triangulate solutions							✔			✔			✔	✔							✔			✔		
Focusing or channel design team members towards a project objective or away from a wrong path										✔			✔	✔							✔					
Idea generation, development or refinement							✔																	✔		
GUARDING THE DESIGN TEAM and PROCESS																										
Hands off management: Secure commitment and results through political influence																										
Influence design through positive engagement with design team					✔		✔		✔					✔					✔				✔		✔	
Framing difficult decisions in the context of project goals, through reference to analogy or previous experience					✔				✔									✔								
Secure compromise from client to satisfy design team need for time and space					✔													✔								
Secure compromise from design team to satisfy client needs					✔													✔								
Intelligent monitoring of design process against project goals and programme																✔	✔									
Maintaining forward momentum																		✔		✔						

Web weaving - At a general level both CPMs and CCPMs seek influence over individuals within their teams to achieve results through 'web weaving' activities.

At a specific level Simon's web-weaving activities place the CPM in executive control of the design team: defining the structure of the team, the make-up of the team, the activities and tasks of individual team members, and the interactions between team members. The findings of this research suggest that CCPM do not seek this degree of executive *control*, favouring instead a hands-off style of management style aimed at *influence* rather than control. A CCPM preference for the use of political power, in favour of authority, depends upon a strong and broad power base. To this end, CCPMs describe how they build and maintain personal as well as professional relationships with both the client and design team right from the outset and how these relationships are used and maintained over the course of the project to influence both process and outcomes. This is not explicit in Simon's model.

CCPM actions such as being present, being open and transparent, being dependable and reliable etc. respond to behaviours needed to gain the trust and respect of the design team. This is not reflected in Simon's model, perhaps signifying a structural difference in the project organisation structure and/or the proximity of the client to the design team and process.

Simon's model describes a CPM who is embedded within the team, who is delegating activities and tasks to those within his team who are best capable of doing them. Research findings suggest that CCPMs employ a middle tier of management – described as Captains – who are then responsible for this operational level of management. In this context, the definition and role of the CPM and CCPM differ; it is therefore unsurprising that the approach therefore to engaging with, and managing, those actually doing the work and their activities differs.

Simon's model also recognises that CPMs must adopt a poly-centric perspective and sensitivity to bridge cultural misunderstandings. To this extent, CPMs engage in sense-making actions - unveiling assumptions and beliefs in action, and interpreting the situation – alongside web-weaving activity of 'connecting conflicting worldviews through translation'.

Research findings suggest that CCPMs act out of a similar concern for cultural misunderstandings, by engaging in dialogue with the design team to interpret, communicate and represent the design frame, channelling and redirecting the team where necessary through political influence, and where this fails through private conversations to more forcibly correct misunderstandings. Their behaviour as an equal member of the design team, sets a benchmark for appropriate behaviour on the project.

CCPMs collaborative approach to project planning also mirrors Simon's descriptions of CPMs efforts to connect conflicting worldviews through translation. In this context, CCPMs engage the design team in project planning to build a common understanding of risks and support for mitigation measures which otherwise could otherwise be viewed to compromise the conditions needed for creativity.

This same collaborative approach to compromise is adopted by CCPMs in to secure concessions in demands made by the design team. Research findings describe how, in this situation, CCPMs will engage the team in dialogue to draw design team members to the same conclusions as the CCPM or Client. In this way, they protect they force the design team to take ownership of these decisions by working to make people think that the alternative path is their idea.

Sense maker – At a general level both CPMs and CCPMs are embedded within the design teams they are mandated to manage, adopting a participatory role in the design process. From this position of influence both CPMs and CCPMS attempt to influence perceptions of the project context to focus on, and build a common understanding of, the issues in hand. This is covered in Simon's model as a web-weaving activity "connecting conflicting worldviews through translation".

These sense-making activities may be considered as 'problem definition' in the context of traditional problem solving; 'uniting stakeholder perceptions of the problem situation' in the context of soft systems methodologies; or ‘framing’ or ‘building the decision making frame’ in the context of Design Thinking.

Both CPMs and CCPMs recognise interpreting, communicating and representing the design frame as a core function of project management. Some CCPMs described best practice project management tools such as project briefs, plans of work, minutes of meetings and action trackers as a means of doing so.

Research findings reveal another strand of sense-making activities not explicitly covered in Simon’s model of CPM action, which appear to be the reserve of older and more experienced CCPMs: Triangulating solutions.

Actions associated with ‘triangulating solutions’ see the CCPM actively engage the team in identifying solutions, by seeking synergy between ideas put forward by the team, and through reference to decisions taken in similar situations on previous projects.

This process of triangulation is also used to intuitively recognise ideas worth refining or developing, building support for these ideas through political influence, and encouraging their development in a collaborative format.

Game master – Both CPMs and CCPMs are concerned with fostering a project environment which focuses creative teams towards useful outcomes, and in doing so defines expectations and appropriate behaviours. Simon’s model suggests that CPMs do this through setting rules, keeping scores and imposing sanctions on the team; whereas research findings suggests that CCPMs do this through framing, encouraging and building support for ideas. This indicates that CCPMs possess a fundamental softer management style than the CPMs described in Simon’s model. Both CPM and CCPM take action to define the project plan – expressed in Simon’s model as ‘setting the rules’. Simon’s model implies that this is defined by the project manager and imposed on the team. Research findings suggest that CCPMs do this in an inclusive collaborative way, building team design ownership over the plan, and reducing the need to actively implement, promote or police it.

Both CPM and CCPMs act as goal bearers, adopting and representing the goals and objectives of the project in their professional interactions with the team. Research findings offer greater insight into *how* this is achieved, than is exposed by Simon’s model, describing how CCPMs may frame goals and objectives through reference to precedent and their previous professional experiences.

Both CPM and CCPMs act to ‘define and guard the borders of the playground’, to encourage divergent or innovative thinking, but also focus and orientate the teams ideas towards project goals. CCPMs achieve this by expressing a genuine interest in, and appreciation of designers and what they are doing. In doing so, they may express wonder, excitement and support for certain ideas, whilst questioning and interrogating the logic of others.

Both CPM and CCPMs actions in ‘defining borders’ to divergent creativity represents a pragmatic outlook which acknowledges that projects ultimately serve business needs: that the creative imperative must be balanced alongside the commercial and programmatic imperative.

Simon's model does not describe how these borders are defined. Much of the CCPM's discussion of 'visioning' actions focused on the formulation of an appropriate project brief – a best practice tool – in doing so. CCPMs described the danger of overly prescriptive project briefs and the need to focus on core goals and objectives – particularly in initial pre-concept and concept design stages.

CCPMs and CPMs also acting as a goal-bearer with an intuitive understanding of the project vision. In the context of a loosely defined brief, CCPMs actions as goal bearer allows them to focus the team and correct misunderstandings.

Research findings offer further insight into specific actions which CCPMs may take to focus or redirect the team towards project goals: Compromise is secured by interpreting, communicating and representing the design frame: framing difficult decisions – including those which may be perceived to constrain the team's creative freedoms - in the context of project goals through reference to analogy or previous experience.

Both CPMs and CCPMs attempt to animate the team through their social engagement with the team. The focus of Simon's model considers both the social dynamic of the team and the intrinsic motivation of individuals. Research findings suggest that CCPMs are less concerned with influencing the social dynamic of the team, but more concerned with influencing design through positive engagement with the team. This may again be a factor of the CCPMs delegation to design champions to manage the social intricacies of their teams; whereas under Simon's model this is a function of CPMs.

A further point of divergence between Simon's model and research findings relates to the response of CPMs to success and failure. Simon's model describes a culture of rewarding success and punishing failure; whereas research findings suggest that whilst CCPMs would build support and excitement around 'project successes' and treat the team at key project milestones, they would not punish failure nor undermine people's ideas in a group context.

Furthermore the language of Simon's model presents creative design as a game where people are motivated to win. Research findings suggest that internal competition is not conducive to creativity, and that creative design requires a tolerance of failure out of a respect and understanding the design process and concern for people and their intrinsic motivations.

Flow balancer - At a general level, CPMs and CCPMs are both concerned with maintaining the intrinsic motivation of individuals within their teams. Where research findings differ from the model is in the efforts made to adapt and adjust the design process and the division of work to appeal to design team member's interests and sensitivities.

Simon's model suggests that CPMs attempt to plan, monitor and organise the work in a way which responds to design team member's interests and sensibilities; whereas research findings suggest that although CCPMs will accommodate alternative ways of working where not detrimental to the project, they ultimately recognise personal goals are subservient to project goals. As such CCPMs focus less on appealing to intrinsic motivation, than acting to ensure that they do not undermine intrinsic motivation.

CCPMs actions aimed at not undermining intrinsic motivation are orientated around building design team ownership over project planning, the design process and project goals.

However, again it is necessary to bear in mind the structural differences in the creative teams studied and the professional culture of construction industry professionals: Simon's research considers small creative teams working on computer game design and advertising campaign projects; whereas this research considers large multi-disciplinary professional teams working on major engineering projects. The structure of the teams, and by extension the project managers mandate for micro-management of the work, is significantly different: Where Simon's CPMs set challenges to motivate the team, CCPMs revert to design champions to divide the work amongst their teams, manage egos and manage the social dynamic within their teams.

In this context, CCPMs are more process-orientated than their CPM counterparts, and their role is more concerned with guarding the design process, than it is managing the work itself. At a general level, actions relating to 'guarding the design process' reflect Simon's description of CPMs flow-balancing actions of 'balancing constraints and freedoms' and 'game-master' actions of 'setting the rules'; however under Simon's model, the focus of these actions is largely goal and objective orientated rather than process orientated.

Simon's model also refers to the culture that CPMs attempt to engender through reference to 'belief in fun' (a flow-balancing action), 'instituting knowledge sharing contexts' (a games-master action).

Research findings suggest that CCPMs are more likely to revert to professional culture, rather than attempt to engender a project organisation culture. They do however engage in activities aimed at ensuring they have a mechanism to influence the design process and design: Building a collaborative atmosphere where constructive criticism is welcomed. In doing so they are able to broaden the knowledge base of the team, as well as personally influencing the design team and the design process without undermining design team members intrinsic motivations.

5. Research Output

One of the most interesting outcomes of this research is what has not been said: The actions described by CCPMs do not contradict current project management best practice methodologies: They have not suggested that neither commercial nor programmatic objectives are not significant; nor that the tools nor processes need to achieve them be adapted, loosely implemented or otherwise compromised.

Indeed the research findings offer support for the "and/in-addition-to" attitude towards the management of social issues associated with creativity management, in parallel with the largely technical aspects of commercial and programmatic management (Lewis, Welsh, Dehler and Green, 2002; Gustavsson and Hallin, 2014); through the definitions of creativity as a function of quality, we ultimately recommend that the dichotomisation of time, cost and quality objectives – a paradigm accepted by the majority of construction project managers – be robustly challenged in future project management research.

In this context the proposed CCPM purposeful action model (see table 3) is recommended as a value-adding complementary “frame” for considering PM conduct and the application of project management best practice on building design projects.

Table 3: CCPM purposeful action model

PERSONAL-PROFESSIONAL RELATIONS	VISIONING
Build personal relationships with Client and influential team members; **B**e open and transparent and willing to engage in debate; **B**e dependable and reliable, success aligned with that of the team; **N**ever undermine people's contributions in a group setting; **C**hannel or redirect people with a negative outlook; **B**e Present; **B**ehave in a courteous and professional manner; **R**esolve disagreement and conflict amicably.	**B**uild an intuitive understanding of what the client is attempting to achieve; **F**ocus on goals and objectives, not prescriptive solutions; **C**ommunicate 'solutions' through reference to precedent or analogy; **A**dopt a transparent open book approach to financial and planning info; **B**uild respect and understanding of [concessions needed for] a creative design process; **E**ngage the team in risk identification and mitigation; **U**ncover goals and objectives; **S**elect partners with aligned vision.
Secure commitment and results through political influence **I**nfluence design through positive engagement with design team **F**rame difficult decisions in the context of project goals, through reference to analogy/ experience **I**ntelligent monitoring of design process against project goals and programme **M**aintain forward momentum	**F**acilitate direct interactions between design champions & the client **T**riangulate solutions: Focus & channel design team towards an objective or away from a wrong path **T**riangulate solutions: Encourage idea generation, development or refinement **I**nterpret & relate design issues to goals & objectives **B**uild support for creative ideas or solutions of merit **S**hare in success and failure of the design team
GUARDING DESIGN TEAM & PROCESS	**SENSE-MAKING**

6. Conclusion

This research proposal was borne from an observation of the dysfunctional and disruptive influence of mainstream project management practice on design team’s motivation and output. The ultimate aim of this research was to examine and learn from the positive and integrative approach of CCPMs, and where possible promote and broaden the project management agenda. The proposed CCPM purposeful action model may be viewed as making a contribution to that agenda.

The theoretical claims of the proposed model are limited by sample size, the lack of effort to triangulate research findings, the skill and experience of the researcher in data collection under an ethnographic approach, and the analysis and categorisation of research findings at an appropriate level. As such, the proposed CCPM purposeful action model does not propose strong theoretical claims. As with Simon’s (2006) model, further direct observations of CCPM action are needed to validate, challenge or supplement this model and secure greater insight into CCPM perception of the problem situation.

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Project Managers Skills Assessment in the AEC Industry

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Abstract

Construction project managers develop projects in changing, hostile and complex environments, where their skills determine their ability to make decisions. Usually, this decision-making process may be affected by deviations in human beings rationality associated with emotions, perceptions and personal interests. Therefore, it is important to determine and establish the most important skills required by a project manager in the Architecture, Engineering and Construction (AEC) industry, according to the particular needs of projects and specific characteristics of individuals.

This research aims to evaluate the perception of different industry stakeholders regarding required project managers skills in order to determine the most relevant ones. Similarly, differences between respondents' perceptions (if there are any) are identified as well as factors leading to these differences such as geographic location, gender, level of education, certifications acquired or methodological implementations, among others. Moreover, this study seeks to assess whether project managers technical skills are subordinated to primary emotions, since recent studies suggest that emotional skills are more important than technical skills.

Stakeholders' opinions were quantified through a survey sent to AEC companies in Colombia and to different people from this industry around the globe. Responses were analyzed using multiple regressions with dummy variables finding that technical skills are not subordinated to primary emotions, and that social skills are more influential to project management than technical skills.

Keywords: project managers, skills, perceptions, emotions, AEC industry.

1. Introduction

Construction projects are developed in complex environments requiring different skills from their managers to accomplish project goals. This is achieved by making accurate and effective decisions at the right timing. However, human beings may be affected by emotions, perceptions and personal interests. Therefore, it is important to determine and establish the most important skills required by a project manager. Authors have written about project managers' skills leading to the following findings.

Until 1980, though researchers considered that technical skills were essential for construction and engineering, personal features started to be relevant. Lippitt (1966) assigned great importance to skills in design, construction, management and operations for transportation developments in communist China associated to technical skills. Conversely, authors like Gaddis (1959) stated that, in addition to field experience, project managers should have a certain profile to develop their work, including their personal characteristics, determining individuals' behaviour on different situations. Martin (1976) proposed that effective project managers had personal characteristics and skills to perform their duties properly (e.g. leadership, honesty, integrity, as well as technical aspects such as planning and monitoring activities, quick thinking, search for information and decision making). Katz and Kahn (1978) assured that efficient communication and maintaining harmony and motivation between the working team was fundamental.

Between 1981 and 1990, in addition to project managers' achievement of objectives, authors like Allen et al. (1980) and Luthans (1988) identified personality traits to define key skills, where respect for others, confidence and vision (not only to anticipate situations but to conceive the project as a whole) were included. Stickney and Johnston (1983), besides using models composed of grouped skills, proposed that authority delegation and sharing promoted the commitment of all the people involved in development of projects. Certainly, authors from this period added more personal skills to project managers' profile.

Methodologies and project management processes played a key role in the 90s as they allowed companies to adapt and adopt practices (standardization), and develop new procedures to improve the efficiency of processes (Fisher, 2011; Wells, 2012). However, methodologies and certifications do not identify the skills that project managers require. Hence, Thomas and Mengel (2008) specified that this level of education does not prepare students to deal with the current projects environments. In fact, they confirmed that "trained" managers are afraid of change, do not adapt to unexpected situations, and avoid using strategies and new techniques. The latter definitely shows the gap between education and project needs.

In 1995, Goleman published Emotional Intelligence, a book referring to the importance of emotional intelligence for personal development. Goleman insisted on managing personal emotions, self-consciousness, and handling interactions with others, emphasizing on the fact that only intelligence is not the key. Self-awareness, tolerance and ability to work in teams began to play an important role on individuals' lives and in the perceptions of what is considered important in various fields. In project management some of these variables started to have relevance, to meet project needs.

Recently, a growing interest on skills and competencies has arisen and several authors continue to look for relevant skills in project managers, finding that, in addition to technical skills, there are key skills for the profession (Zhang et al., 2013). Moreover, the ability to recognize, interpret and manage emotions is critical in interpersonal relationships (Lopes, Salovey& Straus, 2003). In fact, El-Sabaa (2001) stated that social skills have more influence on project management than technical skills and Edum-Fotwe and McCaffer (2000) believed that the essence of relationships is social, not technical, and that relevant skills for managers of construction projects are leadership, communication, negotiation and problem solving. Zulch (2014) makes an interesting statement recognizing that "without emotional skills, interpersonal skills may not be used effectively, and without interpersonal skills, technical skills may be wasted".

Finally, Giraldo et al. (2013) conducted a study to characterize project managers' profiles in the construction sector in Bogota, Colombia. The authors stated that managers of successful projects require experience, educational background and a set of skills to respond in a more accurate and fast way to challenges and changes within the Colombian construction sector. They found that technical skills are the most representative skills for project managers, considering the other skills as complimentary. However, respondents belonging to professional associations, considered the interpersonal skills more important than other skills.

Figure 1 summarizes how the perception of important skills has changed over the years.

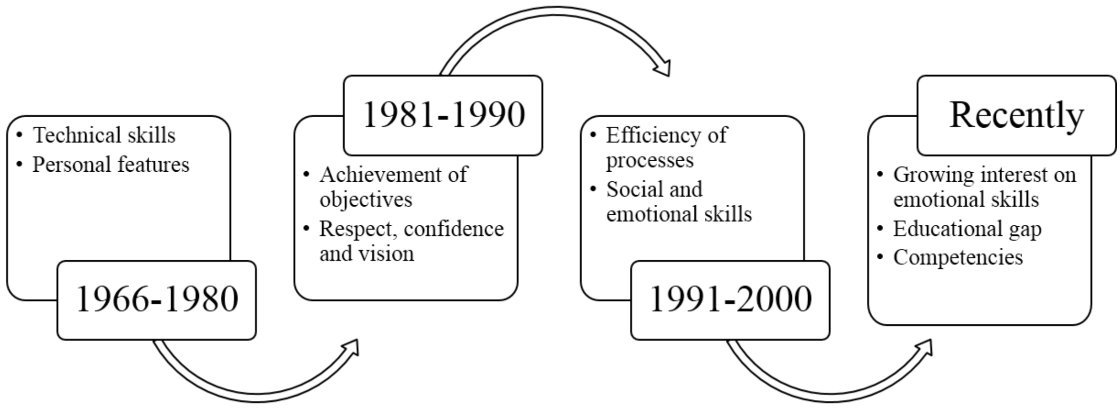

Figure 1: Important skills through time

This paper includes the methodological approach for developing a survey to assess project managers' skills, the results for each studied variable and the analysis done with multiple linear regressions. The final section contains conclusions based on our findings.

2. Research methodology

2.1 Preliminary stage

This stage included literature review, research hypotheses formulation and research strategy definition.

Literature review showed the opinions of different authors towards skills and served as a basis for classifying the skills and formulating the hypotheses. Our hypotheses are: 1) technical skills are subordinated to emotional skills, and 2) skills are independent from demographic conditions.

This research is framed in a mixed methodology which includes qualitative and quantitative approaches. According to Naoum (2007), the qualitative method considers an attitudinal approach to evaluate opinions; points of view or perceptions towards the skills that project managers require (variables). The quantitative method refers to the validation of the hypothesis through statistical analysis of the variables. The selected approach to data collection was fieldwork research, a primary data collection method that considers a survey approach with a postal questionnaire as a practical collecting technique.

2.2 Survey development

To develop the survey, first, a preliminary list of skills (variables) identified as relevant and common to different authors was completed. These variables were grouped into four broad categories, called factors: Cognitive (knowledge base); Technical (specific to a profession); Social (interactions with other people) and Emotional (personal knowledge and understanding, i.e. emotional awareness).

This first draft was checked several times, some variables were rewritten and those which were similar were pooled, reaching to a final definition of 31 variables: 4 cognitive, 5 technical, 12 social and 10 emotional. This distribution was used to develop an analytical survey, aiming to establish relationships and associations between answers and respondents to validate the hypotheses (Naoum, 2007). Table 1 shows all the variables included in the survey.

Authors considered that the most suitable technique for collecting data was the postal questionnaire. This instrument has been widely used to find out facts and opinions on specific themes. It is characterized for having closed-ended questions with specific answers or scales for factor or variable ranking (Naoum. 2007). Our postal questionnaire had opinion questions with quantifiers on a numerical rating scale from 1 to 9 for variables. The scale is odd to have a middle or neutral point. The quantifiers refer to:

- 9 = Extremely Important
- 5 = Important
- 1 = Extremely Unimportant

It also contains a ranking scale to indicate the factors importance or preference (4 - the most important and 1 - the least important). Vocabulary and questions were carefully examined to avoid bias and ensure their understanding. Two versions of the survey were made; one in Spanish and one in English, to enlarge the number of participants.

The survey had 6 sections: 1) Cognitive factors; 2) Technical factors; 3) Social factors; 4) Emotional factors; 5) Factor ranking; and 6) Demographic information. Last section had questions to characterize the sample such as gender, age, years of experience, working geographical area, sector, industry, use of methodologies/certifications acquired.

Survey sample was a selective sample of people related to the AEC field, considering teachers, contractors, and members of groups or associations worldwide. Respondents database was built from public information mainly from companies. Some participants were contacted through emails and social networks (LinkedIn and academia.edu). An introductory letter confirming anonymity of the respondents and the link to the survey were sent. The questionnaire was developed with Google Docs.

Before final data collection, a pilot study was done to test the survey with some experts. Their feedback was used to improve or modify questions. This questionnaire included a closed-ended question section regarding the survey length, the scale used, the instructions provided, the layout of the questionnaire and a space for additional comments.

2.3 Data analysis

After gathering respondents' opinions, the chosen method for data analysis was multiple linear regressions with dummy variables. These variables take the value of 0 or 1 to indicate the presence or absence of characteristics that may modify the outcome. Multiple linear regression models take the form:

$$y_i = \beta_0 + \beta_1 \cdot x_{1i} + \beta_2 \cdot x_{2i} + \cdots + \beta_n \cdot x_{ni} + u_i$$

Where: y_i =dependent variable, $\beta_0, \ldots, \beta_n$ =regression coefficient, x_{ni} =independent variables and u_i =error term.

Obtaining regression coefficients and their significance to examine the relationship between the independent and the dependent variables was possible due to the use of specialized software in data analysis (Stata/SE 12.1). Significance was verified with the following statements: 1) The null hypothesis states that $\beta_n = 0$ and 2) The alternative hypothesis considers that $\beta_n \neq 0$

Each coefficient has a P-value and a significance level of 5% (as the test chosen value). When the P-value is higher than the significance level, the null hypothesis is not rejected and the coefficients are not significant for the model, hence, the variables are independent. On the other hand, when the P-value is lower than the significance level, the null hypothesis is rejected and it is concluded that the coefficient is significant for the model and that the variables are dependent (i.e. the independent variable affect the dependent variable).

The results allowed validating or rejecting the research hypotheses mentioned above.

3. Results

3.1 Pilot study

For the pilot study 23 experts from different countries (e.g. Brazil, Chile, Colombia, Germany, Mexico, New Zealand, Spain, UK, and USA) were contacted, 12 experts (a response rate of 52.17%) participated in the survey and send their comments. Their feedback helped to introduce adjustments such as the scale modification and addition and removal of variables and questions.

3.2 Respondents

The questionnaire was sent to professionals related to project management in the AEC industry worldwide. There were 139 responses, however, a conventional response rate was not calculated due to the social network approach to sampling. The link to the survey was published online, making it almost possible for everybody to answer it and preventing authors of knowing the factual number of respondents. All replies were validated to include only the people related to AEC industry.

Sample demographic information showed that 79% were male and 21%female; 39% were from Spain, 28% from Colombia, 20% from America (North and South), 4% from Europe, 4% from Middle East, 3% were from Africa and 2% from Oceania. Due to the number of respondents in Colombia and Spain, both countries were excluded from America and Europe, respectively. Age distribution revealed that 15% were between 46 and 50 years old; 14% between 41 and 45; 14% between 31 and 35; 13% between 26 and 30; 12% between 36 and 40; 9% between 51 and 55; 9% were between 21 and 25; 7% between 56 and 60; 5% between 61 and 65; and 2% older than 65 years old.

Educationally, 75% had advanced studies (graduate), 23% had bachelor's degree, 1% were technicians and the remaining 1% were high school graduates. 77% worked in the private sector and 23% in the public sector. Respondents roles were classified under the categories 1) academy (professor, researcher and student), 2) business (investor, manager, owner, developer), 3) designer (architect, designer) and 4) production (project manager, resident engineer, construction work supervision and contactor. The occupation distribution is 51% production, 19% business, 18% designer and 12% academy.

Respondents also indicated that 24% relate to the Project Management Institute (PMI), 22% use lean construction, 19% apply LEED, ISO (International Organization for Standardization) or IPMA (International Project Management Association) and 35% do not use methodologies or have acquired certifications of any kind. The sample geographical working areas are 29% in Spain, 26% in Colombia, 21% in North and South America, 9% in Europe, 5% in the Middle East, 5% other regions, 4% in Africa, and 1% in Oceania.

3.3 Cognitive factor (CF)

Results show that the average importance rating and the ranking of the most and the least important variables are consistent (i.e. the variable perceived as most important is the one that has higher average and the one considered less important has the lowest average). The most important variable is *1.3 Evaluate different alternatives and their consequences* with a mean of 8.09, and the least important variable is *1.1 Search and collect information from different sources* with 7.09.

As it was mentioned before, the coefficients affect the model when their P-values are below 5%. Consequently, results define that the independent variable *sex* affects the dependent variable *1.1 Search and collect information from different sources,* which is also affected by those working in *Africa.* The variables that affect *1.2 Identify opportunities and challenges* are *nationality* and *geographical working area,* excluding *Middle East* in both of them. *Education* and the *Middle East* in *geographical working area* are significant variables for *1.3 Evaluate different alternatives and their consequences. Production* and the following geographical areas *America, Colombia and Africa* affect *1.4 Develop creative, innovative and original ideas*.

The only variable that influences every dependent variable of the cognitive factors is *geographical working area* in contrast to *sector* and *methodologies/certifications,* both insignificant for the cognitive skills.

3.4 Technical factor (TF)

The most important variable is *2.5 Design, plan, organize and control* with an average of 8.50, and the least important variable is *2.1 Use of specialized tools* (mean=6.37). The ranking of variables is congruent with the rating. Variable *2.1* is the only dependent variable that is not affected by any of the independent variables. *African nationality, education* and *other regions* in *geographical working areas* influence variable *2.2 English proficiency*. *Graduate degrees, academics, private sector* and *other regions* in *geographical working areas* have an impact on *2.3 Budget development and management. Bachelor's degree* and *geographical working area* are the independent variables that affect *2.4 Efficient resource management*. Finally, the use of anything related to *PMI* and *other regions* have an effect in variable *2.5*.

Results for technical factors show that none of the dependent variables is affected by *sex* and that *geographical working area* and *education* are the most affecting variables, therefore, workplace and education are crucial to assign the degree of importance for technical variables.

3.5 Social factor (SF)

The most important variable of the emotional factor is *3.7 Teamwork* (mean=8.32) and the least important variable is *3.4 Availability for others* (mean=6.80). The variable ranked as most important is also the rated most important variable (*3.7*). However, the variable ranked as least important, is not the one that has the lower average. Thus, this factor is incongruent in rating and ranking (i.e. the respondents assigned a slightly higher importance to the least important variable). Only considering the ranking, the least important variable is *3.6 Build long-term relationships*.

The independent variables that are more influential to the dependent variables are *education* and *geographical working area*, meanwhile *sector* and *methodologies/certifications* do not affect any variable. *Sex* is the only variable that influences *3.8 Effective oral and written communication*; therefore, being male or female alters the degree of importance given to the variable. *Nationalities* such as *Colombian, European* and *African* affect *3.1 Encourage others' participation, 3.2 Provide constructive feedback, 3.10 Encourage others' development* and *3.11 Promote learning*. The latter shows that people from developed and developing countries have an impact on the variables that concern about the progress of others. Similarly, *Colombia* and *Africa (geographical working areas)* affect variables that seek for the progress, motivation, development and consideration for the others. In addition, *education* also influences variables that relate to the efforts that a manager can do for them.

3.6 Emotional factor (EF)

4.2 Leadership is the most important variable of the factor with a rating of 8.32 and the least important variable is *4.6 Aware of own feelings* with an average of 6.57. The ranking of variables for this factor is consistent with the rating. *Geographical working area* influences the rating of variable *4.2*, whereas *Africa* is the only area affecting *4.6*. Furthermore, the *working area* is the most affecting variable for the emotional factor. *Occupation* and *sector* do not influence any dependent variable.

Males affect the rating of variable *4.7 Stress management*, causing that males assign less degree of importance to it. *Not having certifications or implement methodologies* is significant for variable *4.5 Adapt to changing situations*, however the rating does not change substantially. *Colombians, education,* and *Colombia* and *Africa (working places)* affect *4.10 Failure-tolerant*, a variable that was included due to the opinion of an expert who participated in the pilot study. The same independent variables are significant to*4.3 Proactivity*, nonetheless, all nationalities except *Middle East*, and only *Colombia* are the influencing classes.

Geographical working area affects four dependent variables. However, the only variable that is affected by all of them is *4.9 Recognize own strengths and weaknesses*. For the remaining variables: *Middle East* and *others* do not influence *4.1 Self-confidence*, *Colombia* is the only area that affects 4.*4 Being visionary* while only *Africa* impacts*4.6 Aware of own feelings.*

3.7 Ranking of variables according to their average

Table 1 shows all the variables ranked according to the degree of importance given to them. Some of the variables have an asterisk (*) on the side of the factor, that represents remarkable variables for the authors. For instance, *2.2 English proficiency* is relevant because some job offers in our country (Colombia) require proficiency in this language. Another example relates to variable *4.2 Leadership*, which is also considered important for many authors (Giraldo et al 2013). Some of these variables have a high average rating (*3.7 Teamwork, 4.2 Leadership*), though *2.2 English proficiency* and *4.7*

Stress management are in unappealing positions, indicating that those skills are not as relevant for project managers.

Other variables have a plus sign (+) denoting they were ranked the most important variables of its factor and others have a minus sign (-) representing the least important variables of each group. Variables considered as most important are in the top 6 and have averages between 8.50 and 8.09, whereas the least important variables are in the bottom positions with averages between 7.19 and 6.37. Besides, the degree of importance assigned to all variables is in the 6 to 9 range, suggesting that all the studied skills are important and extremely important.

2.5 Design, plan, organize and control is the most important variable (8.50), it belongs to the technical factor. On second place are *3.7 Teamwork* and *4.2 Leadership* both with the same degree of importance (an average of 8.32). The difference between the first and the second position is 2.11%. Consequently, the most important skill for project managers in the industry of Architecture, Engineering and Construction is the technical ability to *design, plan, organize and control*.

2.1 Use of specialized tools is the least important variable with a rating of 6.37. Even though in the numeric scale this average indicates that the variable is important, it demonstrates that the AEC sector is very conservative and averse to the use of technology. Nowadays countless tools exist to contribute to the planning, development and project control. However, there is still the idea that technology is inadequate to perform the tasks of a construction project manager (ESSEC, 1997).

Moreover, Table 1 shows that in the top 10 variables there are 2cognitive, 2technical, 3social and 3 emotional variables. This is consistent with the findings of Pettersen (1991) and Zhang et al. (2013) who suggest that a project manager must have skills such as planning, monitoring and supervision, leadership and group management. Similarly, Giraldo et al. (2013) claimed for the need of additional skills to the technical ones.

Conclusively, technical skills are still considered very important and emotional skills, despite having close degrees of importance, do not overcome them yet. These results are alike to the findings of Giraldo et al. (2013) for respondents who do not belong to professional associations. Nevertheless, we considered the AEC sector worldwide instead of project managers for a specific city, as they did in their research.

Table 1: Ranking of variables by mean

No.	*Factor*	*Variable*	*Mean*
1	*TF*	*2.5 Design, plan, organize and control (+)*	*8.50*
2	*SF**	*3.7 Teamwork (+)*	*8.32*
3	*EF**	*4.2 Leadership (+)*	*8.32*
4	*TF**	*2.4 Efficient resource management*	*8.22*
5	*EF*	*4.5 Adapt to changing situations*	*8.12*
6	*CF*	*1.3 Evaluate different alternatives and their consequences (+)*	*8.09*
7	*EF*	*4.3 Proactivity*	*8.04*

No.	Factor	Variable	Mean
8	CF	1.2 Identify opportunities and challenges	8
9	SF*	3.8 Effective oral and written communication	7.88
10	SF	3.9 Delegate responsibilities	7.86
11	EF	4.1 Self-confidence	7.80
12	EF*	4.9 Recognize own strengths and weaknesses	7.80
13	SF	3.3 Listen carefully to others	7.73
14	EF	4.8 Acknowledge own mistakes	7.66
15	SF*	3.5 Inspire people	7.60
16	CF*	1.4 Develop creative, innovative and original ideas	7.56
17	SF	3.11 Promote learning	7.50
18	TF	2.3 Budget development and management	7.48
19	SF*	3.1 Encourage others' participation	7.45
20	EF*	4.7 Stress management	7.45
21	EF	4.10 Failure-tolerant	7.36
22	SF	3.12 View from others' perspective	7.32
23	SF	3.10 Encourage others' development	7.29
24	SF	3.2 Provide constructive feedback	7.24
25	EF	4.4 Being visionary	7.22
26	SF	3.6 Build long-term relationships (-)	7.19
27	CF	1.1 Search and collect information from different sources (-)	7.09
28	SF	3.4 Availability for others	6.80
29	TF*	2.2 English proficiency	6.74
30	EF	4.6 Aware of own feelings (-)	6.57
31	TF	2.1 Use of specialized tools (-)	6.37

3.8 Ranking of factors

Table 2 presents the respondents' average preference for factors, ranking them from 1 to 4. It also shows that only *nationality* and *education* affect them. However, the technical factor is not influenced by any independent variable. The most important factor is social with an average of 3.23 and emotional factor is the least important (21% below).

Table 2: Ranking of factors

Factor	Average	Nationality	Education
Social	3.23	African Colombian Spaniard	
Technical	3.12		
Cognitive	3.07		Bachelor's Graduate
Emotional	2.55	All	Bachelor's Graduate

These results indicate that project managers primarily require skills to interact with others, while technical and cognitive skills are complementary. Emotional skills are somehow irrelevant as they are in the last position. El-Sabaa (2001), Edum-Fotwe and McCaffer (2000), and Zulch (2014) identified that social abilities are more influential to project management than technical skills.

4. Conclusions

This study shows that technical skills are not subordinated to emotional skills and that variables such as sex, education, geographical working area, certifications acquired or methodological implementations, and nationality affect skills. In fact, significant variables are *nationality*, *education* and *geographical working area* for almost all factors. Therefore, both research hypotheses were refused.

All variables are important or extremely important according to their average rating. Social and technical skills have similar degrees of importance, showing that project managers require social abilities to interact with others, while technical and cognitive skills are complementary. Emotional skills are overlooked. Consequently, social skills are more influential to project management than technical skills, as several authors have explained.

However, technical skills still occupy an important position among the skills required by project managers in the AEC industry. This demonstrates the conservative results-oriented approach of the sector prevailing since 1981. The indifference to technological uses shows that there is still the idea that technology is inadequate for construction project managers. Hence, the AEC industry seems to be a parallel, archaic world where current global trends oppose to its philosophies.

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Transparency and accountability as antecedents of value for money in construction

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Abstract

Public-sector projects are intended to result in improvements in the quality of life of the citizenry. However, studies show that a proportion of the funds intended for investment in public-sector projects is lost through corruption. This results in sub-standard buildings and infrastructure which are expensive to operate and maintain, and which can also lead to structural failure and loss of lives.

In many countries, the populace, community groups and non-governmental organisations are calling for, and often, taking measure to attain, clean government and accountable public service. These have led to initiatives which have resulted actions in some countries, including the review and strengthening of the procurement process; streamlining of contract administration procedures; and formation or strengthening of anti-corruption agencies. However, the incidence of corruption, malpractice and mismanagement in construction persists. Much effort is being made at the global, national, company and project levels to address the situation. One of these is the Construction Sector Transparency Initiative (CoST), which is being implemented in many countries. This study extends knowledge on how to deal with corruption in construction by exploring the merits of transparency in these regards. It considers the potential of CoST to enable the realisation of value for money in construction.

The literature on corruption, its impacts, its common occurrence in construction and the consequences, together with the underlying reasons, are reviewed. Meta-analysis of data from 216 projects in eight countries obtained in the pilot of the CoST initiative forms the other main plank of the study. It is found that previous approaches, such as legislation and procurement reform, have not been sufficient to address mismanagement on projects. It is shown that CoST has yielded tangible benefits, including avoidance of overdesign, cancellation of contract awards with possible corruption, and disciplining of miscreants. Many authors also support CoST and highlight its merits. It is concluded that project governance should receive emphasis. Given the large number of stakeholders on any sizeable construction project, it is proposed that a multi-stakeholder approach such as CoST would be most appropriate. Suggestions on how CoST can be instituted are made, with a focus on education.

Keywords: corruption, infrastructure projects, governance, disclosure, quality of life

1. Introduction

Transparency International (2005, 2008) suggests that 10% to 30% of investment in construction globally is lost through corruption. Mismanagement, malpractice and inefficiency account for a similar level of losses. Research shows that no country is immune from this. American Society of Civil Engineers (ASCE) (undated) considers corruption in construction globally a huge burden of some US$500 billion annually which occurs in every country. Public-funded construction works form 30% of most governments' budgets (OECD, 2002; CoST, 2013a). The leakage and wastage adversely affect the rate and quality of development. There is a demand around the world for probity and accountability in public office. Laws, institutions and project-based procedures appear unable to deal with the situation. Thus, there is a search for solutions. It is argued here that the Construction Sector Transparency Initiative (CoST) could be an effective response.

The aim of the study is to present CoST as a solution to problems of mismanagement and corruption on public construction projects. The objectives are to: (a) consider the nature and impact of corruption, and how and why it occurs in construction; (b) discuss solutions to corruption and mismanagement on public construction projects; and (c) explore key aspects of CoST. The study is based on a review of the literature on corruption in general and in construction and the consequences, together with the underlying reasons. Meta-analysis of data from 216 projects in eight countries obtained in the pilot of the CoST initiative forms the other main plank of the study.

2. Corruption, its effects and manifestation in construction

2.1 What is corruption, how extensive is it and what is its impact?

A definition of corruption agreed by the multi-lateral banks is (World Bank Office of Suspension and Debarment, 2014): "the offering, giving, receiving or soliciting, directly or indirectly, of anything of value to influence improperly the action of another party". United Nations Development Programme (UNDP) (2008) and Transparency International (undated) define it as: "the misuse of entrusted power for private gain" (p. 6). Corrupt acts take many forms including (GIZ, 2012; Ofori, 2012; Serious Fraud Office, 2014): bribery, extortion, fraud, nepotism, graft, kickbacks, theft, misappropriation, falsification of records, influence peddling, deception, coercive action, cartel price-rigging, illicit enrichment, commission/fee and dishonestly exercising official functions.

Studies show that corrupt practices exist in all countries; and that they are particularly common in construction. For example, in the Transparency International (2014) Corruption Perception Index, 69% of the 175 countries scored below 50 out of 100 ("indicating a serious corruption problem", p. 4). None of the 23 European countries studied by Transparency International (2012b) had a perfect record regarding anti-corruption systems and measures: "All countries in Europe, even …the 'cleanest of the clean', have some deficits in their anti-corruption frameworks" (p. 9). In the Bribe Payers Survey of Transparency International which studies the extent to which firms from 28 largest, industrialised economies pay bribes when doing business abroad, the "public works and construction" sector consistently performs worst. Transparency International (2012a: p. 3) noted: "Bribery is perceived to occur in all business sectors, but is seen as most common in …public works contracts and construction".

Corruption has wide ramifications. UNDP (2008) notes that it weakens national institutions, and leads to inequitable social services, economic inefficiency and unchecked environmental exploitation. It hits the poor hardest and undermines development. It corrodes the ideals of public service. Corruption erodes the rule of law; and harms the reputation of, and trust in, the state (World Bank, 2011b). Corruption deters investment, and distorts public investment decisions. It introduces further risk into business and influences the costs of transactions; it works against professionalism.

Some suggest that corruption can be useful to society as it (Ofori, 2012): facilitates and expedites procedures; and reduces business costs because, for example, expediting approval can reduce financing costs. It is also argued that corruption is part of human nature, and it is impossible to eradicate it; it is the way of doing business in some countries.

2.2 Corruption in construction

Corruption is common in construction. World Bank (2011a) reports that 25% of over 500 projects with a Bank-funded roads component approved in 1999 to 2009 drew fraud, corruption or collusion allegations. On 25 projects, allegations were confirmed, resulting in 29 cases of misconduct including collusion among bidders; fraud in implementation; and false documents and imposed sanctions in Bangladesh, Cambodia, India, Indonesia, Kenya, Philippines and Senegal. Kenny (2007) found a relationship between average unit cost for upgrading a road with a bitumen surface and the country's Corruption Perceptions Index. World Bank (2011a) reports these estimated cartel overcharges on road contracts: Florida, 8%; South Korea, 15%; Tanzania 15-60%; Philippines 20-60%. For a sample of 29 developing countries, the overcharge was 40 percent. Moreover, for all construction contracts, the overcharge in the Netherlands was up to 20%; in Japan, it was 30-50%; and for all cartels, it was 25%. European Investment Bank Group (2014) notes that direct costs of corruption in public procurement in five sectors (road and rail; water and waste; urban/utility construction; training; and research and development) in eight member states ranged between €1.4 billion and €2.2 billion. The probability that certain types of infrastructure would be affected by fraud and corruption ranged from 11% in road works to 27% on waste water plants. K&L Gates (2014) presents corruption cases around the world including Nigeria, Russia, UK, and US. Firms from Canada, France, Japan, UK and US have been fined for paying bribes while working abroad.

2.3 Why is there much corruption in construction?

Several studies highlight how corruption occurs on construction projects (Ofori, 2012); it is evident at all stages. Authors give many reasons why construction projects are prone to corruption and malpractice (Stansbury, 2005; Ofori, 2012; Hawkins, 2014). First, they are large and expensive, making corruption attractive and perhaps easier to conceal. Second, they take a long time to complete and involve many agencies so there is a temptation to influence approval processes. Third, constructed items are geographically dispersed and difficult to control administratively. Fourth, constructed items are technically complex, and it requires knowledge to detect malpractice. As each project is unique, there are no suitable comparators. Fifth, many portions of the built item (such as foundations, floor slabs, beams, roof structure and walls) are covered, making it possible to conceal poor quality of work. Sixth, avoiding responsibility is part of the industry's culture (Ofori, 2012).

PriceWaterhouseCoopers (2009) notes that engineering and construction companies "have a business model that exposes them to a more of the recognised corruption risks than those in almost any other sector. This is because they are involved in one-off long-term contracts, …using complex supply chains" (p. 3). The industry has a culture of using gifts, hospitality, entertainment and so on which might cross the line between good manners, and attempts to influence decision makers.

2.4 What are the effects of corruption on construction projects

FIDIC (undated) suggests that corruption lowers the quality of public infrastructure by diverting resources, and allowing avoidance of codes and standards. It is always unfair; is often criminal; breeds cynicism; and demeans individuals involved. Corruption can lead to unnecessary or wrong items being built; it leads to more capital projects which provide rent-seeking opportunities. It promotes impunity among public officials, practitioners and business leaders, and keeps out good firms from the industry as the playing field is not level. It entrenches inequality in business and in society. Hawkins (2013) notes that the impact of corruption is greater on small and medium-sized enterprises (SMEs) than on large firms. For example, the former are less able to withstand delays in payment. They work for a few clients, and are less able to stop bidding for certain clients. Corruption increases the costs of infrastructure; and raises environmental, health and safety issues. It leads to further deprivation of the poor as the items intended to improve the quality of their lives are sub-optimal in performance including on quality, durability, longevity, and service delivery.

Transparency International (undated) notes that corruption results in projects which are unreliable, dangerous and over-priced. This can lead to loss of life, poverty, economic damage and lack of development. For firms, it results in tendering uncertainty, wasted tender expenses, higher project costs, reduced work opportunities, criminal prosecutions, fines, blacklisting, and reputational risk. It damages individuals, resulting in soiled reputation, criminal prosecution, fines and imprisonment.

3. Efforts to fight corruption in construction

3.1 Anti-corruption initiatives in construction

Several national and international anti-corruption initiatives in construction are presented in the literature. Examples are (Ofori, 2012): UK Anti-Corruption Forum; U4 Anti-Corruption Resource Centre; Construction Industry Ethics and Compliance Initiative; Global Infrastructure Anti-Corruption Centre (GIACC); Transparency International; Water Integrity Network (WIN); World Economic Forum – Partnering against Corruption Initiative; United Nations Global Compact; International Federation of Consulting Engineers (FIDIC); World Federation of Engineering Organisations (WFEO) Committee on Anti-Corruption; Global Anti-Corruption Education and Training Project; Open Government Partnership; Open Partnership Initiative; and CoST.

Le et al. (2014) categorises anti-corruption strategies into: (a) transparency mechanisms – provide the public access to information on projects so that processes can be monitored, and decision makers can be held accountable; (b) ethical codes – seek to attain discipline and probity in professionals; (c) project governance – includes selecting leaders, assigning responsibilities, offering of rewards and imposing sanctions; and (d) audit and information technology – include technical audits; integrity pacts; and on-line procurement.

Some institutions have their programmes. World Bank's (2011a) controls to reduce misconduct on projects include procurement process reviews; financial audits; and field supervision. GIACC provides resources to assist in understanding, identification and prevention of corruption. ASCE (undated) is raising awareness of the real costs of corruption and being a catalyst for co-operation and action by engineers worldwide. It asks engineers around the world to sign "An Engineer's Charter: Combating Corruption in Engineering and Construction". FIDIC's Business Integrity Management System and Government Procurement Integrity Management System are often referred to as an effective set of measures. Transparency International (undated) believes that corruption on construction projects can only be eliminated if all project participants co-operate in developing and implementing actions addressing the supply and demand sides of corruption. It has formulated business tools, reports, actions and information to help actors to do this. In 2007, it developed the Project Anti-Corruption System comprising standards with GIACC which recommend anti-corruption measures on projects; and templates providing the tools by which measures in the standards may be implemented.

To Hawkins (2013), 'tools' to help identify and mitigate the risks of corruption on projects are: (a) Audits - can improve the fiduciary standard of a sectoral programme and help prevent poor quality assets; (b) CoST; (c) Community Monitoring - used where there is a gap in accountability in the project cycle; (d) Red Flags - provide alert indicators which help to identify and track vulnerabilities to corruption; (e) Integrity pacts - address corrupt behaviour of officials and bidders; (f) Project Anti-Corruption System; and (g) Citizen report cards - provide feedback from users of services.

3.2 Transparency as anti-corruption tool

Kenny (2007) notes that transparency, enforcement and focus on outcomes of poor construction are likely to have greater impact than regulation. Other useful tools are output-based and community-driven approaches, complimented by interventions including publication of procurement documents, independent and community oversight, physical audit and public-private anti-corruption partnerships. Kenny (2011) notes that evidence shows that transparency and oversight are powerful tools to reduce corruption. Regular publication of project details: improves transparency; provides public intellectual capital which reduces legal costs of contracting and helps spread best practices.

Hawkins (2013) suggests these components of an anti-corruption strategy in an infrastructure programme: (a) Promote transparency by giving stakeholders access to information; (b) Develop accountability mechanisms that empower civil society; (c) Improve the capacity of government and procuring entities to apply robust policies and regulations; (d) Create trust between procuring entities and potential suppliers; (e) Provide an incentive structure that rewards actors for complying with rules and penalises them when they do not comply; and (f) Identify political leadership to lead a co-ordinated set of actions.

4. Case study: CoST

4.1 What are the origins of CoST?

CoST is a multi-stakeholder initiative focused on public-sector construction projects which "…seeks to help participating countries improve the value for money spent on the construction of public infrastructure …to achieve the delivery of good quality infrastructure projects at lower cost, with increased predictability of outcomes" (CoST, 2013b). The objectives are to: promote transparency and accountability in public infrastructure; develop systems and procedures to collect, verify, interpret and disclose key project information; and reduce mismanagement and corruption and improve value for money in infrastructure investment.

Under CoST, governments, industry and civil society work together to disclose reliable information on public construction projects. Multi-Stakeholder Groups (MSGs) oversee the validation and interpretation of the information and build the capacity of the target audiences to understand the information. With this understanding, stakeholders (citizens, media, parliament, oversight agencies) can raise challenges over poor performance, perceived mismanagement, or corruption. Government responds to concerns raised by commissioning audits into specific projects or wider reviews into the performance of an agency or in a sector. The information facilitates the investigation, and action can be taken to sanction staff or prosecute offenders.

CoST was piloted in eight countries between April 2008 and December 2010. The countries were Ethiopia, Guatemala, the Philippines, Malawi, Tanzania, UK, Vietnam and Zambia. It was funded by the UK Department for International Development (DFID); and the countries. The World Bank hels an advisory position. Similar international multi-stakeholder transparency programmes are Extractive Industries Transparency Initiative (EITI), for the oil and gas industry; and Medicines Transparency Alliance (META). The pilot countries realised many benefits from it, including cost savings, regulatory reforms and institutional building. Examples are given below. After a critical review, the CoST international programme was launched in October 2012.

4.2 What were the results of the pilot phase?

During the pilot phase of CoST, information on 216 projects of many types (schools, housing, government buildings, hospitals, roads, airports, harbours, irrigation, flood control) across 29 procuring entities in the eight countries was collected, verified and disclosed. The meta-analysis of the data revealed significant levels of inefficiency and mismanagement in all the countries. Major causes for concern were unjustifiable time (10-120%) and cost (8-58%) overruns; and low levels of competitive bidding. Examples of shortcomings on projects included: (a) on average, only half of the information required by law in the countries to be disclosed was actually disclosed; (b) even where information was disclosed, the coverage was limited (in most cases, only information on tendering was disclosed); (c) the disclosed information was complex and opaque; (d) access to disclosed information was poor; and (e) stakeholders' involvement in projects was limited. A positive sign was that procurement reform had been effected in all the pilot countries.

4.3 What is the current CoST programme?

CoST is a global programme registered in the UK as a not-for-profit organisation, with a Board of Directors and a UK-based International Secretariat. There are now CoST programmes in 14 nations: Afghanistan, El Salvador, Ethiopia, Guatemala, Honduras, Malawi, Philippines, United Kingdom, Vietnam, Tanzania, Thailand, Uganda, Ukraine and Zambia. Over ten countries have expressed interest in joining CoST including Botswana, Colombia, Costa Rica, Indonesia, and Mexico.

After the pilot, CoST has been funded from a World Bank grant; the government of the Netherlands; resources from the government; and country offices of bilateral donors and regional development banks (for country programmes). Currently, much of the funds are from DfID.

The mission of CoST is: "Improved quality of life for all as a result of better infrastructure." The vision is: "To improve the value for money spent on public infrastructure, by increasing transparency and accountability in the delivery of construction projects."

A National Secretariat, under the direction of the MSG, administers the CoST programme. That secretariat is located in a Host Organisation which can employ personnel, and enter into contracts. Its tasks include: (i) providing administrative and management support to the MSG; (ii) procuring and administering necessary consultant services; (iii) facilitating necessary technical support, capacity building and related events; (iv) implementing the communications strategy of the MSG; and (v) maintaining liaison with the International Secretariat. Countries might establish an independent legal entity (usually a non-governmental organisation) to manage the functions of the MSG and the National Secretariat. A CoST Champion provides guidance to the national programme, and facilitates access to government leaders, and sources of project information. Champions have been ministers or prominent members of the society with a reputation for probity.

The International Secretariat provides technical guidance, support, start-up funds, and exchange of international best practice. The overall CoST programme is overseen by the International Board which includes representatives elected by each stakeholder group.

4.4 Disclosure of information

How does CoST work? Government departments or statutory agencies which procure public-sector construction projects (procuring entities (PEs)) are responsible for disclosing information on their projects proactively using the framework in the CoST Infrastructure Data Standard in Table 1. If such information is not legally required to be disclosed, an Interim Disclosure Requirement can be established. Eventually, the government should establish a Formal Disclosure Requirement (FDR). In Ethiopia, the FDR was established through a series of proclamations, regulations and directives, requiring PEs to disclose information on the website of Public Procurement and Property Administrator Agency (PPPAA). The FDR in Guatemala was set up through the 2014 Regulations of the Organic Law of the National Budget. In Malawi, CoST disclosure requirements will be part of the new Procurement Act.

Information is also disclosed reactively (i.e., on request by stakeholders). Items include the project brief, feasibility study, budget, project officials and roles, contract agreement, and list of variations and changes. PEs would respond to questions from stakeholders on the information which has been disclosed. There are differences in the disclosure process adopted in the CoST member countries.

The International Secretariat has produced several “guidance notes” on CoST (CoST, 2013c). These includes directions on how a country can join CoST and templates aspiring CoST countries can use.

4.5 What are the benefits and possible misgivings of CoST

CoST would lead to a reduction in fraud, corruption and mismanagement on public projects, resulting in improved quality of life for nations’ citizens. For governments, it leads to greater efficiency in managing public investment and expenditure; enhanced value for money on public projects; improvements in the quality of public services and durability of built items; and reduction in risks to public safety from poor building practices. The government can provide credible information on its projects to citizens, leading to greater public awareness and confidence.

For the private sector, CoST would transform the business climate, with a level playing field, predictability and fair competition. CoST can create new markets overseas. There would be improved relationships between businesses and the communities they operate in. Reduction of risk and uncertainty would lead to improved access to finance for firms. Fairer opportunity to compete for work would foster the development of companies and professionals. Transparency of project information will make practitioners seek to improve their operations and performance. For civil society, CoST gives it a voice in relevant aspects of decision making on projects. For citizens, there would be better value for money and improved service delivery on infrastructure items.

Table 1 CoST Infrastructure Data Standard

PROJECT PHASE	*PROJECT INFORMATION*	*CONTRACT PHASE*	*CONTRACT OR PACKAGE INFORMATION*
Project Identification (6 items)	*Project owner*	***Procurement (13 items)***	*Procuring entity*
	Sector, subsector		*Procuring entity contact details*
	Project name		*Procurement process*
	Project location		*Contract type*
	Purpose		*Contract status (current)*
	Project description		*Number of firms tendering for the project*
Project Preparation (7 items)	*Project scope (main output)*		*Cost estimate*
	Environmental impact		*Contract administration entity*
	Land and settlement impact		*Contract title*
	Contact details		*Contract firm(s)*
	Funding sources		*Contract price*
	Project budget		*Contract scope of work*
	Project budget approval date		*Contract start date and duration*
Project Completion (6 items)	*Project status (current)*	***Implementation (6 items)***	*Variation to contract price*
	Completion cost (projected)		*Escalation of contract price*
	Completion date (projected)		*Variation to contract duration*
	Scope at completion (projected)		*Variation to contract scope*
	Reasons for project changes		*Reasons for price changes*
	Reference to audit and evaluation reports		*Reasons for scope and duration changes*

Advantages of multi-stakeholder working include the ability to pool knowledge to pursue common interests, and give more weight to decisions, but it can be time-consuming and difficult. Calland (2014) notes these concerns: bogus representation by government or industry; marginalisation of some stakeholders; self-selection by civil society groups; harassment or coercion; and uneven access to information. Thus, forming the MSG and building trust among constituents requires effort.

CoST does not impose any additional burdens on business. Disclosing project information can help firms to identify efficiency savings. Many top firms have endorsed CoST; they include Skanska (Sweden), Balfour Beatty (UK), Bechtel (US), Ramboll (Denmark), Halcrow (UK), Strabag (Austria) and NCC (Sweden). Institutions include European International Contractors and FIDIC. Some PEs fear that CoST involves additional work for them. However, under CoST, PEs release information, already available information in a standard format which is useful to PEs in monitoring projects. The CoST programme in Uganda was initiated by one PE, the National Roads Authority.

4.6 What is the impact of CoST?

Implementation of CoST has led to significant achievements. Examples are: (i) changes in government procurement and administration procedures which resulted in greater openness and accountability in Malawi, Tanzania and Ethiopia; (ii) improvements in human and financial management practices in procuring entities in Tanzania and Malawi; (iii) improvements in government policy on data management in UK; and (iv) enhanced scrutiny of contracting parties.

4.7 Endorsement of CoST in the literature

Several authors recommend the adoption of CoST as an effective anti-corruption programmes and measures in construction (see FATF, 2012; Runde et al., 2014). Hawkins and McKittrick (2012) explain why CoST is important to governments, firms and professionals globally. An Independent Joint Anti-Corruption Monitoring and Evaluation Committee expressed "serious concerns" over impunity in some of Afghanistan's "high-profile corruption cases". Among its recommendations was the setting up of CoST "which provides for multi-stakeholder monitoring and oversight of construction projects" (UNAMA, 2014). CoST was highlighted as recommended good practice by a UK parliamentary committee. In the UK's National Infrastructure Plan (HM Treasury, 2011), the government indicated that it would use the CoST template as a tool in managing its projects. B20 Panel of Six International Accounting Networks (2014) reproduced an extract from the CoST factsheet on the benefits of the initiative to the private sector. CoST was endorsed by the G20 group of countries in 2011. The G20 (2013) noted that, in October 2011, the Multi-lateral Development Banks Action Plan of G20 recommended the scaling up of CoST. In a letter to leaders of the G8, in January 2013, British Prime Minister, Mr David Cameron, identified transparency as a priority for the G8 during the UK Presidency. He referred to CoST as a programme that should be supported.

5. Recommendations and conclusion

Corruption is almost uniquitous in construction. It is pernicious and corrosive. There is need for 'proactiveness' to deal with this cancer and improve the image of the industry while contributing more for society by providing value for money on projects. All construction stakeholders should invest effort to deal with this challenge. Among initiatives at global, national, institutional, company and project levels to reduce corruption and mismanagement, CoST has proved effective, leading to enhanced value for money from projects. The multi-stakeholder disclosure process is a viable component of project governance systems in all countries. Governments, construction firms and practitioners, and civil society should collaborate to introduce CoST in all countries.

CoST disclosure requirements and related provisions should be authorised in national statutes and incorporated into governance systems, with a high degree of compliance and effectiveness. Modules should be introduced in tertiary educational institutions to build awareness and knowledge of students of corruption in construction and possible solutions such as CoST.

Professional institutions could include coverage of anti-corruption initiatives such as CoST in continuing professional development programmes and highlight transparency on projects in codes of conduct and other ethics codes. CoST can be a valuable source of data on infrastructure projects which can be used for research and decision making by governments and investors. This study adds to knowledge on ways of addressing corruption in construction by showing the merits of transparency.

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Improving alliance projects through facilitation

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Abstract

Alliance and other collaborative project delivery models such as integrated project delivery (IPD) represent a solution to decrease the fragmentation in the construction industry. New technology such as building information modelling (BIM) is also claimed to introduce more integration into the design and construction processes. However, an intensified collaboration is required for successful alliancing and BIM processes. The intensified collaboration does not seem to occur automatically after committing to a contract, but might often require help in the daily project activities. Facilitation is an activity used in other industries to help in accomplishing tasks by concentrating on the social processes of groups performing the activities. Currently, very little is known about the facilitation in the context of construction projects. Facilitation literature suggests that facilitation can support collaborative task performance with three elements: 1) the management of group process, 2) the management of content, and 3) facilitator's substantive expertise. With a qualitative case study approach, we studied what kind of facilitation occurs in a Finnish alliance project and how current facilitation methods meet the project needs. The results suggest the presence of all the three facilitation elements, but also suggest possibilities for improvement. The results connect facilitation literature to collaborative construction projects. The empirical analysis also offers practical suggestions on how to apply facilitation in construction projects efficiently.

Keywords: Facilitation, alliance, construction, management, collaboration

1. Introduction

Alliance and other collaborative project delivery models such as integrated project delivery (IPD) represent a solution to decrease the fragmentation in the construction industry (Lahdenperä, 2012). Furthermore, new technology such as building information modelling (BIM) is claimed to introduce more integration into the design and construction processes (Succar, 2009). However, successful alliancing and BIM processes require intensified collaboration (Alhava et al., 2015). Collaboration has been studied as an essential element of construction projects (e.g. Cicmil and Marshall, 2005) but it does not occur automatically after signing a contract, it is rather created in daily practices (Smits and van Marrewijk, 2012). Meetings are key events in a project where the representatives of the stakeholders perform collaboration. This collaboration can be enhanced with facilitation. Facilitation is scarcely studied in the construction project context, even when it is known that facilitation can help meetings to be more efficient (Vivacqua et al., 2011). The existing literature does not describe what kind of facilitation is performed in construction projects.

Within this study, we ask what kind of facilitation activities are performed in the meetings of an alliance project and how current facilitation methods meet the project needs. We observed two meetings, a formal design meeting and an informal designer collaboration meeting, of an alliance project in Finland to understand the various facilitation activities. The findings help us understand the role of facilitation in inter-organizational collaboration in alliance projects. The paper is structured as follows, the relevant literature on the construction sector and facilitation are presented. Then we describe the empirical case and methods. This is followed by presenting the results and the discussion based on results. We conclude by discussing the potential of facilitation in the context of inter-organizational construction project management meetings.

2. Facilitation of Collaboration

2.1 Facilitation of Collaboration in an Alliance Construction Project

Collaboration between construction project parties is crucial in order to design and construct buildings that meet the quality needs of customers. Unfortunately, collaboration in construction projects is often hindered by traditional design-bid-build contracts and silo-based working methods. Relational contracting, such as alliance contracting is a promising way to improve collaboration in construction projects. Alliance contracts usually include two or more parties who decide to cooperate throughout the project, based on 'shared risk and shared reward' thinking. In Finland, alliance contracts have been mainly used in infrastructure projects that include lots of uncertainty and complexity (Lahdenperä, 2011). Relational contracting has been considered to facilitate collaboration because it steers the project parties towards shared objectives. However, the relational contract alone does not suffice as a facilitative mechanism, but also, organizational mechanisms are needed (Lavikka et al., 2015).

Alliance projects can use several organizational mechanisms, such as a joint management and decision-making structure, early involvement of key project parties, alliancing workshops, co-location of teams, transparent financials, and lean principles of design, construction and operation (Lahdenperä, 2012). Jefferies et al. (2014) have also found that alliance projects can benefit from the facilitation of workshops that include both office and site personnel. (Jefferies et al., 2014) However, facilitation is not a trivial task and it requires facilitation skills (Hogan, 2002).

Research on facilitation in the construction project context is still scarce. Few studies exist such as Pala et al.'s (2014) work on ICT as a facilitator of a collaboration process. They found that ICT-enabled inter-organizational information exchange (Pala et al., 2014). Another study about facilitation in the construction sector context discusses intensive big room as a facilitator that enables value co-creation with the customers (Alhava et al., 2015). However, in this paper, we focus on facilitation that takes place in project meetings and where a facilitator is a person. Davis and Love (2011) and Rowlinson et al. (2005) studied alliance contracting and found that trust, commitment and open communication need to be maintained throughout the alliance relationship. Constant facilitation was found important to build open communication between project parties. According to Lahdenperä (2009:31), a facilitator "can be used to promote team formation and evaluate workshop performance." Professional, external facilitators seem to be used in alliance projects (Rowlinson et al., 2005) but to our knowledge, the practices and success of internal facilitators in construction project meetings is an unexplored research area.

2.2 Facilitation of collaboration in group situations

Facilitation aims to aid accomplishing tasks (Keltner, 1989). It has been studied in different circumstances such as a mode of management performance (Raelin, 2012), as enhancing collaboration in meetings (Cooren et al., 2006) and as helping group problem solving (Keltner, 1989). A great part of the literature on facilitation concerns group situations such as meetings and workshops. Earlier literature affirms that facilitation can help meetings to be more efficient (Vivacqua et al., 2011). Apart from efficiency, facilitation has also been suggested to have some positive effect on the satisfaction of the participants as well as the consensus of the group, at least in cases where facilitation is not too rigid (Vreede et al., 2002). These positive effects are welcomed as meetings can be unproductive, costly and dissatisfying (Romano and Nunamaker, 2001).

As facilitation aids to accomplish tasks, it also intervenes in the process and activities of a meeting. Concerning this, a facilitator needs to decide how strongly he or she should intervene in the meeting. If facilitation is too strong, the participation might reduce when a participant becomes more passive and leans on a facilitator (see Miranada and Bostrom, 1999). The facilitator can also be an outsider of group tasks (Hogan, 2002). In this case, the facilitator does not have his or her own interest involved in the meeting outcomes (Huxham and Cropper, 1994). Scholars such as Griffith et al. (1998) argue that facilitator should be neutral and not comment on the context of the meeting. However, the facilitator working also with the group tasks might have a better understanding of the relevance of the outcomes. As technology can be applied to aid facilitation (Vivacqua et al., 2011), technology or other artefacts can have a great role in a group process (Cooren et al., 2006).

The activities of group facilitation can be divided by the way they contribute to the task performance of the group. Earlier literature suggests the facilitation activities can be divided based on if they influence the content of the meeting or group process (Eden, 1990). Later Huxham and Cropper (1994) extended these ideas of facilitation and included a third category as influencing the decisions with expertise. The first facilitation area, the *content* of the meeting, means that a facilitator can manage the content of the meeting, by collecting information on the problem, leading the thinking and discussion of the group (Huxham and Copper, 1994). The activities found by Clawson and Bostrom (1996), can also be considered here as relating to the content. These are clarifying and integrating knowledge, encouraging multiple perspectives, presenting information to the group and keeping group outcome-focused. The second category concerns activities in which the facilitator can influence the *group process*. This category can include managing group interaction, managing meeting-design, managing the relationships between individuals, and tracking and responding to the needs of the group (Huxham and Copper, 1994). The following activities found by Clawson and Bostrom (1996) can also be considered as relating to group process; creating a participative environment, applying well-suited technology, managing conflict and negative emotions, managing flexible considering evolvement of the situation. The third category is the group's decision making that facilitator can give *input with expertise* (Huxham and Cropper, 1994). In this case, the facilitator has some expert knowledge concerning the substance of a decision. In facilitation situation, these three areas of facilitation relate to each other.

3. Research Approach and Methods

3.1 The Case Study of an Office Building Alliance Project

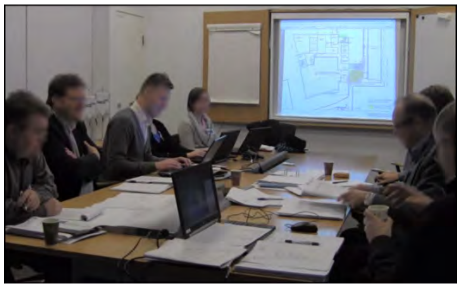
We conducted a qualitative case study of an alliance project in Finland. A case study strategy allows the investigation of a contemporary phenomenon that is difficult to separate from its context (Yin, 1989). Thus, the case study method enabled the investigation of facilitative activities in the alliance project. The aim of the €12 million alliance project was to build a 6-story, 6000 square meter office building on a tight lot in the middle of an operational campus area in Southern Finland. The project started in 2012, the construction phase started in the fall 2013 and the project was finished in 2015. The alliance contract was made between an owner and a general contractor but an architect and design engineers joined the alliance project with cost reimbursable contracts later on. The owner was also represented by the end user organization and a construction management company in project meetings.

3.2 Data Collection

Our overall data consists of six initial interviews in 2013 and seven follow-up interviews in 2014 with key representatives of participating organizations. In addition, we collected video data during 2012 and 2013 from 12 different meetings on different organizational decision-making levels. The meetings on higher decision-making level were an alliance executive group meeting, an alliance project group meeting, and an official design meeting. Additionally, the meetings on lower decision-making level were an unofficial designer collaboration meeting and a BIM clash detection meeting.

For this study, we chose two meetings, which we compared to understand the similarities and differences in the facilitation activities (Table 1). The two meetings were chosen because they represented typical formal and informal meetings in the project. A representative from the general contractor facilitated both meetings. By comparing these two meetings, we gained understanding from two different facilitation events within a single project.

Table 1: The characteristics of the meetings

Meeting / ***Characteristics***	***Formal meeting (Official Design Meeting)***	***Informal meeting (Designer Collaboration Meeting)***
Date	*January $8^{th,}$2013*	*January $8^{th,}$ 2013*
Duration	*2.25 hours*	*1.5 hours*
Usual occurrence	*Bi-weekly*	*When needed by any of the participants, but often once or twice a week.*
Participants	*13 participants: HVAC engineer, owner, electric designer, end-user, project engineers, structural engineer, architect, geoplanning, and construction management consultant.*	*6 participants: General contractor, architect, structural engineer, geoplanning, electrical engineer, and end-user.*
Facilitator	*General contractor (project manager)*	*General contractor (project engineer)*
Topics discussed	*Safety, clearance, planning requirements, cost effects of plans, and BIM modelling.*	*This time excavation work and the bypass of a tunnel, but usually topics concern the design of the facility or plot.*
Setting		

3.3 Data Analysis Process

The data analysis proceeded in five phases. First, we (three researchers) watched the two meeting videos and discussed them to agree on how to proceed with the data analysis. Second, each researcher watched the videos again on their own and searched for facilitation activities taking place in the videos. Third, each researcher grouped the found facilitation activities following the category of Huxman and Cropper (1994): 1) managing content, 2) managing group process and 3) taking part to a decision with expertise knowledge. 1) *Managing content* meant the activities when the facilitator manages what is discussed and for how long. 2) *Managing group process* referred to managing the ways the issues were dealt with. 3) *Taking part to content by managing with facilitator's expertise* referred to activities where the facilitator's own expertise was used to take part in making decisions. Fourth, to understand the three categories more profoundly we used Clawson and Bostrom's (1996) findings on facilitation activities as described in the theory section. Using these facilitation activities, we performed further analysis round as collating original categorization to more detailed sub-activity level. Finally, we compared the two meetings to identify which of the facilitation activities were emphasized in each meeting. The overall analysis process followed deductive video analysis approach by Derry et al. 2010. The results are presented in the following section.

4. Results

The observed meetings differed both by the nature of the meeting and the facilitation activities found in the meeting. Table 2 presents the facilitation activities found in each of the meetings. Activities are categorized into three areas of contribution by Huxham and Cropper (1994) and further classified under sub-activities found in the literature.

Table 2: Comparison of facilitator roles between the formal and informal meeting

Area of contribution	***Sub-activity***	***Formal meeting facilitation***	***Informal meeting facilitation***
Facilitating content	*Leading the thinking and discussion*	*Facilitator (project manager, GC) guides the conversation with a predefined agenda (security risk assessment excel, meeting minutes document)* *... ends a conversation as irrelevant in the meeting* *... tells that we do not need to discuss this because it is written how it should be done*	*Facilitator (project engineer, GC) states the topic of the meeting (excavation work and renovation of the tunnel)* *... takes the discussion to the next topic when needed* *... interrupts a "wild" discussion by increasing the tone and says it will be continued later on*
	Collecting information on problem	*... asks further questions concerning the project*	*... asks further questions* *... goes through questions from the list*
	Encouraging multiple perspectives	*... makes sure everything is said concerning an issue by asking if anyone has anything to add*	*... asks if new knowledge is still needed on an issue*
	Presenting information to the group	*... uses materials to elaborate the understanding (brochure and material of the façade, 2D drawing)*	*... uses materials to elaborate the understanding (2D drawings on screen and paper, photos)*
	Clarifying and integrating knowledge		*... synthesizes the talk and takes notes* *... asks if the knowledge is certain* *... clarifies the distribution of work*
	COMPARISON	*Emphasis on leading the thinking and discussion*	*Emphasis on clarifying and integrating knowledge*
Facilitating group process	*Managing group interaction*	*Facilitator (project manager, GC) was called formally as "Chairman" by others* *... sounded tough and formal when addressing participants*	*Facilitator (project engineer, GC) lets others talk freely and think together*

	Creating participative environment	*... asks everyone to share their key points one at a time but not reading from the document (as "everyone knows how to read")*	*... appoints one participant to start with the status update* *... asks if someone wants to say something*
	Tracking and responding to the needs of the group	*... says no need to repeat things that were said earlier in the meeting* *... asks if an issue should be written down (project engineer takes notes)*	*... is friendly and calm, confirms often* *... asks if the information can be sent via email to another designer*
	Managing conflict and negative emotions	*... makes no jokes (formal and serious atmosphere)*	*... makes few jokes (less formal atmosphere, some laughing in the beginning)*
	Applying well-suited technology	*... uses projector to show relevant documents*	*... uses a projector to show relevant documents* *... uses laser pointer to point out relevant areas on the screen*
	COMPARISON	*Emphasis on managing group interaction*	*Emphasis on creating participative environment and applying well-suited technology*
Taking part to content by facilitating with expertise	*Giving input with own expertise*	*Facilitator (project manager, GC) answers questions by CM consultant (about design review, maintenance manual, site fences)* *... defines that the tunnel is more acute issue* *... comments risks in the security risk assessment document*	*Facilitator (project engineer, GC) says this is important knowledge on a matter* *... interrupts to say that energy company will not give permission and asks further details*
	COMPARISON	*More input with expertise*	*Less input with expertise*

The formal meeting was an official design meeting held bi-weekly and facilitated by the project manager from the general contractor. The meeting had a predefined agenda in the form of meeting minutes and the facilitator's role was to make sure that all topics on the agenda were covered during the meeting. The nature of the discussion was more expressive rather than conversational as the participants mostly shared their own status updates under each topic. In *facilitating content*, the emphasis was on leading the thinking and discussion. The facilitator guided the conversation with the predefined agenda and ended irrelevant topics fast to keep the discussion on track and on time. Regarding *facilitating group process*, the emphasis was on managing group interaction. The interaction was formal and even tough at times; some participants called the facilitator formally as "Chairman" when addressing the meeting. Finally with *taking part to content by facilitating with expertise*, the facilitator gave more input with her own expertise when compared to the facilitator of the informal meeting.

The informal meeting was a designer collaboration meeting for designers on an as-needed basis and facilitated by the project engineer from the general contractor. The meeting had a predefined topic but the nature of the discussion was casual and interactive. The participants could bring various issues to the conversation and often used paper drawings or 3D models on the screen to elaborate the understanding. Regarding *facilitating content*, the emphasis was on clarifying and integrating knowledge. The facilitator synthesized the talk, took notes and clarified the distribution of work between the designers. In *facilitating group process*, the emphasis was on creating a participative environment and applying well-suited technology. The facilitator appointed participants to share their perspectives and often asked if someone wanted to say something on an issue. He also used a laser pointer to point out relevant areas on screen as 2D drawings and 3D models were often difficult to interpret. Finally, with *taking part to content by facilitating expertise*, the facilitator gave little input with his own expertise but rather let the participants think freely and in collaboration.

In addition to the facilitation activities described by Huxham and Cropper's (1994) categories, we also observed some other elements that influenced the interaction in the meetings. Both meetings were rather long and did not have any breaks to energize the participants. The formal meeting used some methods to build rapport among the participants. First, they had a rule that the person, who comes late to the meeting, will bring some pastry for others to the next meeting. This seemed to work as a nice icebreaker to start the meeting. Second, the client assessed the project team with Plus/Delta at the end of the meeting. This gave the client an opportunity to articulate to others what they appreciated the most (plusses) and what they thought needed improvement (deltas) in the project. The informal meeting did not use any specific methods for rapport building but there was more joking and laughing at least in the beginning of the meeting.

5. Discussion

Huxham and Cropper's (1994) categories are based on single client consultancy situations. In a case of collaboration between organizations, facilitation might be even more important because individuals from different companies and professions might have different communication practices. The findings show that facilitating the *content* in the meetings was mostly about leading the conversation, clarifying and integrating knowledge. This area of facilitation concerns what is discussed in the meeting (Huxham and Cropper, 1994). When the facilitator decides which topics are to be discussed, s/he exercises her/his power. To create a collaborative meeting, the facilitator should make sure that the discussed topics include important issues from the viewpoints of all stakeholders. Integrating knowledge potentially also aids collaboration as it can enhance common understanding.

Our findings on facilitating *group process* were mostly about managing group interaction and creating a participative environment as well as applying technology. Facilitating group process can create better relationships and trust among the participants by managing, for example, how interaction is performed. Good collaboration usually demands to create trust and relationships between individuals, especially in inter-organisational context (Batt and Purchase, 2004). Facilitation can enhance relations by managing active and pleasant interaction. Thus, facilitation of group process in collaborative projects should emphasize active interaction between individuals. The facilitator can also emphasize the relationships by offering open and friendly atmosphere.

Finally, our findings on facilitation *with expertise* show that the facilitator as a representative of the general contractor had expert knowledge and could intervene with this expertise to decisions. When one of the company representatives acts as a facilitator, there is a danger that her/his perspective is highlighted more than other companies' perspectives. An outsider should act as a facilitator if this danger needs to be avoided. In the studied meetings, the general contractor as a facilitator seemed to work without significant problems.

Overall, facilitator seemed to help to create more effective meetings. Also, facilitation seemed to influence the aspects of collaboration and trust which are valued in the specific project. The facilitator role should be given to a person who is skilled in enhancing collaborative practices that are structured socially. This could be especially important in projects where deep collaboration is needed on different levels. The analysis of the results reveals differences between these two meetings. The meetings can be arranged and performed in different ways. It is good to reflect what kind of facilitation would be suitable for the objectives of the meeting and purposes of the project. The findings suggest that facilitation methods depend on the purpose and context of the meeting.

6. Conclusions

Our study presents the performed facilitation practices in two types of meetings and compares them. Facilitation has been studied in different contexts, but few studies have considered facilitation as an important part of construction project management. At its best, facilitation in an alliance construction project helps the project parties to make better decisions and design solutions. However, based on the study it can be concluded that the full potential of facilitation is not always used. When the facilitation was creating effectiveness in the meetings, it could have been used more reflectively to create collaborative and efficient meetings. The facilitators in the studied project were not trained professionally for facilitation practices. Training on facilitation skills and methods could create more purposeful and useful facilitation. Additionally, reflection and planning concerning facilitation can create purposeful facilitation for the specific meeting or project, instead of only following general facilitation guidelines.

For practitioners, our results suggest that facilitation might bring benefits in inter-organizational meetings. The facilitation should be in line with the objectives and values of the specific meeting and overall project. In alliance projects, collaborative decision making can be enhanced by facilitation. In a meeting, practical issues such as breaks, working technology and the functionality of space also play a significant role and should be taken into account as part of the facilitator's role. Future research could measure what kind of financial benefits the facilitation could offer in the alliance project. Also, more research is needed to understand which kind of facilitation techniques and activities could enhance collaboration in construction projects. In addition to the facilitation activities, it would be useful to identify critical project events where facilitation can enhance project performance.

This paper is an important start for the discussion on the benefits and drawbacks of facilitation in the construction project context. The full potential of facilitation is not yet known, but it seems that collaborative work and relational projects are becoming more common in the construction sector. The use of building information modelling requires even more intensive collaboration between construction project parties. The sector is characterized by fragmentation and this has not been a fruitful platform for learning collaboration skills. As facilitation is a way to promote good collaborative work practices between construction project parties, the use of facilitators and training facilitation methods will probably grow within the construction sector in the future.

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Is it faster and is that measurable?

A Quantitative Research Into The Time Effects Of Integrated Contract Forms In Development Processes

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Abstract

Integrated contract forms are seen as a solution to various problems in the construction industry. Some studies found that building projects delivered with integrated contract forms show better performances on time, cost and quality. Other studies state that projects developed with integrated contract forms do not perform better on time, cost or quality when compared to projects developed with traditional contract forms. Conclusions from the studies analyzed vary and these studies have their shortcomings. This study reflects critically on these previous studies in order to promote better research and to reveal a small piece of the puzzle called ‘integrated contract forms’. Empirical findings from a case control study of thirty secondary schools indicate that the use of integrated contract forms do not provide the expected benefits to time performance when compared to traditional contract forms. The data was collected from project managers via online questionnaires. However, when there is above average time pressure during the development process, parties tend to choose for integrated contracts because they assume that projects developed in this way have faster processes than projects developed with traditional contracts.

Keywords: integrated contract forms, time effects, empirical study, case control study, statistical analysis.

1. Introduction

Cost- and time overruns are unfortunately very common in the construction industry (Flyvbjerg, 2011). As a result there is high pressure from society to better control budgets and time schedules. At the same time, governments and the construction industry strongly steer on cost and time savings, as well as higher quality for buildings (Meng, 2012; Visscher, 2011). Other than traditional contract forms are thought to better enable control of budgets and schedules and therefore enhance quality. In the traditional contract form, which is still commonly used, the design phase and execution phase are procured to different parties (Masterman, 2002). The most common integrated contract form is the Design & Build contract form wherein the design phase and construction phase are procured in one procurement to one party or to a consortium. Over the last years Design, Build & Maintenance and Design, Build, Maintenance & Operate contract forms are emerging. In these contract forms maintenance and operation actions are also included in the contract which makes the contracting party also responsible for the exploitation of the building and the reward is a performance- related pay (Masterman, 2002).

Many studies have analyzed the effects of integrated contract forms in construction, all with different outcomes. Some of these studies found that the use of integrated contract forms leads to lower cost buildings, a faster development process and higher quality results (Bennett, Pothecary, & Robinson, 1996; Hale, Shrestha, Gibson, & Migliaccio, 2009; Konchar & Sanvido, 1998)**.** While another study found that projects delivered with integrated contract forms have faster processes, but were not always cheaper (Vasters et al., 2010). In contrast, Ibbs found that projects developed with integrated contract forms do not perform significantly better on time and cost aspects compared to projects delivered with traditional contract forms (Ibbs, Kwak, Ng, & Odabasi, 2003). Conclusions from these studies vary, which may be partly due to their methodological weaknesses. Even in studies where the methodology is strong, results cannot be compared with each other because of the different definitions of measures used. As a result, the effects of integrated contract forms are unclear. Different definitions for time and cost are used in different studies, hence studies have different conclusions and outcomes of studies cannot be compared with each other. Weak methodology of studies is caused by different factors. First, the used samples are often too small or too heterogeneous and there was selection bias present in the sample. Secondly, studies are often based on expert judgements, resulting in socially desirable answers. Last, it can be mentioned the description of the methodology used often is weak.

According to Nyström (2007) studies comparing different contract forms must meet three requirements. First, the study must be based on project data and not on expert judgments. Secondly, the study must be based on comparative analyses. Finally, the study must address project variables other than contract form, potentially influencing the outcome. Since one of the flaws in previous studies concerns the too large heterogeneity of the data, this study focusses on secondary schools in the Netherlands. These schools are assumed a homogenous building type due to their similar appearance, purpose and funding. In the Netherlands, the (re)construction of secondary schools is publicly funded. This homogeneity makes them the better research sample for this study. The aim of this paper is to gain better insights into the effect of the process contract form, on the build outcome, in terms of time, by reducing weaknesses of previous studies. Specifically, the study elaborates on the research question: *"Do projects with integrated contract forms perform better on time aspects than projects with traditional contract forms?"*

The study's focus is on time aspects as the other outcomes, appearance, purpose and funding, are similar for secondary schools. To answer the research question a literature review was conducted followed by a case control study. Data was collected by online questionnaires completed by thirty project managers who were involved in the development of thirty secondary schools in the Netherlands. In the questionnaire project managers were asked to share project data only, the questionnaire did not elaborate on their expert opinion. The literature review provided input for the questionnaire that was developed as part of this study. The data was analyzed statistically to answer the research question. After that, findings were discussed in relation to prior literature, followed by conclusions and discussion of theoretical contributions.

2. Literature Review

Construction projects use a variety of contract forms to control project outcomes, some of which evolved over the last few decades. Research methods have varied across studies from project specific case studies, through opinion surveys, to empirical studies. Results of the most important empirical studies, which analyzed the relation between process and product, are reviewed here.

Bennett studied 332 projects and found that the construction speed (m^2 built per month) of D&B projects is 12% higher compared to traditional projects. The total project time, including design and construction, is 30% shorter for D&B projects than for projects with a traditional contract form. He found that 75% of D&B projects were delivered with a maximum budget overrun of 5%. While 63% of the traditional projects were delivered with a maximum budget overrun of 5%. D&B projects were at least 13% cheaper than traditional projects (Bennett et al., 1996).

Vasters partly disagreed with Bennett. He studied cost and time efficiency of six projects. He found that projects with a D&C contract show better time efficiency but not better cost efficiency (Vasters et al., 2010).

Hale is partly contrasting with Vasters. Hale's focus was on 77 military barracks of the US Navy. His conclusion was that projects with D&B contracts have shorter project times compared to projects with traditional contracts. He also concluded that projects with D&B contracts have less cost and time overruns than projects with traditional contracts (Hale et al., 2009).

Ibbs findings were partly inconsistent with Hale's. From his research Ibbs concluded that projects delivered with D&B contracts did not perform significantly better than projects delivered with traditional contracts. D&B projects have slightly less time overruns, not significant less, compared to projects with a traditional contract. And no cost savings were measured for D&B (Ibbs et al., 2003).

Konchar and Sanvido studied 351 building projects and concluded that projects delivered with D&B contracts performed better than projects with traditional contracts (Konchar & Sanvido, 1998).

By evaluating previous studies it became clear that different definitions for the variable 'time' were used. As summarized in table 1, the studies measured 'time' as building speed, total project time, delivery speed, time efficiency and schedule growth (Bennett et al., 1996; Hale et al., 2009; Ibbs et al., 2003; Konchar & Sanvido, 1998; Vasters et al., 2010). The studies also defined some variables differently.

Definition of the variable time (Time performance).	Explanation	Conclusion
Speed (m^2/time) (Bennett et al., 1996; Konchar & Sanvido, 1998).	**Construction speed=** [(net floor space/end date construction phase – start date construction phase)/30] in (m^2/month) **Delivery speed=** net floor space / (total actual project time/30) in (m^2/month)	The construction speed of D&B projects is 12% less than traditional projects (Bennett et al., 1996). The construction speed of D&B projects is at least 12% less compared to traditional projects (Konchar & Sanvido, 1998).
Time efficiency (Vasters et al., 2009).	**Time efficiency=** standard project time / total actual project time	D&C projects demonstrate a 52% higher time efficiency than traditional projects (Vasters et al., 2010).
Project time (Bennett et al., 1996; Hale et al., 2009; Konchar & Sanvido, 1998).	**Total actual project time=** date of project completion – date of the first contract action	D&B projects have shorter project times than traditional projects (Hale et al., 2009). The total project time of a project, design and construction time included, is 30% faster by D&B projects compared to traditional projects (Bennett et al., 1996). D&B projects are at least 33,5% faster delivered than traditional projects (Konchar & Sanvido, 1998).
Time schedule versus real project time (Bennett et al., 1996; Hale et al., 2009; Ibbs et al., 2003; Konchar & Sanvido, 1998).	**Change in total schedule (%)** = [(total actual project time – total as- planned project time) / total as- planned project time] * 100 **Change in design schedule** (%) = [(total design time – total as- planned design time) / total as- planned design time] * 100 **Change in construction schedule (%)** = [(total construction time – total as- planned construction time) / total as- planned construction time] * 100	It is 50% more likely that D&B projects are delivered on time compared to traditional projects (Bennett et al., 1996). D&B projects have less schedule growth than traditional projects (Hale et al., 2009). In absolute terms, D&B projects have 7,7% schedule growth compared to the planned schedule. Traditional projects have 8,4% schedule growth compared to the planned schedule. In relative terms, D&B projects have 4,1% schedule growth compared to the planned schedule. Traditional projects have 6,5% schedule growth compared to the planned schedule. These are no significant results. (Ibbs et al., 2003). D&B projects have at least 11,37% less schedule growth compared to traditional projects (Konchar & Sanvido, 1998)

Table 1: Used definitions of variables and conclusions of previous studies

In this paragraph some critical remarks on the used methodology of previous studies as listed in table 1, are identified and it is described how these issues are addressed.

In Bennett et al, (1996) report it is not clear how the sample is composed. A very big heterogeneous sample is used, but the report does not describe if smaller homogenous samples are used for the analysis. It is not possible to perform the same study, which makes this study less reliable. Also, the sample is composed with projects from the database of the Glenigan Group. From the report it is not possible to determine whether there was a selection bias. These two shortcomings are diminished in this study by composing a homogenous sample, also the way data is collected is described very precise and in a way that could be repeated. The sample used in Vasters study (Vasters et al., 2010) is too small (N=6). A bigger sample is composed in

this study which makes statistical analyses more meaningful. The variable ‘time efficiency’ as used by Vasters is time consuming to calculate, therefore in this study the variable ‘time efficiency’ is not used. Ibbs’s et al. (2003) sample exists of different building types from different countries, as a result the sample is very heterogeneous. The focus of this study is on the variable ‘as planned project time versus real project time’ which makes it not absolutely necessary to have a homogenous sample. But different countries have different views on schedules and contract forms, which makes the differences between countries too big. Therefore, projects in this study’s sample were built in one country and over a short time span.
Konchar and Sanvido’s study (Konchar and Sanvido, 1998) consists of 351 projects and more than 100 variables are used to compare project performances. Due to the large number of variables (+100) there might be the danger of data dredging. The process of data dredging is the use of a single sample by exhaustively searching for combinations of variables that might show correlation (Field, 2009). In this study fewer variables were used to minimize the chance of data dredging.
Last, Hale’s study (Hale et al., 2009) is evaluated, no shortcomings were identified in this study.

3. Research Methods

When collecting and analyzing data from development processes, a case control study is especially appropriate to measure the performance of processes. In the study two types of contract forms are compared with each other, on the one hand projects with traditional contracts on the other hand projects with integrated contracts. By identifying gaps and modifying prior work, this study aims to extend and elaborate on existing literature for performance measurement of different contract forms.

Forty six secondary school projects were selected through random sampling. The purpose of random sampling is to select projects completely randomly. Constraints for these projects are the eligibility criteria. Schools included in the sample must meet eligibility criteria to give greater confidence that results are caused by the intervention between process and outcome and not by other factors. Three eligibility criteria were specified; one building houses one school; the buildings were delivered between January 2008 and January 2015; the buildings are newly constructed buildings, renovation or transformation projects or an expansion of the existing building. If the building was a renovation, transformation or expansion project then the renovated, transformed or expanded floor space has to be 50% or more of the existing total floor space.

Data was collected through online questionnaires filled in by project managers hired by the client. Furthermore, the outcomes of processes in project management are measured in terms of cost, time and quality, these three control aspects form a triangle (Winch, 2010). The idea behind the triangle is that change in one of the control aspects has influence on the other control aspects. If, for example a project has to be completed in a shorter period of time, the costs are higher. Or, if the costs are lower, the quality is also lower. For clarity, cost, time and quality are interdependent. When the theory behind the triangle is applied to this study, the focus is limited to time aspects. This limitation is the reason secondary schools are chosen as the study subjects.

As mentioned earlier, secondary schools in the Netherlands receive the same funding for buildings; as a result the control aspects of ‘cost’ and ‘quality’ are more or less constant among this building type, which makes it possible to measure performance by time aspects. Therefore this study focused on the ‘time’ variable.

As mentioned, the outcome variables are the time performances. In the literature review four time performances are identified, namely ‘Speed’ (m^2/time), ‘Time Efficiency’, ‘Project Time’ and ‘Time Schedule versus Real Project Time’ (Bennett et al., 1996; Hale et al., 2009; Ibbs et al., 2003; Konchar & Sanvido, 1998; Vasters et al., 2010). ‘Time efficiency’ as used by Vasters is ignored in this study due to the time and effort needed to calculate this variable. ‘Speed’ and ‘Project Time’, as used by Bennett, Konchar and Hale, are not very reliable variables to measure project performance. These variables are project dependent; their outcome depends strongly on the construction type and circumstances of the project. As a result, the most appropriate variable to measure process performance is by comparing the planned schedule with the real project time. To calculate this variable a range of questions were asked to determine what the planned schedule for different phases was, and what the real project time for the same phases was. Nevertheless ‘Speed’ and ‘Project Time’ are also measured to have a complete picture.
The comprehensive online questionnaire included questions about a large number of subjects, namely:

- General questions about the project (m^2, project type, construction type, lay out of the plan and involved parties).
- Procurement method and contract form - Which procurement method and contract form were used and why? On the basis of which specifications was the project procured?
- Time schedule - What was the planned schedule for the different phases within the development process?
- Actual time spent - What was the actual time spent on the different phases of the development process?
- Additional information about the budget, delays, causes of delays, unforeseen circumstances, the role of the architect after the procurement, etc.

In addition to the process parameters and outcome variables, explanatory variables were set up. It is assumed that the contract form has an effect on the explanatory variables. Many explanatory variables were included in this study. The most important explanatory variables are:

- The presence or absence of above average time pressure on the development process.
- The number of parties involved during the preparation, design and execution phase.
- Reasons for choosing the contract form.
- If there is a presumption by the respondent about the kind of contract form and the speed of the development process, then the following question was asked: Was the choice for the contract form partly determined by the desired speed for the development process?

- Is the respondent willing to use the contract form also in the future for projects like the questioned project?
- Questions about the planned schedule, namely; the phase wherein the schedule was set up, how many times the schedule was changed during the development process, the aim of the schedule and commitment to the schedule.

Projectmanagers involved in the development process filled in the questionnaires with only project data (how long, how much, when, what, why etc.). Therefore expert opinions and measuring client/ projectmanager satisfaction were avoided.
To ensure the questionnaire focused on the correct variables, process parameters and outcome variables were set up. These parameters and variables were translated into questions in the questionnaires. Process parameters are the mechanisms which may influence the process performance of projects. This study focused on the influence of the contract form on the process performance of the project: the process parameter is the contract form and the outcome variables are the process performances on time.

For the contract form nine options are distinguished, namely the traditional contract form, the building team, the Design & Build or Design & Construct contract form (these are equivalents in the Netherlands), the Engineer & Build or Engineer & Construct contract form, the Design, Build & Maintain contract form, the Design, Build, Finance & Maintain contract form, the Design, Build, Maintain & Operate contract form and the Design, Build, Finance, Maintain & Operate contract form.
For analysis of the results the contract form is reclassified into two options: integrated contract form and not integrated contract form (which is the traditional contract form). This classification is based on whether the design and execution phase are procured within one contract to one party or to a consortium or are procured with two contracts, one for design and one for execution, to two different parties. The new classification categorizes 'the traditional contract form' and 'the building team' as 'traditional contract form/ not integrated contract form', the other contract forms form the category 'integrated contract form'.

Collected data was analyzed by statistical models with SPSS version 22. Exploratory univariate analyses were followed by multivariate linear regression models with bootstrapping. Univariate analysis of variables gave a global insight into the relationship between variables (Field, 2009). This analysis tested if the relationship found between variables is significant or based on coincidence.

This study applied a significance level of 95% ($p \leq 0.05$), which means that the probability that the observed values would be found without a relationship between the variables is smaller than 5% (Field, 2009). For logistic regression modelling the selection of potential variables occurred using the approach recommended by Hosmer and Lemeshow. Their approach is a purposeful selection process which begins by univariate analyses of each variable. Any variable having a significant univariate test at some arbitrary level is selected as a candidate for the logistic regression model, any variable with a p-value lower than 0,3 is eligible for inclusion in the model (Hosmer, Lemeshow, & Sturdivant, 2013). Logistic regression models were developed to explain multivariate comparisons between contract forms. The logistic regression model predicts the outcome of the process parameter based on one or more outcome variables. These outcome variables are the variables from the 'significant group' and the 'hopeful group'. Bootstrapping is an efficient way to ensure that logistic regression models are reliable and will produce accurate results.

By resampling with replacements from the original data sample thousands of alternative versions of the data set were created. This made the results more reliable and accurate, also the impact of outliers was reduced which helps to ensure the stability and reliability of models (Field, 2009). In this study bootstrapping was applied because of the small sample size (N=30). The sample size was small but large enough for univariate logistic regression analysis. By applying the bootstrap method for the logistic regression model the results from this study became more reliable and accurate compared to not using the bootstrap method.

4. Results

Forty six questionnaires were sent to project managers. Thirty questionnaires were filled in and returned, which is a net response rate of 65%. Prior to sending out the questionnaires the respondents were asked if they would agree to collaborate, hence the high response rate.

Of the thirty projects surveyed, 53.3% were developed using traditional contract forms and 46.7% were developed using integrated contract forms (Design & Build, Design & Construct, Engineer & Build, Engineer & Construct and Design, Build & Maintain). The projects have a good spread across the Netherlands. 86.7% of the projects were completely new constructed buildings, while 13.3% of the surveyed projects were renovation, expansion or transformation projects. The majority of the projects (82%) were delivered between 2010 and 2013. Projects ranged in size from 1.518 m^2 to 26.500 m^2 . The mean of the project size is 9.130 m^2 with a standard deviation of 5.535 m^2. Unit costs (€/m^2) ranged from € 874 /m^2 to € 2153 /m^2. The mean of the unit cost is € 1447/m^2 with a standard deviation of € 367/m^2.

As mentioned earlier, the logistic regression model explains the contract form from differences in outcome variables.

Final modelling turned out to be difficult, as many of the questions are to be considered as describing the type of contract used. Any attempts to explain differences in time related outcomes were not distinguishing;

- Projects with integrated contract forms do not have significantly faster construction and delivery speed compared to projects delivered with traditional contract forms.
- Projects with integrated contract forms do not have significantly shorter project times.
- Projects with integrated contract forms do not meet planned schedules significantly more often compared to projects with traditional contract forms.

As a result, it can be concluded that projects with integrated contract forms do not perform better on time aspects compared to projects with traditional contract forms.

Thereafter a model was fitted using the presence of above average time pressure in the development process as an outcome. It then turned out that time pressure differs between processes covered by traditional and integrated contracts. More particularly, the presence of above average time pressure was found to be differing according to:

Variable	**P-value**
The choice for the contract form is influenced by the desired speed for the development process.	0.00
The presence of the contractor during the initiative, definition and design phase.	0.00
The kind of specification documents.	0.00
The contract form.	0.00
Procured on the basis of Lowest Price or MEAT (Most Economically Advantageous Tender).	0.03
The number of involved parties during the initiative and definition phase.	0.09
Control the capacity of the involved parties and commit to the schedule.	0.10
The phase in which the schedule is drawn up.	0.10
The number of involved parties during the design phase.	0.20
The kind of procurement procedure.	0.25
Adjusting the time schedule during the process.	0.26
The number of involved parties during the construction phase.	0.27

Table 2: Univariate analysis which were used as input in the logistic regression model with 'the presence of above average tim pressure in the development process'.

The final model was shaped by stepwise omitting variables that were not related to time pressure in addition to variables which were more significant related to time pressure, and starting with the one with the highest p- value (the number of parties involved during the construction phase, p- value: 0.27). Table 3 summarizes the final model, whereas table 4 shows the most eligible variables for inclusion in the final model. Since the question addresses the whole development process, time pressure concerns the initiative, design and construction phase.

Output of the bootstrapped logistic regression model for the variable 'the presence of above average time pressure on the development process'.						
Variable	**B**	**Odds ratio**	**S.E.**	**Sig.**	**Lower**	**Upper**
The choice for the contract form is influenced by the desired speed for the development process.	2.972	19.531	18.154	0.007	-18.777	56.127
The presence of the contractor during the initiative, definition and design phase.	1.966	7.142	16.040	0.014	-19.411	38.560
The kind of procurement procedure.	-1.852	0.157	16.631	0.017	-52.136	17.579
Constant	0.890	2.435	8.384	0.068	-8.503	26.349

Table 3: Final logistic regression model with process parameter: the presence of above average time pressure on the development process.

Univariate analyses	P-value
The choice for integrated contract forms is also influenced by the desired speed for the development process.	0,003
There is more often above average time pressure during the development process when projects are delivered with integrated contract forms.	0,035

Table 4. Outcome of the most relevant univariate analyses in addition to the final model.

5. Discussion and Conclusions

The purpose of this study was to get more precise insights into the effects of the contract form on the outcome in terms of cost, time and quality. By narrowing down the scope of this study on time aspects the research question became: *"Do projects with integrated contract forms perform better on time aspects than projects with traditional contract forms?"*

This study has shown that projects delivered with integrated contract forms do not perform significantly better on time aspects compared to projects delivered with traditional contract forms. This means that projects with integrated contract forms:
(i) were not developed significantly faster than projects with traditional contract forms.
(ii) did not meet planned schedules significantly more often than projects developed with traditional contract forms.
However, the study has shown that when there is above average time pressure on development processes, parties choose for integrated contract forms significantly more often (p- value: 0.035) because involved parties assume that projects developed with integrated contract forms are faster developed than projects developed with traditional contract forms (p- value: 0.007). But based on this study, the assumption that integrated projects are faster developed or enable greater control over time schedules is not supported.

There was the assumption that the results may be biased by renovation, expansion and transformation projects (13.3% of the data sample). To exclude doubts about the results, all analyses were also conducted for only the newly constructed projects, without the renovation, expansion and transformation projects, but these results did not differ significantly compared to the results from the original data sample.
Nevertheless, the results should be discussed in relation to the different penalty clauses on time overruns for traditional and integrated contract forms, because this may provide new insights.
In the Netherlands the UAC- 2012 (Uniform Administrative Conditions for the Execution of Works and Technical Installation Works 2012) regulates the contractual relationship between the client and contractor in a building process for traditional contract forms. Normally the client and contractor include project specific fines for time overruns in the contract documents. In absence of such project specific fines the UAC- 2012 describes a fine for time overruns which is € 60,- for each day overrun. The UAC- IC- 2005 (Uniform Administrative Conditions for Integrated Contracts 2005) is the same kind of regulation as the UAC- 2012, but for integrated contract forms. But the UAC-IC-2005 does not include any prescribed fines for time overruns. The client and the contractor have to include fines for time overruns in the contract documents.

Scope creep, i.e. extra works added, does not occur significantly more often by projects with traditional contract forms. Therefore it is not expected that projects with traditional contract forms do not meet planned time schedules compared to projects with integrated contract forms.
Almost always project specific fines in contract documents for both, integrated and traditional, contract forms are much more than the described € 60,- per day because the losses for the client are almost always more than € 60,- per day. Fines in the range of € 1000,- per day are not uncommon. But fines have to be proportionate with the actual damage suffered by the client and the reasonable ability of the contractor to pay.

To sum up, the size of fines is highly project specific, but as found in this study, parties choose significantly more often for integrated contract forms when there is above average time pressure on the development process and they assume that integrated processes have time savings. As a result it's more likely that integrated projects have higher fines when time overruns occur. This is an important issue as it shows the possibility of bias being present in studies using contract form as a sampling criterion: when time overruns are stricter penalized in integrated contract forms it makes sense that they will occur less when compared to using traditional contract forms, because contractors will make more effort to ensure that no time overruns occur.
However this study did not find less time overruns when using integrated contract forms. In contrast, almost all previous studies found that time overruns occur less frequently when using integrated contract forms. This argue may lie in the presence of penalty clauses rather than in the characteristics of the process of integrated contract forms. The topic of penalty clauses is not related to time overruns and contract forms in other studies. Further research is needed to get better insights about penalty clauses within different contract forms and time overruns.

Almost all studies discussed in the literature review did show better performances on time for integrated contract forms compared to traditional contract forms. The results of this study align with Ibbs' (2013) findings; projects developed with integrated contract forms do not perform significantly better on time aspects compared to projects developed with traditional contract forms. One argument for this great difference between findings is that previous studies are conducted between 1996 and 2009. Construction processes of buildings became more and more complex over the past decade due to the presence of more stakeholders, more and stricter building requirements and more and stricter regulations for procurement procedures. As a result construction processes from the '90 and early 00's vary a lot compared to processes nowadays and it is not so plausible to compare these studies with recent studies. In this line of reasoning it is legitimate that time savings found in 'older' studies cannot be found in recent construction processes, due to the more complex circumstances involved when developing buildings. This complexity makes that time savings became negligible and therefore are not measured.

This paper offered a performance-based, empirical study of two groups of contract forms. The study achieved several milestones in the field of research methodology and added state of the art findings to the body of knowledge of integrated contract forms.
This study was able to diminish shortcomings of previous research, which resulted in a more reliable study when compared to previous studies.
First, a homogenous data sample with objective data that was not biased by the selection of the

projects and expert opinions was composed. Second, transparency regarding the research methodology and the data collection process increases the reliability of this study. Last, this study's reliability is also enhanced by using the bootstrap method for the logistic regression model, which generates more reliable results.

Nevertheless, this study also has its shortcomings. There was the assumption that due to the similiar public funding for secondary schools, the sample is homogenous on the aspect of cost per m2. But analyses show a wide spread in costs per m2, this is caused due to extra funding available for schools by municipalities and school boards. Therefore the sample is less homogenous on the aspect of cost per m2 , but still homogenous due to similar appearance and purpose. Furthermore, this study's purpose was to study time aspects of development processes from the start of the initiative phase up to the end of the construction phase, but this was not possible due to the limited involvement of respondents during the initiative and definition phase (together the preparation phase) of projects.
Almost all respondents were only involved during the design and construction phase and not during the preparation phase. As a result no data is collected about the preparation phase. But when studying time aspects, and therefore time savings, it is essential to collect data about the preparation phase, because there is the widely shared presumption that integrated projects have a significant longer preparation phase and a significant shorter design and construction phase compared to traditional projects. This study was not able to study this presumption comprehensive, though a part of this presumption was subject of this study.

To conclude, this study measured performance as only being time aspects and found no significant better performances for integrated contract forms. This contradicts with many assumptions and statements.

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Equipment Productivity in Infrastructure Projects in GCC Countries

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Abstract

Good site management in construction must continually pursue the efficient utilization and allocation of labour, material and equipment. These elements are all essential in the pursuit of the Gulf Cooperation Council's (GCC's) vision for the future. Improvement of equipment productivity should be a considerable concern for control of infrastructure projects. In GCC countries, whilst the direct unit cost of equipment per hour in terms of cost rates paid may not be significantly high, findings indicate indirect costs are significant include hiring, transporting, storage, technical support, supervision and insurances.

Productivity in construction in analytical methods is defined as unit output per hour. It is important to note that equipment productivity is a measure of the overall effectiveness of organisation systems in utilizing labour, equipment and capital to convert labour efforts into useful output, and is not a measure of the capabilities of labour alone. Efficiency and effectiveness of organisation systems in utilizing resources will lead to minimizing construction waste. The selection of the appropriate type and size of construction equipment often affects the required amount of time and effort and thus productivity.

Research findings indicate that construction equipment is used to perform essentially repetitive operations, and can be classified according to its functions into: (a) that requiring operators such as cranes and graders which stay within the confines of construction sites, and (b) haulers such as dump trucks and ready mixed vehicles which transport materials to and from sites.

The aim of this paper is to identify and analyse major and common factors affecting equipment productivity on construction projects. A comprehensive literature review and factors recommended by authors from previous studies will be the foundation of the paper. The method for the study was a quantitative questionnaire supported by exploratory qualitative interviews with industry practitioners in GCC countries, and the survey findings indicates the major factor impacting equipment productivity is rework due to external factors like design changes or/and scope change.

Keywords: Construction, Productivity, Equipment, Factors

1. Introduction

Productivity in construction is often broadly defined as output per labour/equipment hour. Since labour/equipment constitutes a large part of construction cost and the quantity of labour/equipment hours in performing tasks in construction is more susceptible to the influence of management than are materials or capital, this productivity measure is often referred to as 'labour/equipment productivity'. However, it is important to note that labour/equipment productivity is a measure of the overall effectiveness of organization systems in utilizing its resource and capital to convert into useful output, and is not a measure of the capabilities of labour alone. For example, by investing in new equipment to perform certain tasks in construction, output may be increased for the same number of labour hours, thus resulting in higher labour productivity. An increase in productivity was noted prior to the mid-1960s in the construction industry (Stall, 1983). Later, a decline in productivity became an issue of great concern in the construction all over the world. In 1968, the Construction Roundtable was established due to concern about the increased cost of construction resulting from an increase in inflation and a significant decline in construction productivity (Thomas and Kramer, 1988). It was necessary to implement, as far as possible, industry-wide principles of production throughout the construction process. It was argued that careful adaptation would be required, to implement knowledge and experience gained in manufacturing to construction (Alarcon and Borcherding, 1991).

Past studies and research show that a number of factors affect productivity, but there are still unidentified factors that need to be further studied even in developed countries (Makulsawatudom and Emsley, 2002). A study by Polta and Arditi (2005) stated that policies to raise productivity are not always similar in each country. Their study identified different factors affecting labour productivity and grouped them according to their characteristics such as design, execution plan, material, equipment, labour, health and safety, supervision, working time, project factors, quality, leadership and coordination, organization, owner/consultants, and external factors. Adrian (1987) classified the factors causing low productivity as industry-related factors, labour-related factors, and management-related factors. Industry-related factors, essentially, are the characteristics of the construction industry, such as the uniqueness of construction projects, varied locations, adverse and unpredictable weather, and seasonality. Labour-related factors included lack of training and learning for labour, and lack of motivation. Management-related factors usually refer to a lack of management, and inappropriate use of tools and techniques. Olomolaiye et al. (1998) classified productivity factors into two categories: external factors are outside the control of organization management and internal factors relate to productivity issues originating within the organization. Thomas and Sakarcan (1994) developed ideas to describe factors affecting labour productivity. One study suggested that scheduled overtime always leads to efficiency losses because of the inability to deliver materials, tools, equipment, and information at an accelerated rate (Ginther, 1993). Productivity in the construction industry is not only influenced by labour, materials and equipment. However, most researchers and construction practice to date has primarily concentrated on labour productivity, as though labourers' performance is the sole contributor to increased construction productivity (Alwi, 1995). Investigation conducted by (Alwi, 2002) concluded that there was now concern over the high level of non-value adding activities within the construction industry. The activities, known as construction waste (disposals), have been identified as major factors affecting construction productivity. The foundation for this paper is built upon the work of Abdelaal et al, (2014) which examined labour productivity in GCC countries.

2. Literature Review

Productivity is the outcome of several interrelated factors. Discussed below are various factors affecting construction productivity and are reviewed from past studies.

2.1. Site working time:

During construction projects, working overtime initially results in increased production rates, but continuing overtime may lead to increased costs and reduced productivity (Hinze, 1999). Alinaitwe *et al* (2005) found that employees in the field only work effectively for 3.5 hours of an 8-hour shift and spend only 20% of time on direct value-adding activities.

2.2. Managing site equipment:

The Construction Industry Institute states that material and equipment currently comprise 50-60% of construction project costs (Materials Management Task Force, 2007). In addition, lack of suitable equipment is considered one of the major causes of construction delays. Good equipment management begins at the time the equipment is purchased/hired. Purchasing/hiring the proper equipment that matches the need of assigned tasks, while achieving the lowest costs, is necessary to attain suitable equipment management. Proper record keeping provides information for planning maintenance/ replacement, ensuring that they occur at the proper time. Managing equipment includes preventative maintenance, planning maintenance, and replacement activities (O'Brien et al 2007).

2.3. Communication:

Good communication is necessary to efficiently complete a project. Some of the more commonly used forms of work site communication include two-way radios, mobile phones and mobile wireless internet. Lack of communication can cause delays due to mistakes causing rework, lack of information causing downtime, and misinterpretation. Other common problems associated with communication on construction projects include understanding the chain of command and continuously communicating about the project and foreseeing potential problems in the future. This can be avoided by holding regular project management team meetings (Cingoranelli, 2007). As stated in the Project Management Institute's Standard (PMI, 2009), about 90% of project manager time is spent in communication.

2.4. Work schedules:

When there are early delays in projects, compression of the overall time frame for later activities is often used to compensate interruptions and to complete assigned tasks on schedule. From a professional scheduling perspective, schedule compression may be possible without accelerating individual work activities by utilizing float in project schedules; however in many projects, schedules are not fully resource loaded. As a consequence, an updated schedule reflecting delays may show the project finishing on time without shortening individual activities (National Electrical Contractors Association, 1983).

2.5. Working tasks types:

To accomplish acceptable productivity, every member of a crew requires adequate space to perform tasks without being affected by other crew members (space constraint). When more labourers are allotted to perform particular tasks, in a fixed amount of space, it is probable that interference may occur, thus decreasing productivity. Additionally, when multiple trades are assigned to work in the same area, the probability of interference rises and productivity may be reduced. Interference among the various crews and labourers is due to mismanagement on construction sites. For example, a steel-fixing crew has to wait before fixing reinforcement bars if the carpenter's formwork is incomplete. Types of activities and construction methods also influence labour productivity (Sanders and Thomas, 1991).

2.6. Safety measures:

Accidents have high impact on labour productivity. Various accident types occur at sites, and some may cause fatal injuries and result in total work stoppage for a number of days. An accident that causes an injured person to be hospitalized results in a work decrease of the crew for which the injured employee worked. Small accidents resulting from protruding nails and steel wires can stop work and, thus, decrease productivity (Sanders and Thomas, 1991).

2.7. Quality control:

Inefficiency of equipment, unskilled labourers and poor quality of raw material are factors which cause low productivity. The productivity rate of inefficient equipment is low. Old equipment is subject to a great number of breakdowns, and it takes a long time for labourers to complete the work, thus reducing productivity. Poor-quality material used for work is another reason for reducing productivity; also unskilled labourers causing rework, which leads to low productivity.

2.8. Managerial factors:

Project manager skills and attitudes influence construction productivity. In many organizations, productivity is low even though the latest technology and trained labour are made available. Low productivity is often because of inefficient and immature management. Advanced technology requires knowledgeable labourers who work under professionally capable leaders.

2.9. Skilled labourers:

A lack of labour experience is the factor which negatively affects labour productivity and proves that, to achieve good productivity, labour plays a significant role. Contractors should have sufficiently skilled labourers employed to be productive. If skilled labour is unavailable and a contractor is required to complete specific tasks with less-skilled labour, it is likely that productivity will be negatively impacted. Lack of compensation and increased labourer age negatively affect labour productivity because labour speed, agility, and strength decline over time and reduce productivity (Heizer and Render, 1990).

2.10. Motivation:

Motivation is one of the important factors affecting construction labour productivity. Motivation can best be accomplished when labourers' personal ambitions are aligned with organization strategic goals. Factors such as payment delays, a lack of a financial motivation system, non-provision of proper transportation, and a lack of training sessions are grouped in this topic (DeCenzo and Holoviak, 1990).

2.11. Scope changes:

Construction projects often have design, drawings and specification changes as work proceeds. If drawings or specifications are unclear, productivity may decrease since labourers in the field are uncertain about what needs to be done. As a result, tasks may be delayed, or have to be completely stopped and postponed until there are clear instructions. There can be a 30% loss of productivity when work changes are being performed (Thomas *et al*., 1999). Work inspection by supervisors is an essential process before proceeding to subsequent stages. For example, contractors cannot cast concrete before an inspection of formwork and steel work, thus affecting labour productivity (Zakeri *et al*, 1996).

2.12. Availability of material/tools:

Productivity can be affected if required materials, tools, or construction equipment are not available at the correct location and time. If the improper tools or equipment are provided, productivity may be negatively affected (Alum and Lim, 1995; Guhathakurta and Yates, 1993). The size of construction sites and material storage locations have a significant impact on productivity especially in infrastructure projects where there are often large space areas for work, and labourers spend time moving materials from inappropriate storage locations, thus resulting in productivity loss (Sanders and Thomas, 1991).

2.13. Over planning and work methodology:

Improper scheduling of work, shortage of critical construction equipment or labour, may result in loss of productivity. Improper planning of project-initiation procedures may lead to lost labour productivity. Also, poor site layout can contribute to a loss of productivity. According to the Association for the Advancement of Cost Engineering (AACE, 2004) labourers may have to walk or drive long distances to lunch rooms, rest areas, washrooms, entrances, and exits, affecting overall productivity.

2.14. External factors:

Various natural factors affecting equipment productivity collected from previous studies are weather conditions and geographical conditions. Others factors such as fuel, water, and minerals also affect productivity to a certain extent. Productivity is found to be highly affected if the weather is too extreme (too cold, heavy rainfall, or too hot, as in the case of this study in GCC countries).

3. Methodology

This research investigates important factors affecting equipment productivity in construction in GCC countries. Understanding these factors is helpful for construction professionals who work on all project phases, especially on the initial phase of construction planning, in order to efficiently deliver project plans. The main goal of the research is to provide essential information about factors affecting construction productivity. Factors which affect construction productivity are a lack of required materials, disputes between the major parties, weather, changes during construction, accidents, and other items. The research study aims to provide knowledge of construction project-related factors that affect productivity. The data collection instruments used in the research are a questionnaire survey, followed by interviews with practitioners. The research passed through the following phases in figure 1:

Background of productivity

↓

Review of literature/Issue identification

↓

Design of questionnaire

↓

Survey and data collection

↓

Data analysis

↓

Conclusion/Recommendations

Figure 1: research phases

The data collection process used in this research had the option of two basic methods: questionnaires and personal interviews. A questionnaire was preferred as the best effective and suitable data-collection technique for the study. The questionnaire was a self-administered tool with web-design questions. A questionnaire in a web-survey format comparatively requires less duration and saves cost for the researcher while permitting participants to respond to the questionnaire at their convenience. However, for this approach the response rate is usually lower as compared to face-to-face interviews. Data was collected for the literature review from books, journals and articles. The population for the survey was employees from different professions involved in construction in GCC countries.

3.1. Questionnaire and results

Participants were asked to indicate to what extent factors affect equipment productivity on infrastructure sites in GCC. Responses were scored as 1 – not applicable; 2 – does not affect it; 3 – somewhat affects it; 4 – directly affects it.

3.2. Survey and questionnaire revision

Face-to-face discussions were conducted with ten construction practitioners. This procedure improved the formation of the web-survey. A total of 130 questionnaires, were sent by e-mail to contractors, architects, owners, project managers, and project engineers of various construction organizations. In addition conducted collection process with qualitative interviews with construction professionals.

3.3. Questionnaire distribution

The target groups in this study were professionals from the construction industry. A list of 550 building-construction organizations was obtained from the Construction Week online the GCC magazine. The sample size can be calculated with the following equation for a 94% confidence level (AlShahri, M *et al.*, 2001; Moore *et al.*, 2003):

$$n = \frac{n'}{\left(1+\frac{n'}{N}\right)} \qquad (1)$$

Where, n = total number of population, N = sample size from a finite population, n' = sample size from an infinite population= S2/V, S2 = the variance of the population elements and, V = a standard error of the sampling population (usually, S= 0.5, and V = 0.06). n'= S2 / V2 = (0.5)2 + (0.06)2 = 69.44, for N=550, n = 69.44 / [1 + (69.44 / 547)] = 62, to obtain 94% of confidence level, it was calculated to send the questionnaire to minimum of 62 participants.

3.4. Data collected from the web survey

To successfully achieve the objective of the study, one of the most important phases is collection of accurate data. Data collection is a procedure of collecting crucial data records for a certain sample or population of observations (Bohrnstedt and Knoke, 1994). shows the participant's characteristics: The characteristics of participants involved in the survey were tabulated in Table 1. The average work experience of the participants involved in construction industry is 15 years with managerial level and majority belongs to control debarment. This indicates reasonably a high work experience profile within GCC construction industry.

Table 1: Characteristics of participants/ Company classification

Participants	*Questionnaire distributed*	*Responses returned*	*Percentage of responses*
Client	*5*	*3*	*18.80%*
Consultants	*5*	*2*	*12.50%*
Contractors	*100*	*11*	*68.70%*
Sub-contractors	*5*	*0*	*00.00%*
Suppliers	*5*	*0*	*00.00%*
Total	*130*	*16*	*13.33%*

3.5. Analysis method used

In order to facilitate the study, after the literature review and the focus interviews, a plan was formulated for collecting field information and creating an evaluation process and numerical values. It was necessary to provide straightforward communication to participants to ensure a clear understanding of all the applicable definitions, procedures, and guidelines that were used in collecting data.

3.5.1. Ranking

Ranking of the various factors according to their relative importance index (RII) for affect ranges: (1 – Not applicable; 2 – Does not affect it; 3 – Somewhat affects it; 4 – Directly affects it). RII for each factor as follows: $RII=\Sigma W/A*N$, where W is the weighting given to each factor by the participants (ranging from 1 to 4), A is the highest weight (i.e. 4 in this case), and N is the total number of participants. For the interpretation of the *RII* values, *RII* is ranked from the highest to the lowest.

3.5.2. Analysis

Table 2 illustrates RII a rankings of 29 common factors affecting productivity of equipment as per previous studies, and factors were categorized into five major groups and were ranked. The results show that clients, consultants, and contractors all agreed that the external group of factors affecting productivity was the most influential. Resources factors were considered the second most important factor affecting productivity in construction projects followed by Misc., Operators and communication.

Table 2: Top factors affecting equipment productivity in construction projects in GCC

Factors affecting construction equipment productivity at infrastructure sites	*RII*	*RANK*
1- *Operators*		
Lack of experience	*0.83*	*2*
Disloyalty	*0.73*	*6*
Age	*0.41*	*31*
Personal problems	*0.50*	*30*
Absenteeism	*0.70*	*10*
2- *External*		
Implementation of standards, government laws & regulation	*0.83*	*3*
Rework	*0.84*	*1*
Lack of Supervision	*0.81*	*4*
Permits delays from the authorities	*0.73*	*6*
Variations & design changes	*0.61*	*23*
Complex designs in drawings. Incomplete drawings	*0.72*	*9*
Payment delays	*0.63*	*18*
Lack of training	*0.63*	*18*
3- *Communication*		
Misunderstanding between owner, contractor and designer	*0.61*	*23*
Disputes with owner/designer	*0.64*	*16*
4- *Resources*		
Lack of required construction materials or/and price increase	*0.73*	*6*
Availability of required equipment	*0.78*	*5*
Poor site conditions or/and differing from plan	*0.69*	*11*
Differing from plan	*0.61*	*23*
Poor access within construction job site	*0.61*	*23*
Violations of safety laws	*0.61*	*23*
Insufficient lighting	*0.61*	*18*
Inadequate construction method	*0.63*	*11*
Inadequate transportation facilities for workers	*0.69*	*23*

Material storage location	*0.58*	*29*
5- *Miscellaneous*		
Shortage of water and/or power supply	*0.66*	*15*
Working overtime	*0.63*	*18*
Power supply	*0.63*	*18*
Weather conditions	*0.64*	*16*
Accidents during construction	*0.67*	*13*
Project objectives are not well defined	*0.67*	*13*

4. Conclusion and Summary

This research provides study and knowledge of construction productivity and focus on factors affecting equipment productivity in infrastructure construction projects in GCC countries. The study sought the views of clients, consultants, and contractors on the outcome of infrastructure projects especially public projects that influence economics. Prior knowledge of labour/equipment productivity during construction can save cost and time. Investments for these projects are very high and because of the complexity in construction, various factors can highly affect overall productivity, thus projects can end up adding even more time and cost. The research is intended to identify major common factors affecting equipment productivity in infrastructure projects. This study investigates all possible factors through a structured questionnaire administered in GCC countries. The survey results are subjected to analysis, and the ranking of factors is calculated using Relative Importance Indices (RII). The study showed that all the three groups-clients, consultants and contractors of participants generally agreed that out of a total of 29 factors the top 10 influencing factors affecting equipment productivity arranged in descending order of RII are:

- Rework
- Lack of experience
- Implementation of standards, government laws & regulation payment delays
- Lack of supervision
- Availability of required equipment
- Disloyalty
- Lack of required construction materials or/and price increase.
- Permits delays from authorities.
- Complex designs in drawings. Incomplete drawings

The results show that clients, consultants, and contractors all agreed that the external group of factors affecting productivity was the most influential. Resources group of factors were considered the second most important factor affecting productivity in construction projects followed by miscellaneous, operators and communication factors. In addition, the study showed 10 factors that affection productivity of excavator in infrastructure projects, that the top influencing factor affecting excavator productivity using RII is soil characteristics. From previous studies, it has been shown that the nature of the construction industry, usually involves the separation of design and construction functions. This has affected construction productivity through delays in drawings, design changes, and following rework. Clients have sometimes delayed projects because of their lack of suitable knowledge about construction procedures. Moreover, being an outdoor industry, construction performance is significantly affected by weather conditions. In addition to the factors discussed, health and safety regulations, and codes of practices are other external factors influencing task operations and productivity. Factors internal to construction companies include management inadequacy resulting in a waste of resources and consequent losses in productivity; adoption of modern technology and training for labourers would increase productivity. This research was carried out in infrastructure construction projects in GCC. It may be that the issues of the key factors, the model developed and the alternative solutions here can provide guidance to the other studies and researchers. Concepts such as waste and value are not well understood by construction personnel. They often do not realise that many activities they carry out, do not add value to work. Waste is not only associated with waste of materials in the construction , but also other activities that do not add value such as rework, waiting time and delays. These issues contribute to a reduction in the value of construction productivity.

5. Recommendations

Construction projects are high risk and often lead to a disputes and claims as work progresses, which then subsequently further affects progress. The environment within construction organisations should be suitable to successfully complete projects. In construction, it is necessary to identify potential problems in advance, in order to avoid and overcome possible impacts on cost or project time. Detailed below are recommendations which were found to improve equipment productivity on the infrastructure projects in GCC countries:

> Material delivery schedules should be provided for projects and monitored closely by contractors. Using suitable materials and tools also has a positive effect on tasks and thus, better labour productivity can be achieved. Material should be stored at appropriate locations and should be easily accessible. Project managers should provide suitable logistic plans at the initial phase of projects. Good equipment management begins at the time the equipment is purchased/hired. Purchasing/hiring the proper equipment that matches the need of assigned tasks, while achieving lowest costs is necessary to attain suitable equipment management. Proper record keeping provides information for planning maintenance/ replacement, ensuring that they occur at the proper time. Organizations should make sure sites are safe and undertake continuous safety training. Various external and natural factor risks should be considered in budget estimations to minimize delays due to closures and material shortages. There should be suitable contingency budgets to cover increased costs of material. Motivation and training systems, should be implemented to create competition among the employees, thus achieving better productivity. Complex designs and incomplete drawings should be avoided and care should be taken to avoid confusion among the various construction agencies. Absenteeism at work site can be reduced with inclusion of appropriate paid time off and vacations to all employees.

6. Future Research

Further research should focus on the holistic barriers of implementing models for managing site resources (labour, equipment and materials) in addition to construction waste management, and development of a universal implementation framework that can fit into any construction environment and type. In the same vein, further work should be undertaken on applying the research in other developing economies. Similarly, additional research should be made in the adoption of lean construction tools and techniques within GCC countries such as Location Based Management Systems (LBMS) and Last Planner Systems (LPS) (Abdelaal, *et al.,* 2015).

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Walking the line: Navigating the space between calculus-based and relational trust in construction supply chains

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Abstract

Literature suggests that trust can take a number of forms, two notable ones being calculus-based and relational trust. Researchers have also argued that it is important to understand how these forms can be blended in different situations. However, there is limited empirical work that has explored how this blending can be managed in construction settings, where calculus-based forms of trust have often been overemphasized. In these situations, parties often depend excessively on contracts, incentives, and deterrents in ways that are counterproductive, perhaps even leading to distrust. Existing models of trust provide limited guidelines on how to achieve an optimal mix. We use qualitative case studies and actor-network approaches to explore these forms of trust, along with the movements between them, in two settings. Based on our findings, we argue that trust can initially emerge not just as calculus-based but also as dominantly relational and that trajectories of trust reflect complex, non-linear paths between the two pure forms. These findings allow us to enrich existing models that suggest that trust begins as entirely calculus-based and eventually changes to relational forms. We also point to potential areas for future work in terms of exploring the antecedents and outcomes of trust in various forms.

Keywords: trust, calculus-based, relational, capital, construction supply chains

1. Introduction

Trust has been defined as “a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another” (Rousseau et al 1998, p. 395). In collaborative contexts, trust has been described as “the glue and lubricant” that that holds relationships together (Bryson et al 2006, p. 47). Trust as a construct has received considerable attention in the field of construction, an arena where relationships have been described as conflict-laden, lacking in trust (Chan et al 2004), and adversarial (Phua and Rowlinson 2003). Studies suggest that trust in construction settings has multiple benefits: it helps supply chain partners fulfil their commitments in terms of service or product delivery, allocate appropriate resources to the required tasks, and facilitate team work among the project development team (Chow et al. 2012). High levels of trust among partners also result in a clear focus on the long-term benefits of their relationship (Davis 2008). An appropriate organisational culture that values trust is also a prerequisite to maintaining a sustainable supply chain partnership (Cheung and Rowlinson 2011). In the same vein, a lack of trust would result in unsuccessful collaboration (Akintoye and Main 2007). Trusting relationships therefore play a critical role in developing long-term relationships among partners. Interestingly, trust can have surprising complexities: studies have shown for example, that trust can lead to inefficiencies and waste as reported by Khan et al. (2011).

Researchers from within and outside the domain of construction have sought to understand trust theoretically and empirically by developing models that unpack trust in different forms. A number of these have analysed trust by proposing typologies ranging from calculative, economic, highly rational notions of trust, to affect-driven, relational forms that are seen to emerge from long-term interactions. In management literature, for example, Rousseau et al. (1998) proposed that trust as a micro, meso, or even macro-level construct, can come in three different forms. Calculus-based trust, they claim, emerges when one party concludes, based on the assessment of credible information (reputation, academic credentials), that a trustee (the actor being trusted) “intends to perform an action that is beneficial” (p. 399). The actor therefore becomes willing to engage with the trustee. The process is described as a highly rational approach, and is utility-driven in the sense that it focuses on benefits that can come from deciding to trust. However, this type of trust is limited in the sense that actors engage only in a small pool of select exchanges, and the actor seeks to maintain its own well-being maintaining some protection through the presence of deterrents. In contrast to calculus-based trust, relational trust emerges when one party engages with a trustee in repeated interactions over time, forming a relationship which in itself becomes the basis for trust. The relationship usually involves emotion and a higher level of faith as compared to calculus-based trust. The result of this type of trust is a broad range of exchanges typically transcending arms-length transactions (Rousseau et al. 1998). Apart from calculus-based and relational trust, Rousseau et al. (1998) also discuss a third type of trust, institution-based trust, which explores the role of entrenched norms, rules and practices in shaping conditions for trust. Other researchers have proposed similar typologies. Lyons and Mehta (1997) likewise argue that trust can be economic in nature, resulting in what they call “self-interested trust” (SIT); in contrast, trust can be social in nature, resulting in what they call “socially-oriented trust” (SOT). There are considerable overlaps between SIT and calculus-based trust, just as there are considerable overlaps between SOT and relational trust. SIT is based on an actor's calculating a future returns or benefit as the outcome of trusting in another party. SOT, on the other hand, assumes that social factors (for example an affective component) drive an actor to behave in trustworthy ways to others.

Similar categorizations of trust have emerged in the field of construction. Khan et al. (2011), for example, distinguish between cognitive- and affect-based trust. Cognitive-based trust is based on the professional competence of the service or product provider. In contrast, affect-based trust is the emotional attachment that gets developed among partners over a period of time. Zhagloul and Hartman (2003) likewise propose different types of trust, two of which are trust based on competence (based on the question "can you do the job?") and trust based on intuition ("does this relationship feel right?").

The persistence of typologies (economic/ rational/ calculative versus affective/ relational/ social) across these four models is worth noting. Also common across at least two models is the idea that different types of trust can be present in a single situation. Rousseau et al. (1998), for example, argue that different situations can be characterized by all three forms of trust, combining into a trust bandwidth. They propose a model that shows the changing composition of this bandwidth over time:

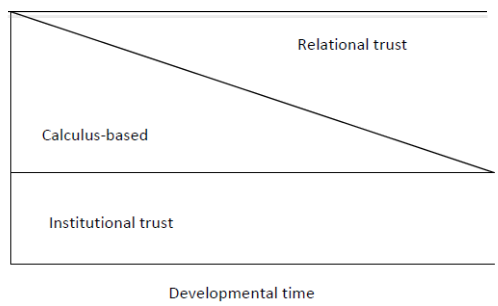

Figure 1: A model of trust (Rousseau et al. 1998, p. 401)

A key feature of this model is the proposal that the calculative component of trust begins as dominant relative to relational trust, but is gradually replaced by relational trust over time.

Lyons and Mehta (1997, p. 254) likewise argue that multiple forms of trust can be present in a situation, and that "[different forms of trust] may be used to reinforce each other, though they are likely to be present in different blends of relative importance". However, they argue that the specific blend of trust that is present in a given context is an empirical question often riddled with complexity:

> *We do not claim that one is universally true and the other is not, nor that there is room for only one type of trust in each relationship…It is possible that one type dominates in one group of firms and the other in another. It is also quite possible*

that the same individuals act with SOT with respect to one trading partner, but only SIT with respect to another. Certainly, we must expect both to evolve differently over time.

Our purpose for this paper, then, is to explore the two types of trust (economic/ rational/ calculative versus affective/ relational/ social calculus-based trust) in the context of two qualitative case studies. For the sake of brevity, we refer to these two types as calculus-based versus relational trust, although our findings for this specific paper would also support SIT/SOT and cognitive/ affective categorizations. The empirical examination of this blending process is particularly important, given that researchers have argued that "[i]n today's complex business relationships, like construction projects, the most effective approaches to developing 'business trust' are based in between these two extremes of egoism and altruism" (Rahman and Kumaraswamy 2002, p. 47). Still, negotiating this "space in between" has proven to be far from straightforward. Lyons and Mehta (1998, p. 254) warn against making simplistic conclusions, for example those that argue that "both [types of trust] are equally important". Equally dangerous is the tendency to ignore one type of trust completely. In the field of construction, for example, calculus-based forms of trust have often been overemphasized, with parties depending excessively on contracts, incentives, and deterrents in ways that are counterproductive, perhaps even leading to distrust (Kadefors 2004). There is therefore a need to explore, particularly in construction-related situations, how different forms of trust can best be combined in specific situations, and how the nature of these blended forms of trust can be allowed to emerge, rather than forcing them into a predetermined path. In our empirical study, we seek to discern and unpack how this blending takes place in nuanced ways. Our findings allow us to propose, among other things, a number of ways that the model of Rousseau et al. (1998) can be enriched.

2. Methods

This study is part of a three-year project exploring collaboration in housing supply chains using novel offsite manufacturing approaches in Australia. The study's emphasis on collaboration makes an examination of trust necessary, as there is a close link between the two (Bryson et al., 2006). For this paper, we focus on the issue of trust in the context of two qualitative case studies. Organization A is a large national developer that operates in a large Australian capital city. It focuses on the design and construction of medium-storey timber-framed apartments. Over the last decade, the organization has made it a priority to move away from purely site-based construction approaches and to explore alternative construction methods. In 2013, it began a five-storey apartment building project that involved the design and use of an innovative cassette floor that could be manufactured offsite and later craned into place. Upon completion of the project, it was assessed that the use of the cassette floor led to a cost savings of 25% per apartment. While use of the cassette was successful in retrospect, the development of the prototype of the cassette was a stage that was fraught with considerable uncertainty and resistance. There was therefore a period when Organization A found itself having to build relationships with suppliers and contractors in ways that fostered trust and encouraged these partners to launch into this new undertaking with them.

Organization B is a regional provider of housing solutions with two main locations, one being a small town in South Australia. The company specializes in both site-built houses as well as transportable homes that are manufactured on company premises then trucked to specific locations. Organization B has evolved over time, having its beginnings with a small firm founded by a single entrepreneur, and then expanding over time to include multiple businesses, four owners, and multiple managers. Apart from building homes, the firm also maintains properties and provides kitchen solutions. Organization B has, until recently, been operating with partners who have long-standing personal relationships with the owners, relationships that have persisted even in the absence of formal contracts. In 2014, Organization B took on a new general manager, and one of her goals is to professionalize and formalize structures and processes in the organization.

Our purpose is to examine trust in the context of the two construction-related organizations that are embedded in larger supply chain networks. Data was gathered primarily through interviews of managers and external partners of both organizations. Fourteen interviews have so far been conducted across both organizations. Interviews lasted one hour, were fully transcribed, and then analysed thematically using NVivo.

In analysing the data, we employed actor-network theory (ANT) as a methodological approach. ANT overarches a range of theoretical and methodological approaches based on the premise that much of social reality can be understood as the outcome of actors (human and non-human) interacting in heterogeneous networks (Law 1992). From an ANT perspective, complex phenomena such as organizations, technologies, IT systems, and communities are all networks made up of people, objects, documents and other entities exercising some form of agency, shaping their relationships with other actors, and in doing so creating network effects. Much of the "work" of creating network is often, though not completely, carried out by a key actor (referred to as a prime mover). The prime mover seeks to enrol other actors into a network, and to subsequently stabilize this network, in order for the network to address a certain problem (Callon 1999).

We used ANT to identify key players in both organizations, to examine how they established interactions with other actors, and to explore what forms of trust emerged between human actors. Many of the quotes can be understood to be coming from "prime movers" with considerable influence on the direction of an organization. These prime movers' views (whether on strategic issues or on things like trust) are important, but are not to be taken as the views of the overall organization. Acknowledging this also highlights that in these case studies, it is not the organizations as monolithic entities that "trust"; it is specific people who trust in certain ways. Trust in this case is therefore examined primarily on a micro level (as linked to an individual's notion of trust), although it should be noted that when referring to "trusting a partner", the term "partner" is loosely employed, at times referring to a partner organization, other times to a representative of that organization. It should also be noted that trust can be multifaceted to the extent that people "possess" it different forms and mobilize it in different ways. Analysing organizations as composed of different actors with different interests and views is consistent with the assumptions of actor-network theory.

3. Findings

We discuss our findings as follows. First, we describe what we discerned to be the roles of calculus- and relational trust at the relationship formation stage, that is, at the stage when managers from Organizations A and B were selecting and recruiting partners. Second, we examine the trajectories of these two types of trust over time, suggesting that the so-called switch between calculus and relational trust requires more complex conceptualizations than the suggestion that relational trust eventually replaces calculus-based. These two sets of findings become the basis for discussing future areas of research, specifically in terms of exploring antecedents and outcomes of various forms to trust. Due to space limitations, we do not discuss institutional-based trust here.

3.1 Forms of trust: the role of the relational component

The model of Rousseau et al. (1998) suggests that trust begins mainly as calculus-based. This may seem intuitive, given than trust based on economic thinking has tended to dominate business settings (Lyons and Mehta 1997). Our data from Organization A also supports this, as key managers describe partner selection for their innovative project as a systematic, well-researched process. For example, a manager who played a lead role in the 2013 project we described recalled,

> *I mean we still tendered out all the other basic trades but we knew who our core subcontractors and suppliers needed to be. And in doing so we had to **research** on that company and make sure they were capable of doing what we needed as well. So we went out to the **largest** frame and truss manufacturers who had the best detailers in their, I guess, pool of employees. We went to a flooring company **who had the ability** and cashed up to be able to do all the independent testings that we wanted to be done. And we had the **best engineers** on board. All those things all clicked, that's all. So **we knew who we needed to make it to work.** (emphasis ours)*

The reference to "research" suggests that there was a deliberate and systematic search for credible information about potential trustees, and this is consistent with the definition of calculus-based trust. Managers at Organization A thus moved to the decision to trust partners on the basis of trustworthy attributes: being "capable", being the "largest", being the "best".

We do note, however, that the case of Organization B was not as straightforward. Our data-gathering at Organization B was not at a point when new partnerships were being formed; however, it was at a point when a new general manager and sales director had just been appointed, and were reassessing existing relationships with suppliers, as well as how these relationships came about. Their assessments did yield some insights on the basis of these existing relationships, and a number of points were noted. First, there was no mention of screening or researching on potential suppliers at the start of the relationship. References to the history of partner relationships were mostly centred on the role of the owners "because [the owner] obviously built the relationship over the years". When this owner was interviewed, he made reference to what was important in partnerships:

I know a lot of builders will chase the dollar, and we don't seem to and it's a good place to be when you don't chase the dollar because you sort of burn those relationships... So yeah, I do like running the business where I can keep relationships alive with suppliers.

This seemed to indicate that relationships were important in partner selection; in fact, the statement may even be interpreted to mean that monetary targets ("chasing the dollar") were less important. Either way, an argument can be made for saying that relational trust can be significant from the very start of the relationship.

Adding weight to this argument is the fact that many of these long-term partners were not providing the most in terms of economic benefits, but they were still being kept on as partners, often as the sole partner for a specific good or service. A new manager commented,

…one of my bug bears with [owner]… is he won't switch suppliers sometimes. When I know we can get it cheaper …and that's why we love him and people love us because [he says] no, he's a good guy, he's honest, he looks after me, the price, he's around the mark, he's not, you know, so we'll stick with him... So, we've got a core group of suppliers for each products, usually it's only one, other builders are a bit more intelligent…

…you've got to love [owner] for it because he's just about relationships and but, you know, just got to find that happy balance, we're a bit too happy families at the moment, yep, but that's fine.

A third point that seems to emphasize the dominance of relational trust over calculus-based trust is that there had never been any formal agreements in place that could have protected Organization B. The new general manager commented

… there's no agreements in place, there's no pricing grid there's no SLRs [service level reports], there's no any of those things. So I'm trying to bring to that, like get some agreements in place. Because I want to understand timeframes, for me, it's about, time costs quality, and get that, and less of the handshake.

The emphasis on "not chasing the dollar", the need for "less of the handshake", along with the persistence of long-term relationships without formal agreements and despite suboptimal economic benefits, seem to suggest that these relationships did not start out as purely calculus-based. The argument we make here, then, is that, contrary to Rousseau et al.'s (1998) model (see Figure 1), relational trust can have a role at the beginning of a relationship. It is worth exploring in future studies, therefore, how relational forms of trust can exist even without a long history of repeated interactions.

3.2 Trajectories of trust over time

A second point about the model of Rousseau et al. (1998) is related to what we call the trajectory of firms in the journey related to trust development. Rousseau et al. (1998) suggest that over time, firms move away from calculus-based trust, and as they do so, relational trust comes to dominate. The model thus suggests a simple, linear trajectory with calculus-based trust decreasing as relational trust increases.

We can see this, albeit only up to a point, in the case of Organization A. Organization A is largely characterized by a professional work environment, and multiple interviewees discussed how work and processes have been explicated and formalized in programs, minutes of meetings, and contracts. Still, key actors in projects have on occasion chosen to depart from these formal program and contractual commitments, in order to accommodate partners in vulnerable situations:

> *Look, there are contractual boundaries here and we have got a serious job to do, and that element of contracting is still black and white. But for the sake of getting this moving I want to have another element which sits above it, and that is that we're all here to work together and to cooperate.*

The quote seems to suggest that Organization A can shift from calculus-based trust, to relational trust. The shift to relational trust, though, does not proceed indefinitely to the point of completely removing the need for calculus-based trust. Our data shows that, even as managers create space for relational trust with partners, they still curb this trajectory by moving "back" to calculus-based trust. A manager describes how a situation involving an underperforming partner once came up, one involving a "brilliant" man who for some reason had begun underperforming, with the project starting to "come off the tracks." The manager then described how this was dealt with:

> *I wanted to find out why… Now, if ultimately we can't get it back on track we have got a contract sitting behind it. I can't do anything about that. We're both commercially - we're both commercial entities and we've both got outcomes we have to achieve. So that will come into it at some stage.* ***But at this point in time they're not the place I want to be. Right now I want to work out how can we get you back on track, because if I can get you back on track I'm going to win, you're going to win and everyone is going to look good.*** *(emphasis ours)*

This would suggest that, prior to the occurrence of problems with this partner, there was a clear contract embodying clear accountabilities (calculus-based trust, with deterrents). A lapse in partner performance took place, and a decision was made to accommodate this (relational trust, despite the contract). However, in the end, in the end, the expectation was that the contract would still take force (back to calculus-based trust).

This non-linear movement between calculus-based and relational trust can also be seen in Organization B. In this setting, people have operated primarily in a space of relational trust, but they have begun to move this into something more calculus-based and formalized:

> *So yes, I am very conscious of, now, that I'm bringing in price agreements, service level agreements, and all of those things, and I'm very conscious of how I deliver the message to the supplier and to the business….the conversation is, I value the relationships and I appreciate those, but at the same time again my instruction is to make a profit.*

Again, this trajectory is not expected to continue indefinitely, this time with calculus-based trust completely replacing relational trust. Data shows that, despite the move to more calculus-based trust, the manager still brings in the ideal of "valuing the relationship", but it must now be weighed side by side with economic accountabilities. The persistence of the relational component of trust was mentioned again when this same manager clarified, "I don't want to burn the relationship, but I want to find the boundaries in a relationship, too, that we need."

Close scrutiny of the data suggests, then, that these firms are weaving complex, non-linear paths which, at different points in time, mix both calculus- and relational trust. In the case of Organization A, calculus-based trust seems more important at the beginning of the relationship, as well as at times of "final accounting", but relational trust is privileged during times when pre-screened partners go through periods of vulnerability. In the case of Organization B, relational trust seems to have been privileged in the beginning and for much of the organization's life, but the organization is now in a period of transition where key people are seeking to carve out a space for the long-term institutionalization of calculus-based trust. A possible representation of these pathways is shown in Figure 2.

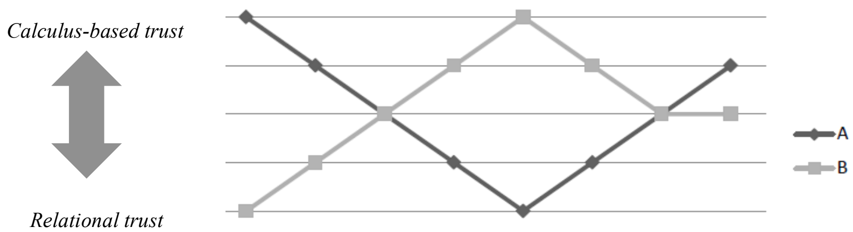

Figure 2. Trust pathways of Organizations A and B (note that the figure is meant to illustrate trajectories, and is not meant to show a precise mathematical function)

4. Discussion

The argument that trust often emerges in blended form foregrounds a number of questions that could lead to enriched understandings of it in organizational contexts. We note two that are important questions here: the question of antecedents of trust, and the question of outcomes of trust. We discuss these as two potential research directions.

The question of antecedents of trust could focus on the specific conditions and resources that give rise to trust, whether calculus-based or relational. In Organization A, trust emerged when managers obtained information about potential partners' competencies and accomplishments, and processed this in a rational way. In Organization B, trust emerged mainly from the nature of a long-running relationship. We believe that these forms of trust did not arise in a vacuum, but were closely linked to different conditions for trust that can be examined systematically. Pierre Bourdieu's (1986) concept of fields and symbolic capital provide an analytical apparatus for examining these conditions. Bourdieu argues that much of the social world can be explained by treating parts of society as fields, such as the fields of art, politics, and education (Swingewood 2000). Each field, for example housing construction, has its own rules, practices, and ideals as to what makes up the good life. Importantly, fields can be understood as networks of positions, some of which are dominant, others dominated. Positions are occupied by actors, and actors consistently seek to ascend to better positions. Fields are thus "a terrain of contestation among occupants of positions differently endowed with the resources necessary for gaining and safeguarding an ascendant position within that terrain" (Emirbayer and Williams 2005, p. 692).

To ascend to a better position in a field, actors seek to accumulate capital in various forms: economic (money), social (relationships), and cultural (which can be embodied, objectified, or institutionalized). Embodied cultural capital is acquired by investing in resources that "form long-lasting dispositions in the mind and body" (Bourdieu 1986, p. 84), a process which takes time and which must be done first-hand. Objectified cultural capital (paintings, monuments, books) takes material form and becomes transmissible. Institutionalized cultural capital generally takes the form of recognized academic qualifications. We are proposing that future work can explore the link between trust and capital two ways. First, researchers can explore the extent to which parties with more capital are considered more trustworthy. Second, researchers can explore the extent to which specific forms of capital are linked to specifically to calculus-based or relational trust.

Preliminary insights on these issues can already be discerned from our case study data. Organization A, for example, chose to trust in firms endowed with embodied cultural capital in the form of capabilities possessed by employees ("You need to judge fairly quickly what their capabilities - capacity and capability is and their expertise"). It also privileged firms with objectified cultural capital, in the sense that these were firms that had a track record of producing good quality artefacts. In contrast, this emphasis on cultural capital was not evident in the case of Organization B. Instead, trust seemed to be based on social capital, and social capital was portrayed to be more important than other forms like economic capital:

> *Like I could get on the phone to any one of my suppliers and if I'm in trouble or I've made a mistake they will get down in the trench with me and help me. Whereas if you burn relationship chasing the dollar you don't get that level of support, you're on your own, because obviously they haven't got that level with you.*

A second important question that can be explored in future research is the question of outcomes, or how different forms of trust actually shape specific behaviour. We are specifically interested in the types of *collaborative* behaviours that emerge from different types of trust. Trust and collaboration are not the same thing, since trust is a psychological state (Rousseau et al. 1998) while collaboration implies some form of interaction, hence it is enacted. This means trust can exist without being enacted in a collaborative relationship; and collaboration can be enforced by other means when trust is absent. Still, they are often linked in the sense that trust can facilitate and deepen coordinative activities (Kadefors, 2004). Our tentative findings suggest that relational trust appears to be accompanied by behaviours of accommodation, but these findings warrant deeper investigation. It is therefore worth exploring if different types of collaborative behaviours and arrangements can be linked to different types of trust.

5. Conclusion

In summary, theoretical work on trust has persistently showed that there are at least two forms of trust. However, attempts to understand the relative importance of one over the other in specific sections have been limited by simplistic conceptualizations. Furthermore, trust in the context of construction projects has not been explored extensively (Bresnen and Marshall 2000). This paper contributes to the small and growing body of work on trust in construction settings. It empirically explores calculus-based and relational trust in the context of two case studies. Our findings call into question the assumption that calculus-based trust tends to give way to relational trust over time. Instead, our analysis suggests that relational trust can have a significant role in the early stages of interaction between parties and that the movement between calculus-based and relational trust is a complex, non-linear path. Future work can explore the antecedents of various forms of trust using the Bourdivian concept of capital as a lens, as well as the behavioural outcomes that emerge.

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Part II: Constructing Commitment and acknowledging human experiences

3. Health and Safety
4. Organisations, Knowledge and Communications
5. Projects, Procurement and Performance
6. Users, Clients and Stakeholder Engagement

Rethinking the link between public engagement and project success

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Abstract

The practice of engaging the public in decision-making during the planning or development stages of construction projects has become prevalent around the world in recent years. This is especially true of government projects, where the end users, and hence the people affected the most, are members of the public. A strong theoretical link exists between public engagement and successful planning, drawn from democratic theory. The same cannot be said for links between public engagement and project management. From a project management perspective, public engagement practices are often justified as a deterrent against public protests which may lead to bad press, political upheaval, and possible eventual frustration of the project. The success of public engagement then is linked to how it might enhance the possibility of success for a project, using whatever metrics by which project success is usually measured. While this view has been useful in its application in numerous studies, conceptualising public engagement in this manner also has its limitations. This paper critically evaluates the theoretical assumptions that have been used to establish the dominant view of public engagement as a risk management exercise strongly linked to project success. In doing so, we propose an alternative way of conceptualising public engagement, which views public engagement as a phenomenon decoupled from project success. An argument is made for accepting the uncertain nature of public engagement processes and placing emphasis instead on how events change and develop over time.

Keywords: Public engagement, project success, project governance, processual research, phenomenology

1. Introduction

In recent years, public engagement has become more commonplace, allowing for the public to be involved in decision-making activities that have formerly been regarded as strictly state-related. Examples of the mechanisms that facilitate public engagement include lay membership on science committees (e.g. Irwin *et al*. 2012), citizens' juries (e.g. Rowe *et al*. 2005), and consensus conferences (*ibid.*). Within the built environment, the mechanisms deployed include the distribution of community surveys and the organisation of focus groups (e.g. Legacy 2012). The moral rationale for engaging with the public is particularly salient for public sector projects, such as urban development projects, since a large proportion of the end users will be members of the public.

As the nature of urban development projects involve transforming conceptual designs into physical built forms, public engagement in this context tends to focus on collecting opinions that may be transformed into design solutions. The questions asked tend to be of a quantifiable nature, such as: How high? How dense? What sorts of land-uses? These types of feedback have to be incorporated into the project as it is being actualised, so the timeframe for public engagement process needs to work in parallel with the overall project. As such, public engagement issues are also project management issues.

The literature on public engagement tends to be more established in planning studies than in construction management studies, perhaps due to the strong philosophical link between planning and democratic theory. From a policy level, planning is seen as an activity of the state, so garnering public interest legitimises these activities. Hence, the public interest has been established as a criterion for evaluating planning and the various policies, projects and plans that are produced as a result of planning processes (Alexander 2002). These same planning and design activities may also be validly viewed as project management activities as part of the development life cycle. Yet the argument linking public engagement to projects in management studies is less congruent. From a project management perspective, public engagement practices are commonly viewed under the rubric of stakeholder theory. The activities are often justified as a deterrent against public protests, which may lead to bad press, political upheaval, and possible eventual frustration of the project. Thus, the success of public engagement is linked to how it enhances the possibility of success for a project, using whatever metrics by which project success is usually measured. However, as this paper will strive to demonstrate, the link between the public engagement and project success concepts are not robust enough to substantiate such a claim.

The aim of this paper is to critically evaluate the theoretical assumptions that have been used to establish the dominant view within construction project management, and assess their robustness. We begin by deconstructing the definition of 'public engagement', using the typology set up by Rowe and Frewer (2005) as our point of departure. An overview is then given of how public engagement is commonly depicted within project management literature, with particular focus on stakeholder theory. The assumptions connecting effective public engagement to project success are laid out and explored systematically, first by investigating what is meant by project success, then by assessing what, if any, causal relationships can be established between the two constructs. We then draw attention to the characteristics of temporal dynamism inherent in public engagement and how this influences the way it may be studied. We posit that focus needs to shift from how public engagement affects project outcomes to how it interconnects with project management processes. We conclude with suggestions of how public engagement should be studied in future.

2. What is public engagement?

The notion of involving the public in the decision-making of governments is in large part driven by the democratic ideal that deems it desirable to promote open discussion between private citizens and the state, within what Habermas would term the 'public sphere' (Habermas 1974). From this democratic ideal, the movement for 'citizen participation' was borne. Arnstein's (1969) seminal work on 'the ladder of citizen participation' remains a cornerstone for the movement, and for debates in the field on how efforts of involving the public should be judged to be sincere rather than tokenistic. In brief, her 'ladder of citizen participation' posits that engagement and participation with the public should aim to lead to a redistribution of power, and that different levels of participation progressively allow for this transfer of power to take place. The various strategies that have been used to put these ideas into practice have operated under a variety of terms, including 'community consultation', 'civic engagement', 'public engagement' and 'public participation', although there is a tendency to favour the term 'engagement' over 'participation' in recent times (Delgado *et al.* 2011). For the sake of consistency, we shall throughout this article use the term 'public engagement' (cf. Rowe and Frewer, 2005).

In their meta-literature review, Rowe and Frewer (2005) identified three main aspects of public engagement: public communication, public consultation, and public participation. These three forms of public engagement mechanisms hold distinctive properties that need to be considered separately when the question of effectiveness is raised for public engagement. In general terms, public communication entails the process of the project owner distributing information to the public, without any effort to collect opinion or feedback in return. Public consultation entails a process initiated by the project owner to collect and record information from the public, without any specific obligation to act upon or deal with this information. Public participation involves information exchange between members of the public and the project owner. A certain level of dialogue, usually in a group setting, is required for information exchange to occur. During this dialogue, each party is allowed time to respond to whatever information might be tabled, which may lead to one or both parties to change their opinions over time.

The comprehensiveness and representativeness of the typology described above may, of course, be debated further, but for present purposes it suffices in forming a working definition. Broadly speaking, 'public engagement' refers to any number of processes which allow the public to participate in decision-making processes; whereas 'public engagement mechanisms' are more specific, and involve mobilising mechanisms to facilitate an open dialogue between parties that enables the privilege of decision-making to be shared. Several distinctions do, however, need to be highlighted. Firstly, the three elements of 'communication', 'consultation', and 'participation' need to work together for the public engagement to have any merit. Secondly, there is an implicit chronology promoted in the definition, namely, that the public first needs to be informed with the relevant facts, then given the chance to discuss the matter at length, and then given time to digest the matter and give their feedback. The project owner, on their part, needs to prepare adequate and appropriate information for dissemination, spend time to communicate this information with the public, collect any views the public may have on the information presented, and be open to discussions that may serve to change their opinion of the project. Additionally, viewing public engagement as a chronology of events means that the time spent between the stages of communication, consultation and participation is a critical component in the engagement process. Participants are explicitly given time to reflect on the project and to give comments and feedback in due course; and the project sponsors must allow time to digest, analyse, and make changes to the program accordingly.

Finally, it should be noted that the underlying assumption for public engagement is that the feedback from the public has a chance to be taken on board by the project owner, although the extent to which feedback could (or should) be integrated is difficult to quantify. If project details are already settled before public engagement commences, with no intention of change, then the exercise will not meet the definition of public engagement. The public participation component will be missing, meaning that it will be public communication and consultation at best. This position aligns with Arnstein's view of 'citizen participation', which aims to redistribute power from the government to the individual citizen. Hence, the 'citizen' must have an avenue to affect the outcome of a decision for the process to claim to be genuine (Lane 2005).

3. Public engagement from a management theory perspective

From a management perspective, stakeholder theory is often used to explain the relationship between the various parties involved in a project. The commonly accepted definition of a stakeholder is "any group or individual who can affect or is affected by the achievement of the organisation's objectives" (Freeman 1984: 46). It follows that a project will have a variety of stakeholders, such as the shareholders, the staff, external governing bodies, and other parties that are not directly connected to the project, but who nevertheless have a stake in its outcomes. The project management literature commonly recognises the wider community as external stakeholders to the project (e.g. Moodley *et al.* 2008; Smyth 2008; Walker *et al*. 2008).

The literature on stakeholders can be classified as being normative, descriptive, and instrumental. It is normative because it acknowledges that stakeholders have legitimate claims on project goals and consequently, their interests have normative validity. It is descriptive because it provides a model of a corporation which describes the network of entities within it. It is instrumental as it allows for the examination of connections between the practice of stakeholder management and the achievement of various critical performance goals (Donaldson and Preston 1995). Extensive effort has been exerted to determine how stakeholders should be identified and how their influence to the organisation may be ranked or judged. For example, Mitchell *et al.*'s (1997) stakeholder saliency view, which is based on resource dependency theory, posits that resources within an organisation is limited and, thus, the resources used to manage stakeholders need to be prioritised. In this manner, any groupings of stakeholders may be sensibly ranked according to their salience, which is determined by assessing their power, legitimacy and urgency in relation to the organisation. Stakeholders who are demonstrated to be more salient should then be given priority in having their issues addressed (*ibid.)*.

In the construction management literature the main focus when dealing with external stakeholders (including the public) seems to be how to manage them in order to minimise the adverse effects they may have on the organisation, or on the project. The key assumption for the application of stakeholder theory is that stakeholders have intrinsic value and the ability to affect the outcomes of the project. Hence, the appropriate management of stakeholders will impact on project success. A large number of studies have in this fashion advocated the use of stakeholder theory for engaging with the public (e.g. Hillman and Keim 2001; Olander 2007; Olander and Landin 2008; Yang *et al.* 2011). It is commonly argued that the effectiveness of stakeholder management can directly influence the success or failure of a construction project (e.g. Bryson 2004; Kolk and Pinkse 2006; Rowlinson and Cheung 2008). The dominant perspective is that the deployment of public engagement mechanisms is closely tied to the enactment of appropriate stakeholder management strategies.

4. Relationship between public engagement and project success

Despite its recent ubiquity in management studies in general, and construction management in particular, it would do well to note that by itself stakeholder theory does not have any predictive power of how stakeholders may behave. It also rarely addresses how the relationship between stakeholders and organisations develop over time (Friedman and Miles 2006). Problems further arise when attempting to apply the standards of project success, which are commonly used to study stakeholder management activities, to study public engagement mechanisms. Firstly, quantifying project success is not straightforward and is contingent on a number of issues, few of which have direct relevance to public engagement. Secondly, the link between project success and public engagement is tenuous at best. Thirdly, studying public engagement retrospectively confines it to be viewed as a product or an object. As public engagement is meant to encompass public communication, consultation and participation, it would be more appropriate to view it as an ongoing process. The following section expands upon the above argument and proposes an alternative method for studying public engagement.

4.1 Measuring project success

There are numerous models for examining and measuring project success; the most well-known of which is the 'iron triangle', coined by Martin Barnes in 1969. The 'iron triangle' places 'cost', 'quality' and 'time' at the triangle's apexes, indicating that a successful project should be on budget, on time, and of a good quality. Its relevance in the modern era has, however, been repeatedly contested. In particular, how it ignores aspects relating to 'people' and how different stakeholders are likely to view success in different ways (cf. Atkinson 1999; Vahidi and Greenwood 2009), and how success is best judged by the primary sponsor (Turner and Zolin 2012). Of particular importance to this line of argument is that stakeholders' attitudes toward project success are likely to change as the project progresses. Or in other words, how success is assessed is time-dependent (Shenhar and Dvir, 1997). For example, Shenhar and Dvir (2007) propose a model of project success that is based on five dimensions judged over different timescales: project efficiency; team satisfaction; impact on the customer; business success; and preparing for the future.

Furthermore, what it means to successfully manage a project, which only considers factors leading up to a project's completion, may be markedly different compared to how a project might be considered successful afterwards. To this end, some scholars have made efforts to distinguish between 'project management success' and 'project success' (Cooke-Davies 2002; Munns and Bjeirmi 1996). A similar argument could be applied to stakeholder management. The successful management of project stakeholders have different implications when comparing long-term benefits, such as business growth and continuity, to shorter-term goals such as client satisfaction and project performance (Rowlinson and Cheung 2008). However, the stakeholders usually referred to in this line of argument are internal stakeholders, i.e. those whose own interests largely align with the intended project outcomes. The same cannot be said for external stakeholders. Due to their proximity to the management and control of the project, as well as their dispersed nature, it is unlikely for all of the interests of external stakeholders to align with the intended project outcomes. At times, the two are in direct conflict with one another. In these cases, the successful management of stakeholders may not lead to long-term benefits for the organisation.

4.2 Relationship between public engagement practices and project outcomes

As alluded to above, there is often a direct clash between the goals of public engagement, and the goals of the project. This is unsurprising, given that the main goal of public engagement is citizen empowerment, whereas the goal of a successful project is the accomplishment of critical success factors for the owners of the project. Acknowledging this clash, some choose to view public engagement as part of a risk management strategy (e.g. Loosemore *et al*. 1993). The main argument put forward is that the failure to manage a project's external stakeholders can lead to the mobilisation of community based protests, which in turn can indefinitely delay or frustrate the project (e.g. Teo and Loosemore 2011). The proposed solution is a conflict management approach that essentially sees the public as a risk to the project, which needs to be managed, suppressed, and minimised. At times this might well be convincing, but the connection between the mechanisms for public engagement and conflict management is by no means clear. The tendency is to assert that public engagement will lead to minimised conflict for the project, without giving reasons as to how this might occur. The literature on public engagement is equally insufficient in support for a causal relationship between an increase in public participation and a corresponding decrease in participants' conflict with project goals. In the cases where it is brought up, conflict management usually refers to managing conflict within discussion groups to facilitate fruitful discussions in order to garner useful feedback. There is, as such, little focus on how to minimise the animosity participants may hold towards the project.

The question then becomes what the rationale for assuming that an increase in public engagement will lead to a decrease in animosity towards the project is. We can think of three lines of argument that goes towards supporting such a link. The first builds on the 'deficit-model' approach to decision-making, where public disagreement with official proposals are caused by sheer ignorance or misunderstanding of the technical details of projects (Rowe *et al.* 2005). The second relates to the 'consensus-building model' approach to decision-making, where project goals are defined and advanced collaboratively between stakeholders and project sponsors (Innes and Booher 1999). The third argument relates to 'trust-building' with the view that successful public engagement should lead to increased levels of trust between the public and project sponsors (e.g. Tsang *et al.* 2009).

Our response to each of the three arguments are as follows: The first argument relates to successful public communication rather than public engagement. The second implies a shifting of project goals, and hence a reassessment of critical success factors, rather than a risk management strategy established to meet certain project goals. Accordingly, both causes are inadequate for justifying public engagement as risk management strategies in project management. As for the third argument, we postulate that the complexities in optimising engagement efforts coupled with the imprecise underlying definitions of 'trust' dimensions means that a link between the two concepts cannot be readily established (cf. Petts 2008).

4.3 Dynamic and uncertain nature of public engagement

Studying and theorising around public engagement is by no means a trivial affair. Public engagement undergoes continuous change through time in response to shifts in the environment, which makes predicting its outcomes difficult. Deploying public engagement mechanisms involve preparing information for dissemination, active discussions with participants, collecting feedback from participants, and careful analysis of the feedback collected. The mechanisms have time sequences in-built explicitly for this purpose. Hence, it would be most appropriate to view it as an ongoing process. During this process, opinions are formed, developed, and morphed as information is presented; as time is allowed for reflection; and as discussion with other participants ensue. Yet, academic discussions have tended to focus on 'efficiency', 'success', and 'optimisation' (Rowe and Frewer 2004), which places emphasis on the results of conducting public engagement, rather than the practices of doing engagement. This predominately results-oriented approach necessitates studying public engagement in hindsight, or at most, under fairly simplistic temporal notions of 'before', 'during' and 'after'. The alternative is to view public engagement as a dynamic and complex phenomenon and acknowledge that a myriad of relationships are formed and disbanded in the process; and that these relationships, in turn, can affect future events. Of course, the tendency to focus on results is not confined to public engagement or stakeholder management. Recent years have, also, seen increased calls for a pluralistic approach to project management that similarly incorporates process research (Söderlund 2011). This means studying the project during different phases of its lifecycle and acknowledging projects as temporary organisations with evolving behaviours and goals.

5. Implications for future research

Having deconstructed the way public engagement is studied in the construction management literature, and the inherent problems of linking it to project success, the onus is now to offer an alternative conceptualisation. It would seem that part of the difficulty in merging public engagement with management theory has been the inability to rationalise public engagement in such a way that it bears clear associations with established constructs within management theory. Another problem seems to be the tendency to neglect the temporal dimensions of public engagement when exploring its impact both within its own system, and on other systems with which it comes into contact.

To address these problems, we posit that instead of trying to rationalise public engagement by finding specific connections to project outcomes, attention should be focused on understanding the public engagement process. This would shift attention to uncovering insights that lead to discovery of underlying connections between public engagement and project management processes. That is to say, it places more emphasis on the processes of managing the public as stakeholders to the project, rather than on how specific types of interaction will impact on project outcomes. The starting point would be to study public engagement as a phenomenon rather than as a means to an end, and to embrace its processes for all its dynamism, multiplicity, complexity and subjectivity. With this goal in mind, three major characteristics of public engagement are presented below.

5.1 Public engagement events attract a loose membership of participants

Public engagement for urban planning projects are exemplified by the inclusion of a large cohort of stakeholders, who break from their usual living routines to come together to discuss a particular project, within a specific and well-defined timeframe. Because many of the events are open to the public, participants may come and go as they please. For many of the open forums, there is no pre-requisite for attendance apart from pre-registration, and someone who participates at one event may not necessarily return to the next. Closed door discussions and focus groups may be more selective in its membership, but individuals may still opt to attend events out of sequence, or may become involved with the discussion at a later stage than the majority. Hence, membership within the public engagement process is changeable and eludes definition, and involvement is contingent on presence and participation. Each member who interacts with the project impacts it in different ways and to varying levels of depth, magnitude, and permanence.

5.2 The public engagement process is subjective and value-laden

All individuals enter the sphere of engagement with their own agendas. A participant may merely be curious about the project and wish to obtain more information. Alternatively, they may be personally affected and have a personal stake in the design, or may wish to lobby on behalf of a collective for certain facilities to be provided in the local vicinity (or conversely, to be removed from the vicinity). These ulterior motives are unique to each individual and will colour how they interact with the process. Similarly, project owners, as well as their technical consultants, also carry ulterior motives and it is worth noting that the value judgements held by owners and consultants, in themselves, have no greater inherent validity than those held by laypersons (Rowe *et al.* 2005). Accordingly, public engagement processes can never be value-free.

5.3 The timeline for public engagement differs to the timeline of the project

There is a temporal mismatch between the public engagement and the project design period, such that what may be achieved during public engagement exercises may be restricted by the information available about the project. For example, if the participants' estate has been earmarked to be demolished to make way for new development, their most likely concern would be the amount of compensation they can receive, and where they will be relocated to. However, the project owner will not be able to provide them with this level of information if they are still in the plan-making stage. Similarly, a hypothetical new development, which may bring vibrancy to the area and bring relief to the shortage of housing and/or employment opportunities, will target to benefit a population that does not yet exist and, hence, is unable to represent its interests at public engagement events. Conversely, those who are presently affected will dominate the proceedings. In these types of scenarios, which are by no means uncommon, consensual decision-making is unlikely to ever be reached, and support for the development are unlikely to be garnered.

6. Concluding remarks

The three observations above sketches out the framework within which public engagement operates, and gives an indication as to the difficulties of managing such a process. Some of these problems might benefit from the application of management theory. Indeed, early on in the paper we pointed out that, because public engagement is conducted concurrently to the project, public engagement issues are also project management issues. We suggest that public engagement and project management theories have much to offer each other, so as long as the underlying assumptions for each are made explicit. Our point of challenge is in the connection between public engagement and project success, a link which has been established by viewing the public as external stakeholders who have the ability to influence a project's outcome.

The dominate view within project management has been to conceptualise public engagement within a stakeholder theory framework. Using stakeholder theory necessitates placing external stakeholders, such as the public, on the periphery of a project. Conversely, the complex nature of public engagement as described supports the premise that these processes constitute complete ecosystems in their own right. Focussing on the complications and idiosyncrasies of these ecosystems, rather than on how public engagement influences project outcomes, frees us from needing to constantly reference it in respect to the project. This in turn allows us to make better sense of the interfaces between public engagement and the project through time and through the eyes of different stakeholders. Accepting the uncertain nature of public engagement processes, and placing emphasis instead on how events change and develop over time, allows us to understand public engagement as a phenomenon that is decoupled from project success.

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Consensus building in the pre-design phase of building projects

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Abstract

Building projects are unique manoeuvres in which numerous participants who possess different skills work together to complete various tasks. Working processes vary in complexity from simple to very complex. Although the building construction sector has traditional ways of structuring projects, project management professionals are continuously seek new process models and ways to cooperate between people and project participants. This paper focuses on processes in the pre-planning phase of a building project and is based on exploratory study where the conceptual and empirical literature about construction processes and decision-making were reviewed. Over thirty existent models were identified and thirteen of these models, which take a decision making into account, were more closely studied. In addition, decision-making models in other fields were surveyed. Using a hermeneutic cycle approach, the aim of this paper is to investigate a preferable model for the pre-planning phase of construction projects that can produce the main objectives, which is to best serve the end user and the project as a whole. As a final result a new model in the case of the pre-design phase of the building process is introduced and discussed. This paper asks what we have learnt from these foci.

Keywords: consensus building, target setting, decision-making, construction project management, pre-design phase

1. Introduction

For a typical building project, many stakeholders work together to set goals and to design and construct a complicated product that is somehow unique. What results is a combination of numerous actions and their interplays, both planned and accidental, that are produced among temporary participants in a constantly changing environment. Overall, building projects are becoming increasingly fragmented and more challenging to manage.

During the pre-design phase of construction projects, decisions are made that have fundamental and far-reaching effects on the product's appearance, performance, and costs. The pre-design phase begins with assessing the initial needs and continues to the schematic design phase, when a project's greatest assets can be added or left aside. In the pre-design phase, each participant in the building project has unique involvement and represents various desires for the project and final building. Those participant needs and requirements do not always coincide. In this type of environment, decisions are not easy to make. Too often, important decision-making is dispersed in a hierarchical manner, with local optimisation procedures hindering the achievement of high-value results (Kähkönen et al., 2013). Decision-making is the process by which organisations are structured and restructured. The variables to be considered are often uncertain, and decisions are constrained by incomplete or missing information. According to Hirokawa and Poole (1996), a group's decision-making process is much more than simply making decisions, as it includes information sharing, socialising, relating to both people and groups external to the group, educating new members, defining roles and status within the group, meeting rituals, and various physical activities.

The aim of this paper is to investigate a preferable model for the pre-planning phase of construction projects that can meet successfully the main objectives, which is to best serve the end user and the project as a whole. Conceptual and empirical literature about the process of construction and decision-making was reviewed. Over thirty existent models were identified and thirteen of these models, which take decision making into account, were more closely studied. In addition, decision-making models in other fields were surveyed. The study is using a hermeneutic cycle approach (Ramberg and Kristin, 2005), going through five deepening cycles to approach a deeper understanding. The acquired information was analysed and synthesised to find preferable decision-making processes for a building project's pre-design phase. In the context of the pre-design phase, a new decision-making model is introduced.

The rest of the paper is organized as follows: in section two the approach and the aim of the research have been presented including selection criterion for the final decision making model for pre-design phase of building construction projects. Section three introduces briefly twelve studied existent models for the pre-planning phase of construction. Section four presents a new decision-making model in the context of the pre-design phase as a result of used method. The discussion and the reasoning from the topic have been shown in paragraph five. Conclusions are drawn in section six.

2. Research approach and aim

The research is conducted by using a hermeneutic cycle approach and utilising literary research. The structural model for the cycles of iteration was a reducing spiral. Each iteration builds on knowledge from the previous cycle. In our study, it was possible to detach five deepening cycles in a hermeneutic approach to achieve a deeper understanding: to seek a model or approach that improves the target setting in the construction pre-planning phase, to define a theoretical approach, to recognize the existing models and those used in other fields, and to analyse and synthesise the results.

The aim of this research is to investigate a preferable model for the pre-planning phase of construction projects. The criteria for literature search were created as a result of the hermeneutic process. The following criteria were used: 1) the decision-making model can produce the innovative main objective, which is to best serve the end user and the project as a whole; 2) the know-how of all participants is obtained to support decision-making; 3) a systematic process for decision-making is used; and 4) an integrative method is used to control the fragmented building process.

Conceptual and empirical literature about the process of construction and decision-making were the main sources for understanding current practices and models behind those. Over thirty existent models in the pre-design phase of the building project were identified. Thirteen models which take a stand on the decision making were examined more closely. These models are shortly introduced in section three. In addition, potential decision-making models in other fields of industry were surveyed. In the context of a pre-design phase of a building project, decision-making model to determine the objectives was selected and it is presented in section four.

3. Concepts supporting decision making of a building project in the pre-design phase

Various concepts, models and systems can be used in the pre-design phase of a building project. Theoretical and practical concepts have been created to support decision making, albeit the decisions are usually made without using the existing concepts. Thirteen of existing concepts are shortly described.

Many concepts are based on comparison and evaluation of alternatives. Analytical Hierarchy Process (AHP) is a multi-criteria decision technique which is used as a base for many other concepts. It is a numerical approach which includes identifying the objectives, criteria and alternatives into a hierarchy, pairwise comparison, evaluation and the synthesis (Saaty and Peniwati, 2008; Mahdi and Alreshaid, 2005). Non-structural fuzzy decision support system (NSFDSS) is based on AHP and it helps decision making especially with complex construction problems (Tam et al., 2006). Decision support concept (DSC) is an application of multi-criteria method for decision making at the planning phase of construction (Janac et al., 2013). On-line system for construction (OLSC) is a multi-criteria method for analyzing various construction alternatives by taking into account economical, qualitative, technical and other issues (Kaklauskas et al., 2007).

Some concepts like quality function deployment (QFD) (Govers 1996; Kamara et al., 1999) and client requirements processing model (CRPM) (Kamara et al., 1999) help to improve the processing of clients' requirements in construction. Also the Generic Design and Construction Process Protocol (GDCPP) aims to figure out the client's needs at the pre-project stage. The Generic Design and Construction Process Protocol is a model which considers interests of all the parties involved in the construction project. The GDCPP is divided into subphases and the preconstruction phase concern especially the definition of clients' needs. (Kagioglou et al., 2000.)

Some concepts clarify stakeholders' roles and responsibilities in the early phase of project. Fuzzy Similarity Consensus Model (FSC) clarifies the roles and responsibilities of construction project owner and contractor project teams at the project initiation stage. The purpose of the model is to reach common agreement of stakeholders' roles and responsibilities. (Mohamed 2011.) The CPR System Models can be used to present the various parties' responsibilities in the project (Kartam and Ibbs 1996). Alliance is a project delivery strategy which aims to positive outcomes for all the alliance members by sharing the commitment to common project goals (Walker et al. 2002).

Schematic Design In A Day (SDIAD) is a process which is successfully used at project inception and schematic design phase. All members of the project together contribute, typically during a one day, the planning of the incoming construction project. (Miles 1998.)

Building information modeling (BIM) is a 3D-model which is a visualization tool and can contains information of quantity, costs, energy analysis, collision checking and more (Hessedal and Berglund 2012). The BIM can be used from early design phase to construction and also as a management tool. IDEF0 is a method for modelling the decisions, actions and activities and the functional requirements. The model is a graphical diagram where the series of presented hierarchical activities. (Bouchlaghem, Kimmance and Anumba 2004).

4. Consensus building

The consensus building approach has been developed as an alternative to parliamentary decision-making (Susskind and Chruikshank, 2006). Carpenter (1999) has argued that consensus decisions are suitable when a problem affects several parties, a clear solution is not available or when parties disagree with the solution. This method helps participants better understand an issue and the other parties involved and helps them find the solutions that are in the best interest of the whole. Consensus building is a process that enables various stakeholders to work together by helping participants to examine things in new way, which provides an opportunity for innovating and resolving issues (Innes, 1999). With this approach, parties aim for united and overwhelming agreement that is based on informed decision-making (Susskind and Chruikshank 2006). The use of consensus building requires certain things, such as all parties willingness to negotiate. The design of consensus building is commonly initiated by a neutral party, the group of participants, or other interested parties (Carpenter, 1999). The process itself is time-consuming, which is particularly relevant in matters of contention and uncertainty, in which all participants have incentives to find mutual reciprocity that is in accordance with their interests (Innes, 2004).

Consensus building has roots on practices and theories related to interested bargaining (Innes 2004). It is reported to have been utilised in many fields, such as urban planning (Balducci, 1999; Edelman, 2007), budgeting (Baiocchi, 2001), affordable housing (Susskind and Podziba, 1999), environmental management (Regan et al., 2005), health (Hughes et al., 1999; McKearnan and Field, 1999), regulatory negotiation (Ryan, 2001), water resource management (Connick, 2003), Growth management (Innes et al., 1994), international relations (Susskind et al., 2002), and several other fields. Although there have been attempts to make decisions based on the consensus in the construction pre-design phase, consensus building is not seen employed as a theoretical model in this context.

4.1 Benefits and criticism of consensus building

Consensus building can aid participants understand issues of importance, the values of other parties involved, and offeran opportunity to create a shared vision, values, and action. (Innes, 1999). The most important benefit is that using a consensus building process increases the quality of the solutions developed by the parties. This is the outgrowth of a comprehensive analysis of the problem (Gray, 1989). Because participants have different perspectives, more standpoints are considered. A variety of perspectives may lead to more innovative solutions (Gray, 1989; Innes, 1999). Consensus building guarantees that all parties' interests will be protected (Gray, 1999). In the process, participants make final decisions themselves, thus providing all participants with the opportunity to ensure that their interests are represented in the agreement. In the consensus building process, people who are most familiar with the problem are able to participate in solving it. The ability to participate in the problem-solving process also enhances the participants' acceptance of the solution and willingness to implement it. (Gray, 1989.) The participatory process also can foster greater group cohesion and interpersonal connection (Gray, 1989; Hartnett, 2011). As a result, participants have ownership of the outcome of consensus building processes.

Additionally, criticism has been presented concerning the use of consensus building. Consensus building is claimed to be a time-consuming process, but it is a common problem that some participants do not have the time, vitality, or authorisation to commit to this type of process (Yaffee and Wondolleck, 2003). In collaborative administration, one commonly noted problem is a power imbalance between participants (Short and Winter, 1999; Tett et al., 2003; Warner, 2006). Notably, it is problematic when crucial participants do not have their aspects of organisational infrastructure represented in collaborative processes. In some cases, the problem is that organised participant groups do not represent single participants collectively (Buanes et al., 2004) or that some participants do not have the expertise to take part in deliberations about technical problems (Gunton and Day, 2003; Lasker and Weiss, 2003; Murdock, Wiessner, and Sexton, 2005; Warner, 2006).

4.2 Models for Consensus building

The design of consensus building is commonly initiated by a neutral party, a group of participants, or other interested parties (Carpenter, 1999). There are multiple stepwise models for making decisions by consensus, each varying in the amount of detail provided for each step and the ways in which decisions are finalised. This paper introduces two consensus building models.

Strauss's (1999) consensus building model begins with the problems and issue and works toward a shared vision of the future using the following steps: star-up, process design, go/no go, consensus building, and implementation. These phases are introduced in figure 1.

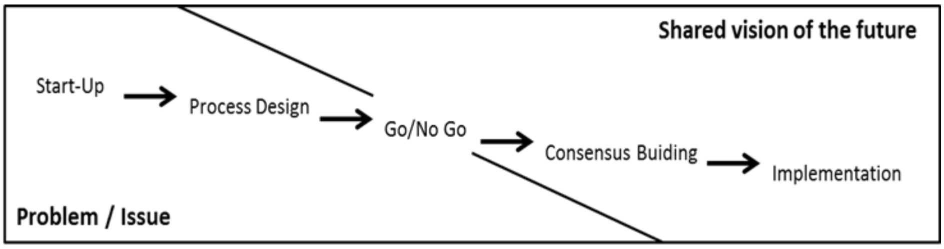

Figure 1. Stages of Consensus building (adapted from Strauss, 1999)

The "start-up phase" begins when some of the initial participants acknowledge that the problem is beyond the decision-making authority of a single participant and decide to explore the possibility of a collaborative decision-making process. Next is the "process design phase", where the assessment of the problem or issue plays a central role. This phase also involves determining who should be involved and how to proceed. After the first two phases, participants must decide whether to commit to a consensus building process, which is the "go / no go phase".

In the "consensus building phase", participants convene in a series of meetings. It is common that these meetings are mediated or facilitated by a third party. The consensus is built step-by-step, from creating a common understanding of a problem or issue to coming to an agreement about a solution. The "implementation phase" is the fulfilment of the agreement. Implementation is often performed by a single organisation; however, participants may want to monitor implementation to ensure that an agreement is precisely and effectively carried out.

Susskind's (1999) definition of the consensus building process differs from Strauss's (1999) analysis, though only slightly. In Strauss's model, the "process design phase" includes a conflict assessment, whereas in Susskind's model, assessment is included in the actual consensus building process, which may or may not continue after the first "convening phase". One interpretation of Strauss's model could be that the initial participant or participants go through a preliminary process design phase and decide whether it is necessary to begin a wider discussion at all (Edelman, 2007).

Similar to Strauss, Susskind (1999) sees the consensus building process as a five-step model: convening, clarifying responsibilities, deliberating, deciding, and implementing agreements. The essential steps of Susskind's consensus building model are shown in figure 2.

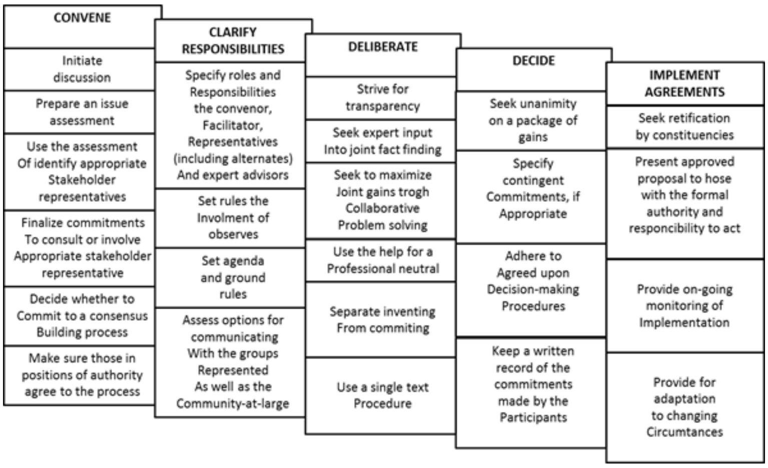

Figure 2. Susskind's essential steps of consensus building (Adapted from Consensus Building Institute, 2004)

The first step of Susskind's (1999) consensus building is convening, which means embarking on a discussion about whether to use a consensus building process. Typically, this is triggered by a key participant or interest group. The convenor or group of convenors must identify the first round of participants and the neutral mediator who will consider a consensus building process. After the initial mapping of interests, the first-round participants should be asked to name others who might be affected by the decisions and should be considered participants in the process. Accurate participant commitment and assessment of interests lead to singular summaries of participant conclusions concerning the issue. The activity associated with convening is the preparation of a written conflict assessment. The conflict or issue assessment is prepared by the neutral mediator, and it has two rationales: it maps the interests of all participants and helps identify other possible participants who may be affected by future decisions. The successful creation of an acceptable conflict assessment can lead to organising the consensus building process. Towards the end of convening, a decision is made to commit to the process.

After the conflict assessment and the decision to proceed are completed, the next step is specifying roles and clarifying the responsibilities of all participants. The round rules must be established and attached to final conflict assessment. Typically, the round rules define the general rights and responsibilities of participants, decision-making processes, meeting procedures, communication, ways to handle disagreements, and approaches to implementation of the agreement. All participants are required to sign the round rules.

The purpose of deliberation is to achieve collective gains through the collaborative construction of solutions and alternatives. Deliberation is the opposite of positional hard bargaining. The approach is based on unconditional reciprocal problem solving, even in the face of strong differences and personal antagonism. The consensus building should be transparent in all phases of the process, and the participants should be encouraged to actively listen to ensure that all communication is properly understood.

In a consensus building process, voting is not a primary decision-making method. The aim of the decision-making phase is to maximise mutual advantages without omitting any value-adding solutions. The significant parts of decision-making are to ensure the maximum joint gains of the whole and confirm that all who are affected by the decision can live with it. All available efforts are made to ensure the fulfilment of as many interests among the participants as possible. Consensus building is designed to achieve unanimity within the mutually agreed-upon schedule. In practice, decisions are considered complete when overwhelming support is achieved.

Once the decisions have been reached, the implementation of an agreement may be ratified by all participants and their constituents. The agreement should indicate how the implementation will be monitored and enforced and should provide a process for resolving conflicts that might arise.

5. Discussion

The complexity of construction and the fragmented nature of the construction industry have effectively resulted in linear, uncoordinated, and highly variable project processes, thus making cooperation challenging. Different interest groups of a building project have different points of view about the production of a solution. End users are interested in solutions that support their activities. For the constructor, the building is an investment that must be profitable. A contractor is interested in time schedules, achieving the necessary quality level, and so on. Additionally, teams and individuals who have different skills, knowledge, and expertise but who may not have previously worked together make integration difficult to achieve (Baiden et al., 2006). Nonetheless, the know-how of every participant is needed, and the process must promote the special know-how of all participants and get them to cooperate with each other. Traditionally many operators do not have motivation to work collaboratively, as they promote benefits that maximise their own gains without considering the benefits of other participants. However, in the context of the construction industry, successful project delivery and performance depend on how individuals' knowledge and experience can be integrated as a team (Moore and Dainty, 1999).

In construction projects, decisions that have fundamental and far-reaching effects on appearance, performance, and costs are made in the pre-design phase. However, it is often a disorganised and poorly structured phase that does not clearly add value to the whole project. Many decisions are made using an ad hoc process that subsumes the differences of opinions within participant groups. The targets often remain vague or are not well understood by the entire project group. A decision that has been made in one sector can affect the solutions of several other sectors. In the pre-design phase, a project's greatest values can be added or left aside. The selection of the most applicable management model is critical when pursuing the best outcomes for customers and all participants.

Consensus building is an interesting alternative to top-down decision-making, which is commonly practiced in hierarchical organisations. Consensus building is an organised, group decision-making model in which participants develop decisions in the best interest of the whole project without fear that their interests are not protected. In the process, participants make the final decisions themselves, giving all participants the possibility to ensure that their interests are represented in the agreement. The organised process can aid participants understand the issue of importance and the values of other parties, and it provides an opportunity for innovating and resolving issues by helping participants examine things in new ways. The consensus building model, that includes and respects all parties and generates as much agreement as possible, thus settings the stage for greater cooperation when implementing the resulting decisions.

Consensus building is claimed to be a time consuming process. That can be problematic for some participants who do not have the time to commit to this type of process. However, decisions with fundamental and far-reaching effects on appearance, performance, and costs are made in the pre-design phase. If the participants fail to make fundamental decisions in the early stage of the project, their repair can prove to be impossible or very expensive in the later stages of the project. A pre-design phase must combine the needs and requirements of all participants into one joint project. A decision making model that can utilise the know-how of all participants and find the solutions in the best interest of the whole is highly important for the success of the project.

Although consensus building has not yet been tested in the context of construction projects, it provides promising elements to produce surplus value. Consensus building is an alternative to parliamentary decision-making, and it can be an interesting approach to value adding. Therefore, in the context of construction projects, an integrative decision-making method is needed.

6. Conclusions

In the context of building projects, decisions that have fundamental and far-reaching effects on appearance, performance, and costs are made in the pre-design phase. These decisions involve diverse groups and are often the most difficult to make. The different objectives and opposing views of the parties can prevent them from finding the best viable solution. This is particularly the case when group members have competing agendas, opinions, and different knowledge bases. Decisions are often achieved using an ad hoc process, which lacks a clear decision-making process that subsumes the different opinions within participant groups. Our study reveals that there is a clear need for the participants' early involvement in the decision-making process, which is able to embrace the project in question and its different objectives as a whole.

Consensus building helps participants understand an issue and the other parties, and it offers an opportunity to create a shared vision, values, and action (Innes, 1999). Consensus building has been widely used in many fields. This new process for the pre-design phase of construction can be helpful for maximising the full benefits of diverse knowledge among participants. It includes systematic steps to combines different parties and it can aid them to make decisions, which benefits the project as a whole. Consensus building can be value adding component of early pre-design decision-making. The next logical step is to adapt the model to the context of building projects and test it in action.

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Mechanisms for industry transformation: analysis of organisational citizenship behaviours in a design-production innovation

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Abstract

A well performing housing sector is critical to national economic and social objectives. The Australian housing sector is failing. Significant inefficiencies in the construction process has resulted in a 40 per cent increase in average construction time over the last fifteen years which has resulted in increased costs. The sector is in need of transformation. Our study on design production technology innovation suggests such a transformation is catalyzed by extraordinary leadership that enables integrated systemic solutions in an aggressive, risk averse and litigious industry. The role of exercising such leadership often emerges among housing developers. A challenge to these leaders is that the housing sector is highly competitive and aggressive and actors are motivated primarily by profitability. Such behaviors tend to be institutionalized and thus inhibit change. It is proposed that leaders can institute a major change initiative without compromising on organisational profitability. Large scale innovations require extraordinary levels of collaboration among key actors and it is speculated that they are led by champions who display unusual citizenship traits. This paper reports on a nationally funded 3 year study on offsite manufacturing and seeks to explore the prevalence of such organisational citizenship behaviour (OCB) in the housing industry generally, and in housing developers specifically. OCB is a complex phenomenon which arises when individuals voluntarily assist in the workplace to implement courageous and risky initiatives without either implicit or explicit reward for seeking to achieve this noble greater 'good'. There is a body of research developed on OCB and although theoretically there is support for the conceptual effectiveness of OCB in an organisation there has actually been little empirical evidence linking OCB with effectiveness and outcomes. Some examples have been trivial and there is work to be done to identify linkages between OCB and significant outcomes as well as linking different types of citizen behaviours to different outcomes. OCB has not been explored to a great extent theoretically nor empirically in the housing sector. There is nothing more risky in the housing sector than introducing new policies, procedures or practices that may erode an organisation's profitability and therefore trust in leaders is critical. Identifying the prevalence of this construct both theoretically and empirically will contribute to the field of housing research and also to the practice of leadership in the housing sector.

Keywords: *industrialised building, industry leadership, citizenship, opportunity management*

1. Introduction

The housing sector has always been seen as an important part of the construction industry and is considered a key indicator of the health of the Australian economy. The housing sector generally makes up 50% of the construction industry and in 2012 the construction sector represented 7.7% of the GDP of an economy (ABS, 2012). In Australia in 2009 the residential sector accounted for approximately $70b and from 2000-2009 the average was 47% of the total spend in the construction industry (ABS, 2010). It is a critical time in the Australian housing sector. "Australia's housing system is under acute stress (Yates 2008; Grattan Institute 2013).We were once a nation characterised by good housing for all and the Great Australian Dream, but we now have one of the most unaffordable housing markets in the world (NATSEM 2011), chronic housing undersupply (National Housing Supply Council 2013), a rapidly shrinking public housing safety net (SCRCSSP 2001 and 2013), substantial pockets of concentrated poverty and disadvantage in the private housing market as well as in the social rental sector (Hulse et al. 2012) . Each night more than 100,000 Australians are homeless (ABS 2012)." (Baker et al, 2015). The housing industry is failing to meet demand (NHSC, 2012) and when demand is met the housing is costly because of construction inefficiencies. The industry is faced with a crisis in our capacity to plan, design and construct to meet our nations needs unless we act immediately to improve its capacity for a more efficient, effective and innovative supply system. These inefficiencies have resulted in a 40 per cent increase in average construction time over the last fifteen years (Gharie et al, 2010) resulting in increased costs. Over the last twenty years housing affordability has worsened; with the number of homeowner purchasers with housing costs in excess of 30 per cent of income more than tripled (Wood et al, 2014).

Housing research in the past has focused on policy and planning problems as the way to address supply challenges (Holmes et al, 2008). To date the housing supply debate has been largely focused on housing demand, affordability and land supply. Lack of innovation in housing supply is considered a barrier to the sector's capacity to meet market demand (NHSC, 2012) and yet very little attention has been paid to challenges experienced by those involved in the design and construction stages of supply. One of the suspected overarching key causal factors of poor housing supply is the fragmented nature of housing supply with numerous actors involved with their own objectives. A lack of coordination and integration between supply chain actors can exacerbate barriers to innovation. It is proposed that a more cohesive supply chain would prove beneficial to all housing sector stakeholders.

It has been proposed that one strategy for achieving greater cohesion in the supply chain is through offsite manufacturing. Offsite manufacturing (OSM) is a production technique in which prefabricated components of a building are manufactured in a factory and transported to the site for erection and assembly and is one of the most significant innovations that is now emerging in the Australian housing sector. Key outcomes of OSM is improved quality design, reduction in time, productivity improvements, improved safety and wellbeing, reduced rework and thus overall improved housing affordability. However, OSM requires re-engineering of the entire project development process, since traditional construction is achieved mostly through on-site activities. When housing developers attempt such re-engineering for new ideas it also requires support from key stakeholders for example, government agencies to set up projects to ensure the right conditions for such an innovation – as well as designers and fabricators with a deep commitment to solving design, construction and production problems. Thus a key overarching constraint to uptake is that OSM is perceived to require extraordinary levels of collaboration (London et al., 2014). Introducing innovations such as OSM in construction processes and design production technology can thus effect revolutionary change. Such innovations can only succeed with impact as whole-scale industry transformations through leadership that catalyses the entire development chain. To enable such integrated systemic solutions in what is considered to be an aggressive and litigious industry requires extraordinary leadership qualities. Past research has shown that housing developers are the *linchpin* in the urban development chain; they can significantly influence housing innovations (London et al; 2014). This research will therefore explore:

What is the nature of transformative leadership behaviours in the housing development chain in large scale offsite manufacturing collaborative efforts?

This study is important to housing construction researchers and practitioners because there has been very little sociotechnical research on adoption and diffusion of technical innovations, which are critical to housing sector performance and thus to national economic outcomes and individual/ community well-being. The housing sector is significant in most countries and investigation of innovations that ultimately improves housing affordability is vital. It is universally accepted that a well performing housing sector is critical to national economic outcomes. Housing also affects us at individual and community levels and influences our wellbeing. We all have the right to safe, secure and affordable housing. This paper is part of a three-year national Australian Research Council study: "Efficient Construction: analysis of integrated supply chains on novel offsite manufacturing housing" which is seeking to explore collaborative practice in housing supply chains in Australia. Through our analysis and results from the first two case studies it has emerged that an examination of individual leader behaviours is important, as there appears to be a close link between large scale collaborative efforts in OSM and leader behaviours. For this paper, we focused on the construct organisational citizenship behaviours in the context of two detailed qualitative case studies.

1.1 Conceptual Model of Influences on Collaborative Practice

The role of champions in driving large-scale industry change cannot be examined as a phenomenon separate from the relationships they forge in order to accomplish such change. Therefore it is critical to understand the collaborative relationships that leaders forge in order to carry out industry transformation. A model shall help us to understand the nature of large scale collaborative efforts in theoretical and practical ways as a blend of underlying economic and social structure and individual behaviour. We shall explore collaborative activity across four dimensions:

- Collaboration and the nature of work: Work in construction involves project based work. Work may be unpredictable and volume of production may vary. Work in construction can also have very different outputs ie large scale complex projects that run for many years to small scale short term projects. OSM products and operations may still have to be flexible and responsive to project environments.

- Collaboration and the nature of individuals: Construction collaboration is focussed on performance ie time, quality, cost. However, the link between collaboration and performance measures is not simple. Collaboration achieves other outcomes- new products and processes, learning, power, better coordination and communication which are difficult to capture and quantify but often lead to more tangible outcomes. People invest in the collaboration act to achieve social, cultural, intellectual and financial capital. Such investment may involve trade-offs and failures and may not result in immediate success.

- Collaboration and the nature of markets: Collaboration takes place between organizations or between organizational units. Supply chains are embedded in a larger context shaped by institutional factors: economics, laws, governance, regulations, industry and societal culture. These 'institutions' create and recreate the 'rules of the game' ie the way things are done. The formal and informal dimensions of institutions and organizations and how these shape and are shaped by collaborative activities influences collaborative environments.

- Collaboration and the nature of systems: Collaboration in construction is a mixture of technology and social processes. There is a complex ecology of human and non-human elements. Collaboration should emphasize the role of people. It is important to examine how collaboration arises between people. However, material elements like products, IT systems, artefacts and equipment can play a critical role in collaboration as well.

Underpinning all dimensions of the model is the question of whether collaboration and competition are mutually exclusive. We suggest that there are creative ways to manage the tension between the two. We also suggest that collaborative practice more than likely both influences and is influenced by these four dimensions (see Figure 1). This paper focusses on the *nature of individuals* dimension

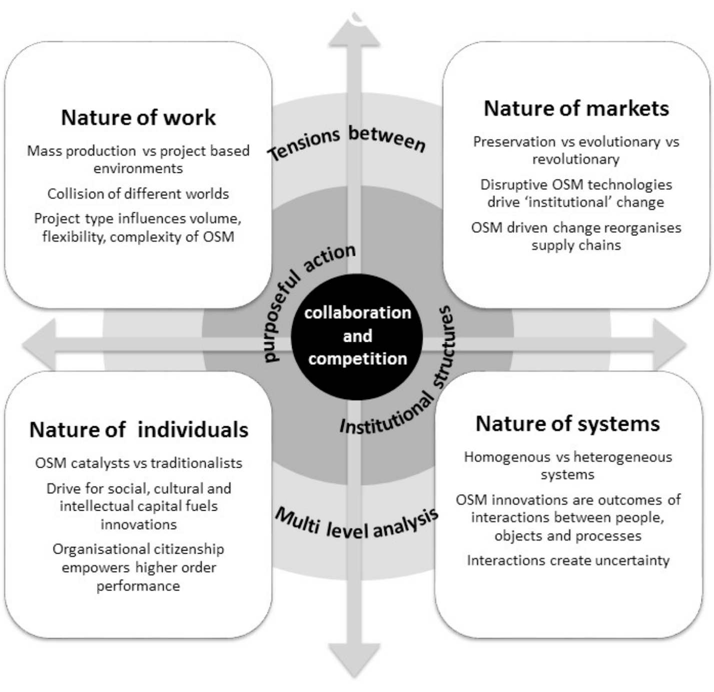

Figure 1 Influences on Collaborative Practice in OSM Housing Innovations

2. Transformative change

Introducing new initiatives is problematic because existing institutions inhibit change. An institution is a tradition, custom, convention, norm or ritual which has developed over time and has become standard practice. Such "rules of the game" can be identified through institutional analysis. In certain sectors such as urban residential development, institutions can hamper opportunities for innovations, in particular when these interlocking institutions are designed to support profitability at the expense of change. Yet leaders with vision may institute a major change initiative without compromising on organisational profitability. Two major change initiatives were explored using urban residential developments as the prime research site where innovations were achieved alongside profitability. The housing developer's role as the key orchestrator and change agent in creating, inhibiting and changing the 'rules of the games' is critical to the housing development process. Importantly, such large scale innovations were found to require extraordinary levels of collaboration among key stakeholders.

2.1 Housing Innovations:

An innovation in the housing industry that has received increasing attention over the last five years is offsite manufacturing. Offsite manufacturing has been posited as a technology solution to many of the problems in the industry particularly increased construction time which is then linked to increased cost and thus decreased housing affordability. One of the suspected challenges that offsite manufacturing can assist with is the lack of coordination and integration between the actors in the development chain. It is proposed that a more cohesive development chain would prove beneficial to all housing sector stakeholders. Ad hoc examples and applications by housing developers attempting to integrate to solve specific problems, such as productivity, has had some success. However, these achievements and the detail of how integration is achieved has not been diffused readily throughout the sector and thus has had little real impact on overall sector performance. Whole-scale industry improvement requires a concerted effort to undertake a stepwise change. A key to the solution is to investigate successful examples of integrated chains which have resulted in wholescale change in the sector (London and Siva, 2011). The current housing construction model is characterized by traditional craft-based on site construction techniques (Loosemore et al., 2003) and there have been very few innovations in the housing sector that have created transformative change. However, one particular example of an innovation in Australia that had significant impact on the sector was a technical system that fundamentally changed the way in which footings are built. The Australian Housing Supply Chain Alliance commissioned a study to investigate this particular innovation so that lessons could be learned about the pathway for highly innovative firms seeking to explore and commercialise novel ideas. The study identified that the housing developer held a significant degree of influence over others in the chain, coalesced the actors and was the champion of the innovation (London and Siva, 2012). This study presented an innovation process pathway which identified the role of social, cultural and intellectual capital in changing barriers into enablers. Through narrative analysis, barriers to innovation and enablers were identified. Through the collection of stories, a key tool in narrative analysis barriers were identified to include; professional jealousy whereby engineers chose not to adopt the system as they were in competition with the inventor of the system; negative perceptions and attitudes to the innovation and to change; high costs incurred by the distributor of the footing system which in turn resulted in inflated prices of the system and lengthy and costly patent disputes and adversarial litigations.

Further to this various enablers to the innovation process were also raised including:

- mutual understanding and trust and strong support between participants to create a solution
- shared but different business and altruistic motivations
- participants shared philosophy towards risk taking which was influenced by the following considerations; economic rewards, trust in the credibility of other players and the authority and influence associated with specific participants whose support for the waffle footing system offered its members the confidence to adopt the system.
- the role of champions in the innovation process was raised as an important enabler. An innovation champion may be viewed as "a charismatic individual who throws his or her weight behind an innovation, thus overcoming indifference or resistance that the new idea may provoke an organisation" (Rogers, 2003, p. 414). In the case of the waffle footing innovation its wider diffusion was reliant upon not just an individual champion but also a group of champions working together across organisations.
- explicit and appropriate identification, alignment and integration of capacities between participants and development of alliances or relationships and collaborative efforts between participants to access required expertise and capacity for the innovation process
- acquisition and use of artefacts in developing reputation enabling credibility to be associated to the innovation. It was important to provide evidence [ie 'artefacts'] that were clearly understood and well accepted by the industry; these included accreditations, approvals and production of publications. They were critical for initial acceptance and also wider diffusion of the innovation.

The nature of leaders' behaviours in this particular detailed case study emerged as important to creating and enabling the innovation to be diffused in the sector. This concept is taken up further in this paper and explored in more detail.

2.2 Organisational citizenship behavior

A key characteristic of transformational leadership is organizational citizenship behavior and it is not well considered in the construction leadership literature. Construction leadership literature tends to focus on the individual's attribute, the 'hero' model, without explicit connection to their place of work or the organization; that is, not just the qualities of the person but underlying this is how the person identifies themselves and their place in the world – '*citizenship*'. Organisational citizenship behavior (OCB) is a complex multi dimensional phenomenon which can be an important aspect of human behaviour at work. Dennis Organ is generally considered the father of OCB. Organ expanded upon

Katz's (1964) original work. Organ (1988) defines OCB as “individual behavior that is discretionary, not directly or explicitly recognized by the formal reward system and that in the aggregate promotes the effective functioning of the organization.” Organ’s definition of OCB includes three critical aspects that are central to the construct. First, OCBs are thought of as discretionary behaviors, which are not part of the job description and are performed by the employee as a result of personal choice. Second, OCBs go above and beyond that which is an enforceable requirement of the job description. Finally, OCBs contribute positively to overall organizational effectiveness. OCBs arise when individuals voluntarily assist in the workplace to implement courageous and risky initiatives without either implicit or explicit reward for the behaviour for some noble greater ‘good’ (Organ, 1988). The ‘good citizen’ model includes the display of such behaviours as altruism, conscientiousness, loyalty, sense of fairness, individual initiative, acts of creativity and innovation, self-development, ‘sportsmanship’, courteousness and civic virtue (Podsakoff et al, 2000). Although there is extensive research on OCB and although theoretically there is support for the conceptual effectiveness of OCB on an organisation there has actually been little empirical evidence linking OCB with effectiveness and outcomes. Indeed according to Podsakoff et al (2000) some examples have been trivial in this area of research and there is much needed work to be done to identify linkages between OCB and significant outcomes as well as linking different types of citizen behaviours to different outcomes. There is a close relationship between OCB and transformational leadership. It is also speculated that individuals that display OCBs may tend to engender trust in followers and this is a most powerful motivator towards taking risky behaviours. This however has not been explored to a great extent theoretically nor empirically (Podsakoff, 2000).

There is nothing more risky in the housing sector than introducing new policies, procedures or practices that go to the heart of the organisation’s profitability and may erode that profitability. Identifying the prevalence of this construct both theoretically and empirically will not only contribute to the field of housing construction research but also to the practice of leadership and change in the housing sector. London and Siva (2012) have conducted a comprehensive analysis of innovation diffusion research and identified numerous studies in different disciplines. Each discipline typically sought to concentrate on investigating one main type of innovation. In this study we would seek to analyse the two innovations with the intent of identifying any industry wide patterns within the context of organisational citizenship behaviours. We build upon the earlier housing innovation small scale study that London and Chen (2011) conducted where some elements of like-mindedness and altruism were identified in the champions of the innovation. We suspect that there is significant merit in developing this construct as a way forward for the industry as we have already seen that the key champion displays some of the behaviours. The housing sector is rarely considered from the vantage point of the ‘developer’ or the development chain and yet this is how change is catalysed or undermined. Not only are there theoretical limits within the research on housing construction innovations but it is well acknowledged that there is a dearth of empirical work and available data supporting delivery of housing innovations. No study captures developers’ responses to grappling with and reconciling the dichotomy of a sense of citizenship towards ‘housing affordability’ and a commitment to organisational profitability.

3. Methodology

In analysing the data, we employed actor-network theory as a methodological approach (see Figure 2). Actor-network theory (ANT) overarches a range of theoretical and methodological approaches based on the premise that much of social reality can be understood as the outcome of actors (human and non-human) interacting in heterogeneous networks (Law 1992). From an ANT perspective, complex phenomena such as organizations, technologies, information technology systems and communities are all networks made up of people, objects, documents and other entities exercising some form of agency, shaping their relationships with other actors, and in doing so creating network effects. Much of the "work" of creating a network is often, though not completely, carried out by a key actor, referred to as a prime mover. The prime mover seeks to enrol other actors into a network, and to subsequently stabilize this network, in order for the network to address a certain problem (Callon 1999).

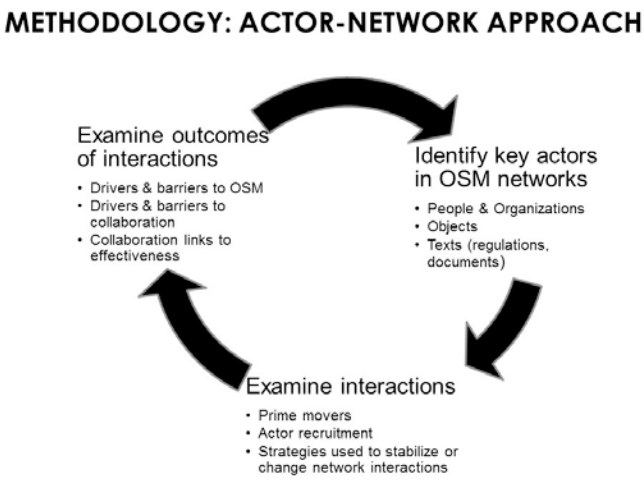

Figure 2 Actor Network Theory Methodology

Data was collected from two case studies. We used ANT to identify key drivers of change in both organizations and to examine how they established interactions with other actors in order to effect such change. Eight interviews were conducted in the first company and six were conducted in the second. The results of the analysis is presented and in particular summaries of the thematic coding of barriers and enablers to offsite manufacturing and then barriers and enablers to collaborative practice are summarised in Tables 1 – 4. The data was then interrogated specifically for evidence of organisation citizenship themes including the display of such behaviours as; altruism, conscientiousness, loyalty, sense of fairness, individual initiative, acts of creativity and innovation, self-development, 'sportsmanship', courteousness and civic virtue. Specific quotations that suggest these leadership qualities were extracted.

4. Results and Discussion

The empirical settings of our study are referred to here as Company A and Company B. Company A is a diversified property group that was recently acquired by an international real estate company. It focuses on the development of residential, commercial, industrial, and investment properties, as well as on income development/ investment and property management, and it has an established reputation for carrying out mega-projects. One of its key projects was its involvement as a partner in a joint consortium undertaking the multi-stage redevelopment of the Athlete's Village for the 2006 Commonwealth Games into a residential estate, a project valued at more than AUD \$40 million. The plan for the residential estate involved the construction of over 1000 dwellings, with one fifth targeted for the provision of social housing. The project also included refurbishing a number of heritage buildings as well as the creation of wetlands and parklands. Such projects are in line with the organization's aim of achieving sustainable communities; as one executive mentioned, it was not the company's style to just "build houses and walking away". An important element of the development effort was the design and construction of low- and medium-storey apartment buildings, usually made up one one-, two-, or three-bedroom apartments, in five stages. In the first three stages of the development, managers from Company A noted that there were recurring problems related to the way floors were laid, notably risks of falls from heights and the potential inhalation of dust by workers as they sought to grind floor panels. In 2012, Company A brought together key suppliers, designers and consultants into a team that developed a prototype for a cassette floor, one that could be prefabricated offsite and was light enough to be craned into place. After six months of frequent, face-to-face meetings, a prototype was developed and was eventually used in Stage 4 construction, which involved a five-storey timber building. The use of the cassette floor reportedly led to the building being completed one month early and to building costs being reduced by 25%. The cassette floor is showing significant potential in terms of driving large-scale projects; shortly after the successful incorporation into the five-storey building, it was successfully used in the construction of 48 two-storey homes which were completed swiftly over a six-and-a-half month period. We chose Company A for this study because of its drive for innovations which have strong potential for driving future large-scale initiatives, coupled with its distinct orientation towards "higher order" performance goals such as community sustainability and worker well-being and safety. Company B is a regional company operating in two locations in South Australia. Organization B has evolved over time, having its beginnings with a small firm founded by a single entrepreneur, and then expanding over time to include multiple businesses, four owners, and multiple managers. The company maintains properties and provides kitchen solutions, but its core business is in the design and construction of site-built houses as well as transportable homes, with the latter being manufactured on company premises then trucked to specific locations. The company's capability for building transportable homes has allowed it to penetrate a number of markets that had previously been underserved, mainly because of the absence of trades in specific areas. In recent years, Company B has pushed its transportable line even harder through the development of a new innovation: a concrete floor that remains light enough to be transported, but allows houses to be buried or installed at ground level. The lightweight concrete floor is in contrast with other transportable examples, which are generally built half a meter above ground level and are generally linked to energy, noise, and ventilation issues. We chose Company B for this study because its innovations in transportable housing have positioned it for potential large-scale projects in diverse sectors. The company has successfully undertaken retirement village projects;

notably this potential for serving aging communities could be further heightened with its new concrete slab innovation because it allows for easier (ground-level) access to homes. Company B has won allocations under national rental affordability schemes, which indicate its potential for serving markets in need of affordable housing. The Company has provided temporary housing structures for the mining sector. It has partnered with the Department of Defense to address housing issues on Indigenous lands and has also explored taking their innovations into more commercial spaces; for example, one of their proposals involved the use of the concrete slab as a component for prefabricated bathrooms for a hospital in Adelaide. At the same time the company executives have stated that they strive to maintain a key position within the community. The company is well-known to its regional customers as a dependable and trustworthy provider of homes, and to its suppliers as a partner who builds fair, long-term relationships that transcend "chasing a buck".

4.1 Barriers and Enablers

The barriers and enablers to offsite manufacturing were identified across the two companies. The four most commonly considered barriers included technical challenges, resistance to the new innovation, need for significant investments and regulatory challenges and the five most common enablers included; champion, performance incentive (revenue), readiness for change, performance incentive (cost) and transferability of innovative solution from another situation. Importantly the role of the champion was considered the most significant enabler to catalysing the offsite manufacturing innovations. Our analysis also included coding text in relation to commentary on collaboration barriers and enablers. The four most predominant collaboration barriers were lack of skills, focus on own goals, lapses in information-sharing and championing the relationship over performance. The most predominant collaboration enablers included; working off shared plans, co-location, frequent meetings; recruiting people with the right qualifications, shared history and loyalty and the leader enablers diverse and multiple contributions. These appear to match the attributes of organizational citizenship behaviours. However we then developed another layer of analysis whereby we selectively attempted to identify commentary and explicitly identify quotes to map evidence of organizational citizenship behaviours.

Table 5 Organisational Citizenship Behaviours Mapped to Cases

OCB CHARACTERISTIC	CASE 1	CASE 2
Altruism *feelings and behavior that show a desire to help other people and a lack of selfishness*	And I guess that's relevant because I wanted to give you that sort of background and who we are as a company, we're very focussed on obviously making money. That's what we're in business for ***but we also have very strong sustainability focus and that's sustainability outside of just environmental sustainability*** even though that's a key part of it ***but it is also just about community sustainability and the development of what we call communities as opposed to just having a development where we buy a block of land and build 300 homes and walk away.*** We actually have a very strong vested interest in how that community operates, how it integrates with a wider community and all those sorts of things, which is a big sustainability focus.	…the company is not one to chop and change. ***It doesn't burn relationships. And sometimes we know we pay a little bit more,*** but we're not – we might get something a bit cheaper down the road. Yeah, I think so, ***but you've got to love Wayne for it because he's just about relationships*** and - but, you know, just got to find that happy balance, we're a bit too happy families at the moment, yep, but that's fine.

OCB CHARACTERISTIC	CASE 1	CASE 2
Conscientiousness *very careful about doing what you are supposed to do : concerned with doing something correctly*	…they're little things. I think some of those things that are just good building practice, like one of the first days that they were out there doing stuff, when I'm out there walking they were starting to do a job to put some bearers up and I said to them, "Show me the screw that you're using," and the screw they were using, to my mind, wasn't long enough, and it just didn't look right, so it was, "Guys, I want to see confirmation that that is even the right screw or you get the right screw," and they went away and they, "Oh, no, they're meant to be 50 ml longer." ***But there's those things that are just attention to detail and you just need somebody to walk around.*** ***So there were a lot of workshops and we went through everything*** from safety, what happens if the cassettes are lifted for the first time and it disintegrates in the air, what are we going to do because you're going to have Work Safe on board - on site, the site is going to be shut down. What do we do now? How do we then determine what the issue was? ***So we went through every scenario you could think about.*** So it wasn't just naively walked into. We certainly went through a lot of planning.	***So I want it to be as foolproof as it can be***. It's like in our new displays we've gone and put set downs and hobs in the showers, so just making sure that was all – so when you start getting flex in a truck with the transportable side of it, making sure they were going to hold up. So then we had to go back to the glue suppliers and the primers and all that and make sure everything was going to stick properly in there so that it doesn't pop the tiles, ***because I've never had a problem with tiles popping on a floor and I'm not about to start***. So when they wanted to start doing that I said, hang on, we've just got it all right. Because Port Lincoln had a problem with them early in the piece and they were using the wrong primers and wrong glues, so unless you get that right – so that way we're relying on the supplier's technical advice to get that all over the lines ***just to make sure we're putting the best product in we can.***

Table 5 Organisational Citizenship Behaviours Mapped to Cases

OCB CHARACTERISTIC	CASE 1	CASE 2
Loyalty *a loyal feeling : a feeling of strong support for someone or something* *C1: Quotes are more of loyalty in relation to teamwork, that is, being loyal to a collective* *C2: Quotes are more of loyalty in relation to growing a relationship over time*	***You're working as one collective who are delivering one outcome***. So you're not sitting there looking at Joe Bruno saying, "You work for Irwins. You must do this." ***Everyone understood that we were coming together, we were doing something fairly unique and so from that point of view they're helping each other*** and Joe can go over to Rob de Brincat's built site… Factory, and talk to him and sort of helping, "You've got this problem with the cassette." Now, cassettes have nothing to do with Joe in the end. Joe is involved and Irwins are involved in providing the overall structure to the building, not to do the flooring. I think when we finished it all I think we got a third of the way through the project and we had already done the first two levels, I sent out an email and just said, ***"Look, these are the people to thank in the industry for this. It wasn't me."*** I sent it out. I said, "Irwins have done this. Tillings have done the (33.36). Bowens and Timbertruss were involved." I actually named them. I thought, I'm going to name these people and just spray out an email to the whole of Australand and just let people know this wasn't about us. ***This is about them coming together and being able to commit and cooperate the way they did. I think you've got to do that***.	The best part is everybody works as a team, right from council approvals through – you walk past and everybody's firing a question at everybody. It's not, "That's my department done," and walk away from it. ***You can go to anyone at any stage and they're all willing to put their input in*** and say, no this is what's happened. So we had to create our own labour force and then our own - with the view of we knew that subcontractors is the best way to run a business. So we had to create this trade set that turned into contractors. So eventually we could turn it into contractors, which it's worked really well. We've nearly completed it. ***We've probably got I think half a dozen apprentices still on our books and the rest we've turned into contractors that work for us. So yeah, it's just been a fantastic result.*** ***Don't burn bridges.*** I mean - - - there will be a time where you've got to work with that person again I'm sure, and it's happened, it's happened, and I've had to work with people. I've called them up to come back in on other occasions. So if I had to get nasty I wouldn't be in this game.

OCB CHARACTERISTIC	CASE 1	CASE 2
Sense of fairness	*C1: Fairness here is related to making sure that in a relationship, neither party ends up being taken advantage of by the other* ***There's things you can do. So that gives him a bit of relief from a financial point of view and then you start paying him as soon as cassettes come on site***. You've actually already got the invoice and you're ready to pay him on that day. ***So the cassettes come on site, boom, the money is straight into his account.*** Now, what you have to explain to them is once we get this up and running that's not going to be the normal contractual arrangement. …***But for a first-off project if that's what gets the industry going*** and still gives me a cheaper building than the rest of the builders in WA, you know.	*C2: Fairness here is related to delivering what was promised to another party, and being up front about it* …***we've got some really good long term relationships, we'll always try and foster those***. We won't try and do the, you know, try and get you down and then play you off each other, we just don't do that at all. We try not to hide anything, that's the thing. You've got an upfront cost, people might say you're dearer, but then they might come back six months later and go, you weren't. There was nothing hidden in ours, ***and that transparency helps you sell stuff too***, especially out in the country.
Individual initiative	Now, luckily for me, I was probably silly enough, ***naive enough that I just thought, let's go***. ***I'm the sort of person who just wants to go for something.*** So if I can see a way that's going to come - the outcome is achievable, my view is let's go for it, and that's what we did from that meeting.	And like, yeah, anything with this one, the – particularly Keith, he is the one that's our true entrepreneur. I like that, I'm going to go do that. Bang. And the company has to keep up.

Table 5 Organisational Citizenship Behaviours Mapped to Cases

OCB CHARACTERISTIC	CASE 1	CASE 2
Acts of creativity and innovation	It's not about one building. ***It's about what innovation we have brought that can actually lead to newer and better things that we can do going forward***… It was a matter how we can actually improve on what we already had accomplished. So that's probably where the company decided to go with that five storey building at Parkville. And in doing so we had to obviously review everything that we've done previously and make sure that we've got all our ducks in line ***to be able to take the next step into building five storeys in lightweight because the whole— it was a completely different challenge to us.***	***We're always open to change***, that's how things move forward. Otherwise nobody would have a concrete slab home, concrete slab transportables. ***So we would be having a beer and he would come up with some silly ideas. We would be throwing just ideas around all the time.*** That's (the concrete slab) only one of many. So we would sit down and we would smash that stuff out over a beer for months until we thought, yeah, no, we've got it, that's the go.
Self-development	…so we did Parkville stage 1, again timber frame construction, a mixture of two and three storeys on top of car parking. It wasn't that efficient and it wasn't very well built. ***I think we were learning a lot within ourselves as to how to put a project like that together.***	***it's probably a bit of a ridiculous reason in some ways but we thought that we should be servicing the market with transportables*** but didn't have – and had had a client, a particular client, that wanted 50-odd cabins, and because I had experience in it we looked at better ways to do it than we've done in it in the past, or I've done it in the past because I knew a lot of the pitfalls and I'd been involved in the industry and then stupidly thought yeah, I reckon I can do it and do it better this time.

OCB CHARACTERISTIC	CASE 1	CASE 2
Courteousness and civic virtue *C2: Civic duty here is one's everyday behaviour being shaped by concern for the community*	*C1: The quote for altruism can apply*	For me ***the owners are your typical country sort of people, very open, very trusting, very focused on relationships and just good people to work with***. You don't – it's not – and I'm coming from a real corporate environment, so previously I worked for Rivergum Homes and I was there for 10 years – a cut-throat corporate, very difficult to work in that sort of environment for any length of time anyway. For 10 years I made it. That was the goal. And so for me it was ***a really refreshing change to come into a company that cared about its people, its suppliers, its contractors, and its product***. we don't want anyone going around saying we're trying to, you know, rip money off…Yeah, in the community, ***so the community is huge for us***.

5. Conclusions

Theoretical work on organizational citizenship behaviours has indicated that there are at various characteristics associated with leaders' who display OCBs. However, attempts to study the phenomenon and link it empirically to performance outcomes have been limited. In the two case studies we have mapped explicit OCB in the two case study organisations who have lead major transformational change. The introduction of a new way to design, construct and install timber flooring as an integrated cassette module which is built off site and placed onsite as a major unit required significant changes in processes. The second case study whereby all design and construction of a house is completed remotely from the site and then is transported to the final location also required significant process change. The interactions between the various actors required not only technical solutions but also new business models and new ways of working. The two case studies are considered exemplar technical solutions as well as highly successful business initiatives for the lead actor organisations. There was clear evidence in both case studies of altruism, conscientiousness, loyalty, sense of fairness, individual initiative, creativity and innovation, self-development and courteousness and civic virtue. The paper contributes to our understanding of leadership qualities of key actors who champion risky initiatives in the housing sector and in particular offsite manufacturing innovations. Leadership in construction management research has tended to focus on leadership types (charismatic etc) and less so on qualities that engender deep respect and trust – qualities which motivate others to follow. We have confirmed empirically a link between OCB with effectiveness and outcomes. We have not linked different types of citizen behaviours to different outcomes though and interestingly all behaviours were exhibited except for 'sportsmanship'. Future research shall explore the relationship of the different OCBs to an examination of interactions in the actor network; namely how the behaviours enable prima moven actors to recruit other actors into the network and the various strategies that are used to stabilize or change the network.

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Overview of dual process behavioural models and their implications on decision-making of private dwellers regarding deep energy renovation

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Abstract

Understanding both rational and heuristic thinking is important for explaining pro-environmental behaviour. Theoretical findings regarding dual process models can be useful to explain and influence decisions of private owners in the context of energy renovation.

The existing building stock has a big potential in contributing to the reduction of energy consumption. Even though surveys show that dwellers acknowledge the importance of energy efficient buildings and the technologies to achieve nearly zero energy buildings (nZEBs) are accessible, many dwellers prefer minor interventions or the status-quo rather than a deep energy renovation of their dwelling.

The present paper will explain the gap between intention and action with the use of dual process models (DPMs), consisting of a rational, central processing of the information (System 2) and a heuristic, peripheral one (System 1). We will focus on the peripheral System 1 that represents the heuristic, intuitive, fast and not so rational thinking that works as a shortcut for the rational processing of information. Dual process behavioural models will be classified according to the triggers of the heuristic shortcuts. An important aspect is the fragile balance between the two systems that is influenced by the need for cognition and need for affect. An overview of behavioural insights in heuristic thinking that might influence decisions regarding house renovation will be presented. The hypothesis verified with the use of a questionnaire is that positive arguments of the house owners in favour to renovate are mostly rational and the negative arguments are mostly heuristic.

Based on theoretical and empirical findings on dual process models, implications for policy making and informational campaigns concerning deep energy renovation will be proposed.

Keywords: Energy renovation, behavioural change, heuristic thinking, nudges, energy efficiency

1. Introduction

Europe is characterized by a 50% rate of owner-occupied dwellings and many countries including Belgium have even higher rates of over 70% (BPIE, 2011). Therefore in order to reduce residential energy consumption it is important to understand the mechanisms behind individual dwellers' behaviour. The present paper will focus on decision making aspects of private owners regarding deep energy renovation. These one-off decisions are different from daily energy use, where habits and curtailment prevail. When we refer to deep energy renovation we intend energy efficiency measures that aim to achieve a Nearly Zero Energy Building (nZEB). It implies investments in: insulation (wall, floor, roof insulation, energy efficient glazing); energy efficient HVAC technologies; systems on renewable energy (PV, solar panels, geothermal heat pumps).

The existing approaches for the uptake of energy renovation can be divided in two main categories: the one based on neo-classical economics' assumptions and the one based on environmental consciousness. The first approach considers the householder as *homo economicus*, who in his pursue of utility maximization, is able to choose rationally between the multitude of available energy efficiency measures. Nevertheless this approach has the limitation of considering individuals more or less as 'computers' with unlimited cognitive abilities and complete emotional self-control (Thaler & Sunstein, 2008). The Utility maximization model states that eventually the wrong estimations will be corrected with experience, yet the renovation decisions are usually one off and irreversible.

Whereas the first approach is based on financial arguments (extrinsic motivation), the second approach addresses the environmental consciousness of the individuals (intrinsic motivation). Energy related behaviour is explained with values, attitude formation, personal norms and self-efficacy (Perlaviciute & Steg, 2014), (Owens & Driffill, 2008). Various public and NGO informational campaigns have the purpose to relate energy consumption to environmental impact.

The vast majority of dwellers acknowledge the importance of energy efficiency. According to the Flemish Energy Agency VEA more than 90% of Flemish consider energy saving as rather to very important (VEA, 2013). Yet the figures of environmental consciousness resist to translate into action. Large-scale surveys (Bartiaux, et al., 2006), (Ceulemans & Verbeeck, 2015) document the gap between self-reported intentions and the actual energy efficiency measures undertaken.

Consequently, filling the intention-action gap with information regarding monetary or environmental benefits proved to have a lower impact than expected. Both approaches are based on the assumption that dwellers are exclusively rational in their reasoning. In reality decisions are systematically affected by the *"self-control problems, unrealistic optimism, and limited attention"* characteristic to humans (Sunstein, 2014). People tend to escape the slow and cognitive processing of the information with the use of a shortcut called heuristic or bias (Darnton, 2008). Figure 1 illustrates two ways of thinking: **the rational (System 2)** and the

heuristic (System 1). System 2 is the slow and deliberative, while System 1 is fast, automatic and intuitive. These two routes process the information concurrently, hence the models are called Dual Process Models (DPMs).

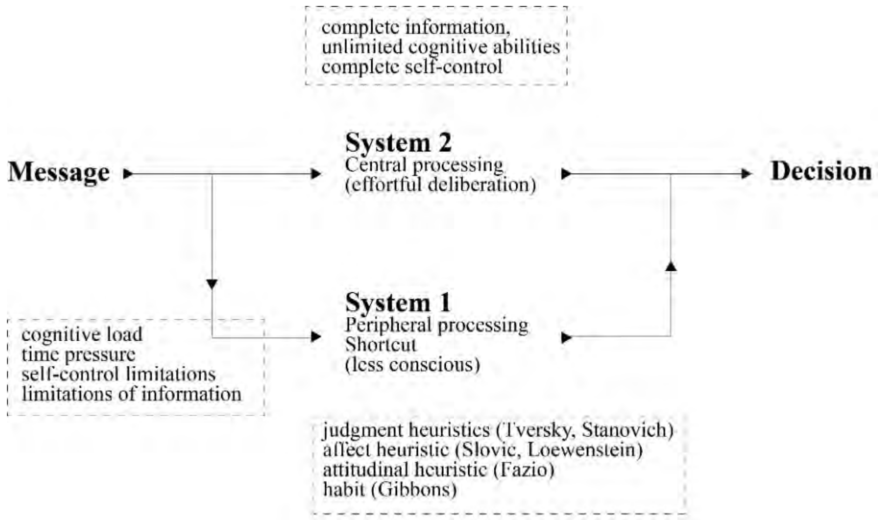

Figure 1 Scheme Dual Process Models

Certain DPMs constitute the theoretical background of the nudges – "*any aspect of the choice architecture that alters people's behaviour in a predictable way*" (Thaler & Sunstein, 2008). The raising interest towards nudges as a policy measure in various fields including energy efficiency provides a vast literature (Momsen & Stoerk, 2014), (Sunstein, 2014), (Behavioral Insights Team, 2011). These mostly contain applied behavioural insights without exploiting the mechanisms and models behind these biases. On the other hand, reports comprising all the behavioural models (Darnton, 2008), (Chatterton, 2011) do not consider the dual process models separately since their purpose is to give a general framework.

The present paper will give an overview of exclusively DPMs, from the perspective of their implications to energy renovation. The second chapter contains a classification of the DPMs and the balance between the rational and heuristic thinking. Part 3 details heuristics and biases of the System 1 that might be applicable in the context of energy renovation. In order to verify if dwellers' arguments regarding energy renovation are mostly rational or heuristic, a questionnaire was elaborated. The target of the questionnaire are the private owners in Flanders and it will be presented in chapter 4. In conclusion will be proposed implications for public policy based on the findings of the survey.

2. Overview of the existing dual process models

2.1 Classification of the DPMs

Starting from 1950s on, research in the field of psychology provides empirical evidence of the dual processing of information as a reaction against the ever increasing belief in rational decision making in economic models. An overview of the existing DPMs is given here below and summarized in Table 1. Insights into how these models apply to energy renovation, is offered in chapter 3.

Certain DPMs focus on decisions taken under uncertainty, time pressure and cognitive load, when people tend to avoid the difficult cognitive deliberation with the use of a fast, intuitive shortcut (Darnton, 2008). This principle is the theoretical basis of behavioural economics, with Simon Herbert's model **Bounded Rationality** (Simon, 2000); Tversky and Kahneman´s **Judgment Heuristic** (Kahneman, Slovic, & Tversky, 1982) and **System 1/ System 2** of Stanovich and West (Stanovich & West, 2000). When considering different alternative energy renovation measures, dwellers usually face difficult technical information. Besides the complexity of the information and the variety of possible solutions, the problem of uncertainty persists. There is little consensus on which option is more suitable or cost effective for a particular dwelling, since the sustainability of a technology in its complete life-cycle is strongly context dependent. For example the efficiency of solar technologies depends on the micro-climate conditions, proper installation; the sustainability of biomass technologies depends on the availability and origin of the biomass, etc. Under these circumstances the effortful analysis of the information is often shortcut by a cognitive bias.

Other two models that stipulate the central (cognitive) and the peripheral (less conscious) processing of the messages are the **Elaboration Likelihood Model** of Petty R. E. and Cacioppo J. and the **Mode Model** of Fazio. These models underline the importance of attitude and motivation when facing effort demanding information (Darnton, 2008). Other factors for heuristic thinking are emotions and perceived risks. According to Slovic's **Affect Heuristic Theory**, "perceived risks and perceived benefits may be inversely related in people's minds" (Finucane, Alhakami, Slovic, & Johnson, 2000). Similarly, **Risk as Feelings Model** of Loewenstein G. F. stipulates a direct path between emotion and behaviour (Darnton, 2008). The characteristics of the individuals that include 'need for affect' will be explained in part 2.2.

Table 1 Classification of the Dual Process Models

Main trigger of System 1	*Model, theory*	*Authors*	*Year*
Uncertainty, time pressure, heavy cognitive load	*Concept of bounded rationality*	*Herbert S.*	*1955*
	Judgment heuristic	*Tversky A. Kahneman D.*	*1974*
	System 1/ System 2 cognition	*Stanovich K.E, West R.F.*	*2000*
Motivation	*Elaboration likelihood model*	*Petty R.E., Cacioppo J.*	*1986*
	Mode model	*Fazio R.H.*	*1986*
Emotions	*Affect heuristic*	*Slovic P.*	*2000*
	Risk as feelings model	*Loewenstein G.F.*	*2001*
Habit	*Theory of interpersonal behaviour*	*Triandis H.*	*1977*
	Prototype/willingness model	*Gibbons F.X., Gerard M.*	*2003*

Finally, for certain DPMs habit is the main trigger of the shortcut from the rational thinking. Models such as **Interpersonal Behaviour** of Triandis (Chatterton, 2011) and Gibbons´ **Prototype⁄ Willingness Model** describe frequently repeated actions that become automatisms. These models might be useful to explain the daily energy use of the dwellers, but are not appropriate for one-off decisions on energy renovation.

2.2 Balance between the rational and heuristic systems

The main feature of DPMs is the concurrent possibility of processing certain information in a slow, rational way (System 2) or in a fast, intuitive, heuristic way (System 1). Understanding the factors influencing this delicate balance is rather significant for policy making. If the arguments of an informational campaign are exclusively rational, it is important to verify if the target processes the information in a cognitive way.

One of the factors influencing the balance between the two systems is the way the message is formulated. Complex information is one of the main triggers of heuristic thinking. In the same line of thought, the BIT (Behavioural Insights Team) states the importance of simple and salient information in their EAST (Hallsworth, et al., 2014) and MINDSCAPE Methods (Dolan, Hallsworth, Halpern, King, & Vlaev). Elaborated in collaboration with the British Government, these methods aim to apply behavioural insights in public policy measures.

According to Baldwin, the 'First Degree nudge' has the purpose to enhance reflective decision-making and avoid an existing heuristic (Baldwin, 2014). If the information is easy, attractive and salient, it is more likely to be processed rationally. Besides the accessibility, the message framing should avoid possible existing biases. The 'Second' and 'Third Degree' nudges use an existing or a newly induced bias towards a predictable outcome, addressing System 1 (Baldwin, 2014).

At the same time, the balance between the systems depends on the individual's characteristics. Apart from intellectual capabilities of processing complex information, there are other parameters measuring the availability to engage in this processing, such as need for closure, need for cognition and need for affect. Due to heterogeneity of the population, the impact of nudges is not uniform, occurring the risk to "*discriminate against vulnerable parties*" (Baldwin, 2014).

Need for closure

Need for closure is defined by Kruglanski as "desire for a firm answer to a question, any firm answer as compared to confusion or ambiguity" (Kruglanski, Mannetti, & Pierro, 2006). In their urge for clarity, people with high level of need for closure are more likely to use the bias as a shortcut. In these cases it is important to implement the 'First Degree Nudge'. By simplifying complex messages, it is more likely to avoid existing biases and redirect towards rational thinking. Table 2 illustrates the characteristics of individuals that are more likely to be receptive to the three types of nudges.

Need for cognition

Contrary to the need for closure refers the 'need for cognition' to an individual's tendency to "engage in and enjoy effortful cognitive endeavours" (Cacioppo, Petty, & Kao, 1984). The higher the need for cognition, the higher is the probability that the individual will process even difficult information rationally via System 2, avoiding the bias. On the contrary, individuals with low need for cognition are more prone to avoid difficult cognitive processing and are more likely to be influenced by 'Second Degree' and 'Third Degree' nudges, see table 2.

Need for affect

Difficult to process information is not the only trigger of heuristic thinking. The dwelling is a home, not merely a physical house. The existing state of the dwelling is associated with warmth, family, pleasant memories. These emotional bounds can be an important impediment in assessing in a rational way the economic benefits of the renovation. For this reason messages or images promoting energy renovation should associate nZEB with warmth, coziness and well-being, and not only with convenience and technology.

The balance between a cognitive and an emotional evaluation depends as well on the individual's motivation to "approach or avoid emotion-inducing situations", also called his 'need for affect' (Maio & Esses, 2001). People with high need for affect and low need for cognition are less likely to process the information in a cognitive way since the two parameters are related.

Table 2 Impact of the three types of nudges depending on individual's characteristics

	First Degree Nudge (avoid existing bias)	*Second Degree Nudge (use existing bias)*	*Third Degree Nudge (induce new bias)*
Need for closure	*high*	*high*	*high*
Need for cognition	*low*	*low*	*low*
Need for affect	*low*	*high*	*high*

3. Applying behavioural insights from the dual process models to energy renovation

While System 2 thinking implies slow and deliberative thinking, System 1 is characterized by shortcuts: heuristics and biases. These are intuitive estimations of probability of the outcome that allow taking fast decisions. While in everyday practice these intuitive shortcuts might be useful in increasing the efficiency of small decisions, they can be dangerous in taking important decisions such as the ones regarding energy renovation. Previous research in behavioural economics has shown that System 1 thinking generates the heuristic assessment of probability and as a result systematic errors that can be predicted (Ariely, 2008), (Tversky & Kahneman, 1974). The present chapter presents relevant heuristics and biases in the context of deep energy renovation decisions. Some of them served as assumptions for the elaboration of the questionnaire described in Chapter 4.

Availability heuristic: the probability of an event or the frequency of an object is assessed by the ease with which it can be, recalled (Kahneman, Slovic, & Tversky, 1982). If the event is present in the memory, the bias is due to '*retrievability*' (Tversky & Kahneman, 1974). Often the choice of a certain renovation measure is based exclusively on its familiarity (already known information or singular cases from friends) or on its salience (PV panels have high visual impact, certain technologies have more coverage in media, etc.). The bias of *'imaginability'* regards the objects and events that are not present in the memory. For example, the aesthetical advantages of the refurbishments the architect describes are easier imagined than the energy efficiency measures' benefits such as thermal comfort, humidity control, etc.

Representativeness heuristic explains how people assess the probability of events merely based on the "*degree to which A resembles B"* (Tversky & Kahneman, 1974) ignoring important factors such as sample size and base rate frequency of the outcome. An example of representativeness heuristic is the way dwellers assess what is responsible for a high energy consumption (and respectively a high energy bill). They might overestimate the impact of their occupancy patterns and underestimate the importance of the characteristics of the dwelling. Everyday actions such as heating, cooking and showering *resemble* other activities such as buying groceries or dining out. All these actions are regarded as expenses depending mostly on the dweller's lifestyle. This way, the bill on the heating is associated more with the temperature chosen and less with the insulation of the dwelling. The characteristics of the dwelling are perceived as external factors such as prices on the menu that you have to accept if you opt to dine out. This heuristic might be an explanation for the distrust in the energy performance certificate of the dwelling. It is calculated for standard occupancy, while people expect the certificate to reflect their actual energy consumption.

Adjustment and anchoring: in order to estimate a certain value, people start from an initial value called '*anchor*' and try to adjust it accordingly. It is a good strategy for assessing subjective utility if not for the heuristic aspect according to which *"*different starting points yield different estimates*"* (Kahneman, Slovic, & Tversky, 1982). This is one of the reasons why framing of the message is highly influential.

The overall probability of a series of events is different from the probability of the elementary events of which it consists. The latter works as an anchor and people *"*tend to overestimate the probability of conjunctive events and underestimate the probability of disjunctive events*"* (Tversky & Kahneman, 1974). The renovation process is a concatenation of '*conjunctive'* events. In order to achieve the final result, all the elementary events have to take place, such as obtaining the renovation permit, etc. The success rate of each phase is very high, but the overall probability of the sequence is much lower. Often dwellers overestimate the overall success rate and underestimate the difficulty of the renovation process. It may lead to excess of optimism in initial planning and disappointment during the process.

On the contrary perform the *disjunctive* series of events, such as the risk of malfunctioning of the building' systems. In this case it is enough that one of the indispensable elements of the chain breaks in order to block the entire system. The probability that each element will malfunction is very low, the overall probability is higher but once again, the initial low probability works as an *'anchor'*. Therefore people underestimate the risk of malfunctioning of the systems and neglect their duly inspection and maintenance.

Satisfice bias: people aim for a satisfactory result, rather than an optimal result**Invalid source specified.**. When confronted with too many options and too complex information, often people rush for the 'good enough' renovation measure and avoid seeking 'the best' option (Frederiks, Stenner, & Hobman, 2014). People with a high level of need for closure are more likely to incline for the first *'satisficing'* option that is encountered. Moreover, satisfice bias might be related to **status quo bias** if the existing state of the dwelling is perceived as 'good enough' and, as a consequence, renovation is discarded altogether.

Social norms: the decisions are heavily influenced by others' opinions or others' undertaken decisions (Frederiks, Stenner, & Hobman, 2014), (Ariely, 2008), (Behavioral Insights Team, 2011). Social norms might explain the choice for under optimal, lock-in technologies. These solutions give the confirmation, recognition that these are the best technical, ecological solutions ("there must be a reason why everybody chooses it"). Besides it spares the hassle to compare multitude of available solutions in order to find the solution that best fits your particular dwelling.

Discount the future: smaller benefits in the present overweight bigger benefits in the future (Behavioral Insights Team, 2011). Time affects as a dimmer thus future savings on the utility bills resulting from energy efficiency investments are less appealing.

Endowment effect: people value more the things they own, not due to their characteristics, but merely because they own them (Ariely, 2008). This bias might be the explanation why people resist to change old appliances and boilers with energy efficient ones.

4. Questionnaire on rational and heuristic thinking in energy renovation

In the context of rational and heuristic thinking, a survey was undertaken to assess the way people process information regarding deep energy renovation. We verified if arguments in favour are mostly rational $\Sigma(R+) > \Sigma(H+)$ and the ones against are mostly heuristic $\Sigma(H-) > \Sigma(R-)$.

These two hypotheses are based on the hemispheric asymmetry theory. According to Schwartz' study from 1979 "*when subjected to positive affects, people tend to move the eyes to the right and when subjected to negative affects – to the left"* (Cacioppo & Petty, 1983). More clues supporting these hypotheses resulted from a focus group on behavioural insights in energy renovation organized in April 2015 with municipal officials in the context of Werfgoed Living Lab. Among arguments in favour of renovation were listed "*to reduce the footprint*" (ecological

1.1		I would place wall insulation because…	Positive	Behavioural Model/ Insight
	A	I want to live in a warm, comfortable house	H+	Affect heuristic (Slovic)
	B	I want to save money on heating	R+	Expected utility
	C	It is good for the environment	R+	Values: Schematic Causal Model of Environmental Concern (Stern)
	D	Everybody does it	H+	Social norms: Structuration Theory (Giddens)

1.2		I would not place wall insulation because…	Negative	Behavioural Model/ Insight
	A	I like my house the way it is now	H-	Affect heuristic by Slovic; Sunk cost fallacy, mental accounting
	B	I prefer spending money on interior design instead	H-	Mental accounts
	C	It doesn't make a big difference, my energy	R-	Self-efficacy: Social Cognitive Theory (Bandura)
	D	It is too expensive	R-	Expected utility

Figure 2 Example of questionnaire item with the explanation of the behavioural models (not visible to respondents) 1.1 Arguments in favour of insulation 1.2 Arguments against insulation

values, beliefs), "*house increases in value*" (expected utility); while among arguments against the renovation were listed "*a lot of cluster, noise, dust*" (affect heuristic), "*I like how my house looks now*" (endowment effect, status quo bias).

Before conducting the survey among Flemish owners interested in renovation, a pilot test was undertaken among 1983 employees of Hasselt University. The response rate was of 15.28% — 303 responses, out of which 248 were complete. The sample is not representative to the population due to high level of education and preponderance of the age group between 20 and 40 years.

The survey was structured in five topics: wall insulation, energy efficient windows, efficient boiler, solar panels and solar water heater. On each measure two questions were presented to respondents: with arguments in favour and against the uptake, see Figure 2. These were based on the most frequently reasons cited by Flemish private owners in large scale surveys (VEA, 2013), (Ceulemans & Verbeeck, 2015). Each question included four options, with two rational arguments (based on values, beliefs, Expected Utility) and two heuristic arguments (based on biases such as endowment bias, affect heuristic, social norms). The description of the behavioural models were not visible to respondents who had to rank the four options of the question. For our analysis we have assigned to ranking a score from 4 to 1 and for each respondent we have summed up the two rational options and the two heuristic ones.

For each measure the responses of the dwellers who installed it were analysed separately with the ones who did not or who are renters. For both categories of dwellers the hypothesis was confirmed for positive arguments, where prevail the rational thinking $\Sigma(R+) > \Sigma(H+)$, see Table 3. For negative arguments the results vary according to the measure. For wall insulation, PV panels and solar water heater still rational arguments prevail $\Sigma(H-) < \Sigma(R-)$, even if with a smaller difference than the positive reasons; while for efficient windows and boilers the rational and heuristic thinking are balanced $\Sigma(H-) = \Sigma(R-)$. It is important to underline that the latter measures are the most popular with respectively 74,6% (N=189) of respondents declared to have placed efficient windows and 59,7% (N=189) efficient boiler. Since these are stated reasons against the measure, the more a dweller acknowledges his own biases, the more likely he will install the measure.

If we compare the responses of the owners who have placed a certain measure with the ones who did not, we find a similar pattern according to the group of measures. Regarding efficient windows and boiler, the former group of dwellers are more rational in their positive attitudes. This underlines once more the necessity of 'First Degree nudge' that aims to enhance the rational thinking and avoid existing biases.

Table 3 Results of the paired t-test

	Owners who installed the measure				*Owners who did not install the measure*			
	Positive		*Negative*		*Positive*		*Negative*	
	mean Δ		*mean Δ*		*mean Δ*		*mean Δ*	
Wall insulation	*1.29***	H_1	*1.17***	H_2	*1.30***	H_1	*1.68***	H_2
Efficient windows	*3.18***	H_1	*0.27*	H_0	*2.69***	H_1	*0.15*	H_0
Efficient boiler	*3.08***	H_1	*-0.11*	H_0	*2.56***	H_1	*0.04*	H_0
PV panels	*2.80***	H_1	*1.07***	H_2	*2.47***	H_1	*1.82***	H_2
Solar water heater	*2.77***	H_1	*2.38***	H_2	*2.04***	H_1	*1.80***	H_2

Δ = Rational-Heuristic (min -4, max 4); H_1 $\Sigma(R+) > \Sigma(H+)$; H_0 $\Sigma(R-) = \Sigma(H-)$; H_2 $\Sigma(R-) > \Sigma(H-)$

A different trend shows the uptake of PV panels. In their negative attitudes, owners who installed them are more heuristic than the ones who did not. It suggests again that the dwellers who acknowledge their heuristics are more likely to undertake the measure. On the other hand, it might be explained by the fact that in the past the PV panels were heavily subsidized, and the social norms played a more important role in decision than the cost.

5. Conclusions

The traditional measures have proven to have a low impact in the uptake of deep energy renovation. New policy instruments that take into account the human limitation, such as nudges, are being tested in various fields including energy efficiency.

The preliminary results of the survey show that positive rational arguments prevail over heuristics, while negative ones are more balanced, depending on the measure. Since biases are already present especially in negative attitudes, there are two main strategies: to avoid them ('First Degree nudge') or to use them in the right direction ('Second Degree nudge'). Framing complex information regarding renovation in simple terms might redirect towards cognitive thinking. If unavoidable, existing biases can be used in a predictable direction. For example a right anchor would be nZEB levels and not the building stock average; right social norm would be the positive statistics (how many dwellers have placed a certain measure).

Since the survey contains stated preferences, it has the limitation of revealing only how people acknowledge they think. It is not likely for a person to admit or even realise his own heuristic thinking. Nevertheless, the survey reveals different patterns among positive and negative attitudes; among measures with a higher or a lower uptake; and in a lower degree, among owners who have placed the measures compared to the ones who did not.

Finally, in the elaboration of nudges have to be taken into account the heterogeneity of the population. Until now, the application of behavioural economics in policy making was mainly a simplified application of biases, ignoring the underlying dual behavioural models. The characteristics of the individual, such as 'need for closure', 'need for cognition' and 'need for affect' influence the balance between the two systems of thinking and might determine an asymmetric impact of the nudges.

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People and Activities in Energy Efficient Buildings: Comparative Study of User, Owner and Facilities Management Perspectives in Schools

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Abstract

Tightening the link between the design and operation phase of buildings is widely regarded as a solid approach towards improving their energy performance. Energy management strategies delivered exclusively from an asset management perspective may often neglect the impact from the people who use, operate and manage the assets. This paper presents the findings from two case studies that aim to deepen our understanding regarding how energy management practice is carried out within "high energy efficient" school buildings in Norway. The methodology includes individual semi-structured interviews with at least one representative from each of the following user groups: building occupants, facilities managers (operational, tactical or strategic) and building owners. Energy data routines have been gathered through interviews and strategic documents. Findings suggest a strong disconnection between the expressed energy ambitions of the buildings (i.e. energy standard to which to which the buildings are designed) and the actual delivery of energy management as a practice. Building occupants relate to the use and management of energy in the context of activities relevant to the building´s core function. Energy data routines as implemented by building operators reflect disassociation from the activities that end-users deem as strategic. Results from this study have strong implications regarding the role that professional bodies, organizations and educators need to play in ensuring that high energy ambition buildings are met with energy aware users. The knowledge developed can support further development of facilities management qualifications. Through an activity-centred approach, we are able to develop key insight that supports in identifying key areas for collaboration between building occupants and facilities managers and building owners.

Keywords: Energy Management, End-user Perspective, Facilities Management, Interdisciplinary, Collaboration

1. Introduction

Contribution from the built-environment to achieve energy efficiency (EE) goals is well established. Efforts to improve the energy performance of non-residential buildings can take the form of initiatives that: a) support the decision-making process at the design phase of a building. This is, to align principles of sustainable architecture with the adequate procurement of energy-efficient plant and equipment, in support of the sustainable operation of the building (Junghans, 2012, Ure and Camyab, 2016); b) support the development of energy measures that can be adapted or retrofitted into existing buildings. Beyond technology-based approaches, this includes solutions that can positively impact the way buildings are used and operated. Increasing evidence shows that buildings often perform worse than their design intentions. This issue is commonly regarded as the Energy Performance Gap (EPG). As suggested by Bordass et al. (2004), the EPG can escalate to affect market perception over the effectiveness of industry proven EE technologies for low-energy buildings. Causes for the EPG are many and stem from different phases in the life of a building (De Wilde, 2014, Valle & Junghans, 2014). Lack of knowledge at the design phase regarding how buildings are (to be) used and operated is often highlighted as one of the main causes for the EPG. Tightening the link between the design and operation phase of the building is widely regarded as a solid approach towards bridging the performance gap (Bordass et al., 2004) Technology-based solutions are the dominant approach towards improving the energy performance of buildings. However, energy management strategies which are delivered exclusively from an asset management perspective may often neglect the impact from the people who use, operate and manage the assets. Occupant engagement is widely acknowledged by both industry and academia as a critical factor towards achieving good energy performance (Janda, 2011, Menassa, 2014, TRUST, 2011, ENERGY STAR, 2013). This paper presents the findings from a selection of two case studies that aim to deepen our understanding regarding how energy management is carried out within "high energy efficient" rated school buildings in Norway. Central to this approach is the development of an activity-centred framework which facilitates identifying potential areas for collaboration between the different user groups that use, operate and manage the building. Findings from this study are complementary to current academic and industry efforts seeking to maximize energy efficiency gains through building occupant engagement.

1.1. Impact of building occupants on the energy performance of facilities: the need for end-user (occupant) engagement.

A report issued by the International Energy Agency (IEA, 2013) identified six key factors influencing building energy consumption, 50% of which can be linked to human interaction, including: a) building operation and maintenance; b) occupant activities and behaviour and; c) indoor environmental quality. Main areas of interaction between users and buildings include lighting, appliance electrical loads, ventilation, space heating, space cooling and domestic hot water (IEA, 2013, Demanuele et al., 2010, Hong et al., 2013). Nicol (2001) concludes that the use of controls in the building is linked: to climate conditions, particularly outdoor temperature, and to physical conditions related to user comfort, such as the need to improve indoor air quality. Haldi et al. (2008) present an overview of studies which led to further development of Nicol´s behaviour prediction model. Knowledge on occupant behaviour can lead to better energy prediction models, avoidance or at least minimization of interactions between building occupants and energy consuming systems. Occupancy patterns have been shown to have an impact on the energy consumption of buildings. Many studies have indicated that often buildings use a significant amount of energy after regular working hours (Bordass et al., 2001, Hoes et al., 2009, Menezes et al., 2012, Korjenic et al., 2012). The effect is felt most in buildings with large plain open spaces, as many of the energy consuming systems (e.g. HVAC, lighting) have to be kept on running on full system capacity just to provide basic working conditions for few people. Different analytical approaches can be used to evaluate impact of building occupants on energy use, including building simulation, site survey and a mixture of both of these approaches. Menezes et al. (2011) make use of Post Occupancy Evaluations (POE) to gather detailed data on the performance of a multi-tenanted (four tenants) office building in the UK. The data gathered is fed to an energy prediction model. Findings highlight that the differences in energy use between the tenants are linked to their particular organizational management styles and context relevant activities. It is reasonable to argue that buildings equipped with the state of the art of EE technologies, provide conditions that can minimize and even annul the impact of the building occupants on energy consumption. However, as pointed out by Stevens (2001), such a system would need to prove effective in keeping up with fast changing user demands for comfort. In addition, many studies on occupant satisfaction have shown that end-users become increasingly dissatisfied as their ability to manipulate their working environment is restricted (Galasiu et al., 2006, Hoes et al., 2009), and will often find ways to intervene the systems (Aune et al., 2009, Menezes, 2009, Morant, 2012). Aune et al. (2009) states: *"... even if user-interfaces are automated with intelligent systems, unexpected user actions, such as creative adaptation or even outright sabotage of systems, are frequent."* In this paper we support that end-users are to play a role in supporting the delivery of energy management practice. End-user engagement approaches are to be part of energy management practice. The benefits from end-user engagement must be perceived beyond the boundaries of energy performance, to include: better educated users, fewer interventions from users on building system and improved collaboration dynamics between end-users and facilities managers.

1.2. FM´s contribution to the delivery of high energy performance in non-residential buildings.

The FM industry deals with a great set of strategic management competences, including: Real estate management, financial management, organizational management, innovation and change management and human resources management (Atkin & Brooks, 2015). The European Standard for Facilities Management (EN15221-1, 2006) defines FM as the *"integration of processes within an organization to maintain and develop the agreed services which support and improve the effectiveness of its primary activities"*. Expansion of the FM industry is primarily driven by the need of organisations to remain competitive in an increasingly regulated business environment. In the built environment, the practices of sustainable production and service delivery are becoming progressively more legislated. Comparative energy performance measurements for buildings over specified floor area have been mandated (Atkin & Brooks, 2015). The strategic position of FM in driving the sustainability agenda at the building level has been acknowledged (Elmualim et al., 2012). The delivery of energy management practice is a service that the FM profession can provide (Junghans, 2013). Novakovic et al. (2012) adopt the energy management definition provided in the report "Energiledelse- Veileder for etablering og drift" (Energy Management – Guide to establishment and operation): *"Energy management is that part of a company´s leadership responsibility that ensures that the energy is used efficiently"*. This definition falls short in failing to address the aspect of on-site energy production. Novakovic et al. (2012) also describe the roles of building owner, property managers and building users from a building and property management perspective. The strategic, tactical and operative levels at which the facilities managers interact with the organization have been theorized (Atkin & Brooks, 2015, Junghans, 2015, Novakovic et al., 2012). It remains unclear whether FM service providers embrace these theoretical models in the delivery of energy management service. The case studies in this project have been collected as part of a larger inter-disciplinary project called MINDER (Methodologies for Improvement of Non-residential buildings Day-to-day Energy efficiency Reliability). MINDER brings together the disciplines of Social Science, Design and Facilities Management, in the delivery of methods that can contribute to narrowing the EPG. The case study framework builds on the findings from a survey delivered in August 2014 which targeted representatives from 49 member organizations from a well-established Norwegian network for Real Estate and Facilities Management (See Valle & Junghans, 2015). Among other issues, the survey highlighted split opinion amongst FM practitioners regarding the impact of building occupants on energy consumption. Most facilities managers at the strategic level perceived that end-users do not have an impact on energy consumption.

2. Methodology

The aim of the case studies is to provide in-depth knowledge on the actual process of energy use and management in non-residential buildings in Norway. Semi-structured interviews are at the core of the process of data collection. Interviewees include representatives from building occupants, facilities managers (operational, tactical or strategic), and building owners. The case study framework is based on the deconstruction of the methods considered to be best-practice in the management of energy in non-residential buildings. This approach was developed during the design of the survey that precedes this study. The process is guided by the understanding that a method can be described as the sum of the actors, processes, tools, competences and outcomes required to meet an objective (See figure 1):

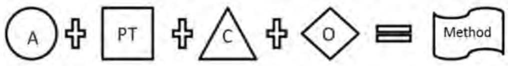

Figure 1. Model for the deconstruction of any given energy management method

- A= Actors. Refers to the key stakeholders involved during the lifecycle of a given method.
- PT= Processes & Tools. Series of actions and functions put in place to bring about a result.
- C= Competences. Range of skills, knowledge and abilities required to implement an action.
- O=Outcomes. Specific objectives of the method, either at a particular stage or as a whole.

From this perspective, it is possible to gain in-depth knowledge about particular actors, processes, tools and competences, to an extent where the risk of adoption or rejection of these individual elements within a particular context can be appraised. The strengths and weaknesses for each of the parts can be studied, and the threads which describe the relationship between the parts can be enquired. Based on the previous, a structure for the case study framework was produced and aims to gather: a) knowledge of the interviewee on the level of energy ambitions of the building; b) perception of the interviewee regarding the people who she/he perceives to have the most impact on the energy consumption and management in the building; c) Perception of the interviewee regarding the activities that she/he perceives to have the most impact on the energy consumption and management in the building; d) Perception of the interviewee regarding the people, processes, tools, competences and desired outcomes influencing delivery of energy relevant activities, and; e) knowledge of the interviewee on energy data routines, including how energy data is collected, stored, analyzed, communicated and used for improving the energy performance of the building. The latter aspect is only addressed with the person responsible for the day-to-day operation and monitoring of the building. For this study, only interview data relating to the activities that each of the interviewees considers relevant to the management and use of energy in the building was extracted. Identifying activity-based context is enabled by the data collection approach, which specifically asks from interviewees to discuss their understanding of energy management and energy use, within the context of the activities relevant to their day-to-day use of the building.

2.1. Case study selection

The criteria behind the selection of the case study buildings are: a) high energy performance buildings: The probability of learning about comprehensive energy management strategies and energy data routines is assumed to be highest among buildings with expressed high energy performance buildings. In addition, one is able to learn about end-user and FM perceptions in the context of highly automated buildings. Buildings complying with passive house standard (Passive House Standard NS3700/3701) were selected; b) significant energy saving potential: The sample is to be contained within the group of buildings considered to have the largest energy saving potential in Norway. The objective is to create solutions that have the potential to significantly reduce energy use from the perspective of the Norwegian building stock. The top three non-residential building types meeting this criterion in Norway are retail, office and school buildings, and; c) private and public buildings: The sample must facilitate comparability between energy management approaches from the public and private sector, as well as between similar building types. In this sense, eight buildings were selected, belonging to either office or school facilities (four from each group). This paper discusses the findings from two “passive-house” certified school buildings in Norway. The buildings are owned by different municipalities (“A” and “B”). The building owners sit at the level of the municipality, from where the energy management process is directed. Municipalities define their own energy management strategies according to their needs, knowledge and understanding of the energy management process. Municipality “A” assigns approximately one caretaker for every three of the 60 buildings in their portfolio (23 caretakers). On the other hand, municipality “B” looks over 41 buildings between kindergartens and other educational facilities. Within municipality “B”, five building operators are trained on energy management aspects and oversee small clusters of buildings within the municipality´s portfolio. Rotation amongst operators is dependent on the knowledge and skills required to care for a particular building. Both passive-house projects were developed as annexes to existing building structures.

2.2. Analysis

This paper develops around the study of the activities that each of the interviewed user groups consider to be most relevant to the use and management of energy in the buildings they occupy, operate or manage. These images are used to identify missed opportunities for stakeholder integration in the context of the energy management process. This is an exploratory study, and findings are limited to the context of the buildings under study. Information on energy data routines is used to assess the extent to which energy data is used to support the high energy ambitions of the buildings.

3. Findings

First, the perspectives from all user-groups belonging to School Building "1" (SB1) and School Building "2" (SB2) are presented. Then, a brief description of the energy data routines as implemented by each of the municipalities is provided.

3.1. School Building "1" from Municipality "A"

The teacher and the director | representing the building occupants: Dancing and working with pupils are two of the main activities that the teacher perceives as relevant regarding the management and use of energy in the building. The first activity (i.e. dancing) was connected to energy consumption through the understanding that ventilation systems have to work harder in order to improve the quality of air: *"when we use this area outside here and we are dancing we can feel the air is with sweat and then the ventilation has to go faster to clean the air, so that's an impact".* Working in rooms with small groups of pupils was directly connected to the need for additional heating. The teacher informs that when rooms are used below their normal occupancy level, it takes much longer for the temperature to stabilize at the desired set-point. From the teacher´s perspective, it is likely that this lag (i.e. the time in between the room is taken in use and the moment it feels warm enough) is consequence of a faulty or unbalanced heating system. Staff meetings were also indicated as activities with the potential to influence energy use in the building, as crowded meetings often result in poor air quality. As a result, participants turn to opening the windows as means to improve both the quality and temperature of air in the room. The director finds it difficult to connect her day-to-day work routines with energy relevant activities in the building. In turn, she narrates how teaching and "health & safety" meetings can have an impact on both how energy is used and managed in the building. With regards to teaching, the director argues that perceptions from both teachers and pupils regarding room temperature can be described as signals that lead to the adjustments of the building systems (e.g. heating and ventilation systems). Staff meetings were indicated by the director as the activity with most impact on how energy is managed in the building. Unlike the teacher, the *director* does not refer to the quality and temperature of air in the meeting rooms; rather, she comments on the opportunity to communicate about pressing matters regarding building use and staff concerns. Meetings are attended by staff representatives from different areas, including teachers, building operators, cleaners and union representative. The director comments on opportunities for integrating knowledge about the building´s unique energy features into day-to-day school curriculum; however, in practice, discussions about energy use and management are limited to complaints about indoor temperature, and rarely about initiatives aiming to improve the energy performance of the building.

The caretaker | representing the facilities manager at operational level: The caretaker comes from a background in general maintenance. Maintenance routines and building monitoring through the building management system (in norwegian: Sentral Driftskontroll or SD) are the two main activities indicated by the caretaker as relevant to the management and use of energy in the building. From his perspective, the first activity (i.e. maintenance routines) is considered to have the most impact on energy consumption in the facility. Reactive maintenance represents a significant component of the caretaker´s daily work. The caretaker indicates that the automated systems in the building were designed and commissioned to maintain an adequate balance of the building energy systems. In this sense, the caretaker fully relies on how the building systems were programmed by the contractors during the handover phase of the building. Accordingly, his role is primarily focused in providing timely response to the alarms generated by the building management system :*"I have some alarms on my SD that tell me if something is wrong… so I do this thing, that's mainly my job".*

The "Cost-focused" Energy Manager (CBO) | representing the building owner and strategic facilities manager: The role of the CBO is that of overseeing the technical aspects of the portfolio of buildings owned by the municipality "A". The CBO accredits most of the energy used in the building to activities which do not take place within the new passive-house portion of the school, but rather on adjacent community-shared spaces (e.g. use of pool and sports centre). The CBO speaks of the facilities and installed energy systems as finished products, meaning that they have been designed, implemented and currently work as intended. In this context, the CBO indicates that the energy efficiency of the building can only be raised by improving the work routines of the caretaker and increasing the energy literacy of all individuals who occupy the building. Energy use in the building is monitored through the monthly assessment of energy bills. In this sense, the municipality only initiates an action for a particular building when the electricity bill for a given period is perceived to be significantly higher than its historical value.

3.2. School Building "2" from Municipality "B"

The educator and the staff representative | representing the building occupants: The *educator* has been working in the passive-house building since it was handed over by the municipality "B" to the school staff. In addition to teaching, he is also part of a managing team that helps to steer school affairs. When asked about activities that impact on how energy is used and managed in the building, he refers to the use of computers by the pupils as well as to the automatic blinds. In the context of computers, the educator comments that equipment with long-battery life is preferred so as to reduce the amount of time used by students in charging their computers: *"...when you have a class you don't want them to be using the charger in the classroom, you want them to take the computer and use it without interrupting*." In this sense, he clarifies that the school's procurement strategy for computers does not aim to reduce energy consumption, but to minimize disruption of classroom activities. In terms of automatic blinds, the educator indicates that the system is meant to reduce energy use in the building; however, he perceives that the functioning of the system is not aligned with that of a school building, with the blinds often interrupting classroom activities. School staffs have demanded that control over the blinds is shifted from the municipality back to the building level. The *staff representative* fulfils a leading role mandated by national health & safety regulations, and acts as key mediator between school staff and the municipality. Ventilation is recognized as the activity with the highest impact on how energy is used in the building. She discusses ventilation in the context of community oriented activities that the school is mandated to accommodate for. The staff representative indicates that many of these services must be provided for free to community members. In this sense, ventilation is perceived as an increasingly requested and energy intensive service which impacts on the energy use and financial bottom-line of the school. The use of windows by building occupants is perceived to be the second most energy intensive activity in the building. The staff representative comments that she is not aware of the impact that opening the windows can have on the overall energy consumption in the building; however, she perceives that freedom to manipulate the windows is necessary as the building is not able to provide a consistent level of air quality.

The building operator | representing the facilities manager at tactical level: There are two aspects which dominate the conversation regarding how energy is managed and used in the building: First, the implementation of adequate automation and building management systems (BMS), and; second, the development of a solid energy metering strategy. The building operator perceives that organizations lacking well trained and knowledgeable staff regarding both of these aspects (i.e. BMS and energy data strategies) are at great disadvantage. Keeping up to date with the advances of technology is perceived as one of the most important aspects in supporting a highly energy efficient environment. In this sense, he argues that in line with current advances of technology, there is nothing else at the time that the municipality can do to improve energy use in the building.

The "System-focused" Energy Manager (SBO) | representing the building owner and strategic facilities manager: The SBO indicates that the most important activity regarding the management of energy in the building is the use of the BMS to monitor the operation of the building's energy systems. In turn, the focus is not to optimize the performance of specific energy systems, but to provide rapid response to the alarms generated by the BMS. Standardization of management systems across the building portfolio is perceived as essential: *"we are the only municipality in Norway with one system for all of our buildings… the absolutely most important (is) you have a system (all) people can use".* The frequency and extent to which the building is used by building occupants is considered to have a strong impact on energy consumption. The SBO indicates there is a gap between the occupancy levels defined in the national building standards for school buildings and the actual use of the school facilities. However, the SBO does not perceive this to be a problem since the building was designed to be used.

3.3. On energy data routines

Municipality "A" | Cost-Focused Energy Management: The building owner (CBO) from SB1 is unaware whether specific energy consumption goals are set for the building. Energy data are registered both by the caretaker by taking readings from the main utility meter, and automatically through a set of sub-meters which measure the energy used by the ventilation, heat pump and domestic hot water systems. Data generated from sub-meters are neither stored nor used. From the data that is collected (either manually or automatically), it is not possible to differentiate between the energy used by the existing building versus the new "passive house" facility. Further breakdown of energy use between different spaces (or uses) is not something the caretaker considers to be an advantage. On a yearly basis, the caretaker reports on the energy consumption of the building. Two actors demand this report: a) the municipality, with the purpose of validating the energy bills as issued by the utility company, and; b) a state owned agency that provided significant funding for the delivery of the passive-house portion of the building. Issues relevant to poor heat pump specification and the difficulty to separate energy use between existing and new facility are often included in reports to justify the building´s underperformance with regards to design intentions. On behalf of the caretaker, the difficulties experienced with the energy systems have led him to lose trust regarding how these systems are supposed to perform.

Municipality "B" | System -Focused Energy Management: The metering strategy implemented by the building owner (SBO) of SB2 follows the recommendations from the Norwegian Standard NS:3031 "Calculation of energy performance of buildings - Method and data". Energy data are collected from the main utility meter and a set of sub-meters, which register the energy consumed by specific systems, including: hot water, ventilation, lighting and technical equipment. The latter includes electricity sockets and computers used by the staff and pupils in the school. This approach facilitates identifying how much energy is used from extra-curricular activities, particularly during the summer when energy consumption from school-relevant equipment should be at minimum. Too much metering within a particular building is perceived to hinder the ability to take good decisions in support of the performance of the building portfolio. Seasonal energy profiles are used to benchmark energy performance data against previous years. Benchmarks are used to identify the building or group of buildings in the portfolio requiring primary attention. Alarms are raised when the performance of a particular building differs from its own performance on previous years. At that time, the SBO drops to the building level and evaluates what can be done to correct a particular issue. Comparing the energy performance between different school buildings in the system is possible; however, it is not a practice considered relevant within the municipality´s energy management approach.

4. Discussion

4.1. Perspectives from same user groups in different buildings

Perception from building occupants (as represented): both the teacher (from SB1) and educator (from SB2) relate to the management and use of energy in their buildings in the context of issues circumventing their daily work with pupils. Their focus is stronger on activities which impact on the consumption rather than the management side of energy in their buildings. Arguably, automated blinds are the only technical aspect discussed as a central activity; however, emphasis is placed on the disruptive impact that the lack of control over the blinds has over the educational activities that take place in the classrooms. As the level of responsibility increases, roles such as that of the staff representative and director embrace responsibilities relevant to stakeholder mediation and strategic thinking. Value is placed in seizing the opportunities created by the building´s unique energy efficiency qualities to further support the educational program. Awareness about impact from activities which fall outside of the building´s core function (i.e. community oriented services) is held at leadership or staff management levels. Broadly, building occupants perceive the use and management of energy in the building as a necessary expense for meeting a desired comfort level and achieving the school´s organizational objectives.

Perception from operational and tactical facilities managers (as represented): The differences in background and work experience between the caretaker (from SB1) and building operator (from SB2) seem to influence their understanding of and approach to energy management. With regards to the first, lack of sufficient knowledge regarding how the building energy systems are meant to operate may limit his ability, and arguably his willingness, to extend his role beyond providing reactive maintenance to the systems in place. In turn, the caretaker builds upon his current strengths (i.e. maintenance background) and focuses his attention on securing that the building systems operate as design intentions. Conversely, the building operator comes from a building automation background. He discusses the use and management of energy in the building from an integrative perspective; this is, through acknowledging the value of technologies (e.g. automation systems), supporting strategies (e.g. energy metering) and the training and knowledge required to seize energy saving opportunities. It can be said that both representatives (i.e. caretaker and building operator) understand the use and management of energy as a product of the technologies in place and the routines required to keep them functioning at optimal capacity.

Perception from building owners and strategic facilities managers (as represented): Both representatives (i.e. CBO and SBO) are responsible for the performance of a cluster of public buildings; in this sense, both relate to the use and management of energy in terms of scalable strategies that can be implemented across their building portfolio. The CBO and SBO hold contrasting views regarding the areas considered critical towards further improving energy use in their facilities. For example, the CBO focuses on activities aimed at developing the knowledge and skills of those who use and operate the building. Arguably, this view is enforced by CBO's perception that the building currently performs as intended; however, from the data gathered on energy metering routines, it can be said that the energy performance of the building has not been properly assessed. On the other hand, the SBO discuss the use and management of energy strictly from a technical perspective. The SBO acknowledges the impact of building occupant activities on the energy consumption in the building; however, the SBO rejects responsibility over the implementation of strategies aimed at managing the interactions between users and the buildings they occupy.

4.2. Perspectives from different user groups within the same building

Different user groups relate to the management and use of energy in the context of the roles, and consequently the activities, that each group embraces. One important aspect to discuss is the focus or objective that brings together the bundle of activities mentioned by each user group. In order to simply this task, this study asks: Is the focus of the activities related to the building´s core function or is it related to the building´s energy performance?

Figure 2 maps for each school building, the relationship between and focus of different user groups in the context of the activities that they consider relevant to the use and management of energy in the buildings they occupy or manage. The "Y" axis represents how much of the focus of the activities discussed is related to the building´s strategic function, and the "X" axis reflects how much of the focus is related to the actual energy performance of the building. As illustrated, building occupants relate strongly to activities aligned with the core function of the building i.e. support the effective delivery of educational and recreational activities. Their perspectives are disassociated from that of the people responsible for the operation and overall management of the building, whose primary aim is to support the continuous operation of the building. Within SB1, the activities carried out by both the caretaker and CBO can be perceived to have slightly more focus on energy performance than that of building occupants.

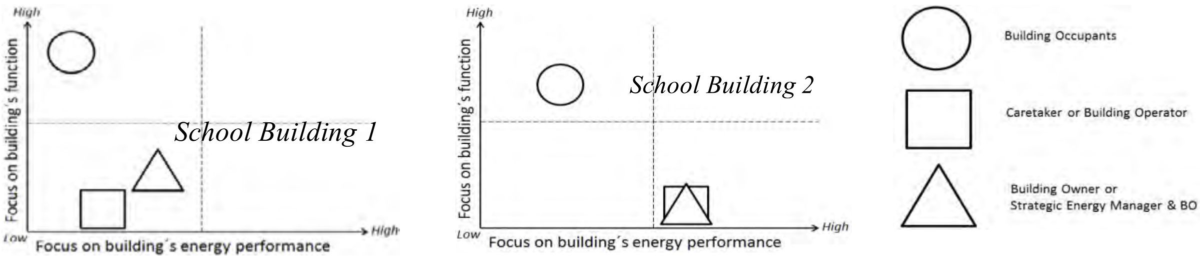

Figure 2. Images which mapping the relationship between and focus of user group perspectives on energy management practice from an activity-centred perspective.

However, energy data routines suggest that the lack of strategic guidance translates into operational routines that seek to minimize day-to-day disruption rather than support the building´s high energy ambitions. In SB2, energy management service is delivered with a solid technical foundation and larger focus on the building´s energy performance (when compared against SB1). With an energy strategy based on national standards, the SBO ensures that the knowledge and experiences gained through the management of one building are more readily applicable to the rest of buildings in the municipality´s portfolio. However, it can be argued that energy strategies that are designed uniquely from a portfolio perspective may fail to support individual buildings in achieving their particular high energy ambitions.

5. Conclusion

This paper described how representatives from different user groups (i.e. building occupants, facilities managers and building owners) relate to the use and management of energy within the passive-house school buildings that they occupy, operate or manage. Although contrasting views regarding energy management strategies were identified within the two buildings under study, strong similarities were identified with regards to how building occupants relate to energy issues on a day-to-day basis. Building occupants have a strong focus on supporting the building´s core function. This creates an opportunity for setting areas for collaboration between facilities managers and building occupants; in particular, collaboration is encouraged around the activities which building occupants consider as most relevant to the use and management of energy within the specific building they occupy. Further research will expand the set of case studies to include office buildings and investigate, among other issues, the attitudes from building occupants, operators and building owners to collaborate on EE aspects within highly automated buildings.

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Approaches to Safeguarding Sustainability Requirements in Public Construction Projects – the Client's Perspective

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Abstract

In recent years, the concept of sustainability has penetrated much of modern political, social and industrial discourse. Its recent popularization, stemming from the Brundtland report of 1987, has led to sustainability becoming a household term in nearly every industry, of which the construction sector is no exception. Considering the importance that sustainability has in the construction industry, and how it is particularly emphasized in construction financed by public funds, questions need to be raised in terms how capable the construction client is in meeting and achieving the sustainability requirements, often set by politics, that exist whilst safeguarding project delivery. The study is based on four interviews targeting public clients in Sweden and it investigates how sustainability requirements are managed in large public construction projects. What is of particular interest is the degree to which public client organizations either develop or procure systems/staff to ensure that the criteria for social, environmental and cultural sustainability are maintained and that the consequences of different approaches are managed. The results support the idea of having a multifaceted approach to sustainable construction, arguing that terms such as social and cultural sustainability may instead be dealt with separately from the more strictly defined sustainability terms of toxicity, waste and energy consumption. There is also a suggestion that once the client organization begins incorporating a sustainability mind-set in all of its affairs, members of that organization may begin working with sustainability on a perfunctory basis without necessarily understanding the underlying reasons for their actions. Finally, the challenge with sustainability is perhaps not so much that there is a lack of capability as much as there is a lack of resources for working with sustainability.

Keywords: sustainability, public client, requirements, capability

1. Introduction

It would be hard put to find an industry which does not find itself affected by the requirements that follows from the sustainability concept. As a strategic issue, sustainable development alongside social responsibility are now important considerations for companies in nearly every industry (Fiksel, 2006). In light of the movement toward sustainability, it has become commonplace for governmental institutions to conceive of grand visions and plans relating to sustainability, but as Wheeler (2000) points out, these are unlikely to come to fruition absent the necessary external pressure from social movements, nongovernmental organizations and the development of a coalition of interest that serves to strengthen the necessary political backing. More significantly, while there has been strong interest in sustainability as it relates to urban development, there has been a lack of clarification as to what constitutes as sustainable in the public construction context, most notably in relation to infrastructure projects. Questions regarding how sustainability can be quantified and the key contributors of sustainability in the urban context have all, to a large degree not been dealt with (KPMG, 2012).

Sustainability in construction is a comprehensive topic with many different facets; it includes a range of topics from air, water and noise pollution to ecological impacts (Shen, et al., 2007). Time delays have a direct impact on sustainability since as an increase in project delivery time is associated with traffic congestion, economic activities being disrupted, increased pollution, damage to ecosystems, and an impact on existing infrastructure systems (Gilchrist & Allouche, 2005). The sheer scale of the industry offers further testimony to the importance of considering the impacts of sustainability. In the European Union alone, it is estimated that the construction industry employs 11.8 million people directly, making it Europe's largest industrial employer accounting for approximately 28 % of industrial employment in the EU-15 (Ortiz, et al., 2009). In addition to this, the construction industry is responsible for nearly 40 % of the total energy consumption thereby cementing its role as a major contributor to the proliferation of greenhouse gas emissions (Abbas, et al., 2009). By the same token, the construction sector is responsible for other types of environmental problems, including both internal and external pollution as well as environmental damage and resource depletion (Ortiz, et al., 2009). With steadily rising populations, and significantly larger shares of people relocating to cities as urbanization rates continue to soar, one can only expect the environmental impact to become further exacerbated in the years to come. This sentiment is certainly shared by the UN as shown in a recent report stressing the sustainability challenges that continued urbanization will pose on society and its disproportionate effect on urban dwellers in the lower socio-economic strata (UN, 2014).

Contractors and consultants are primarily concerned with financial gains. It is therefore hardly noteworthy that these actors opt to adhere to sustainability regulations on the basis of it being a secondary concern. After all, current research shows no direct correlation between short-term business competiveness and sustainability performance although there are certainly grounds for contending that such an advantage could emerge from a long-term perspective (Tan, et al., 2011). It has been a standard belief among contractors that environmental performance accrues more costs than the proposed benefits it brings. Despite this, improvements in environmental performance in construction has been on the rise, specifically with respect to the handling of waste and its harmful effects on the environment (Shen & Tam, 2002).

This leaves the public client, the one actor whose prime objective is to represent the public interest of which the concept of sustainability plays an increasingly more important part (Raisbeck & Wardlaw, 2009). There has been a growing interest for investigating the role that the client has in relation to sustainability. Although there is no shortage of studies investigating the client's role in this regard, the research space has been dominated by studies focusing on sustainability policies that occur at a macro-level, in the realms of politics. This is made evident by likes of Chen and Chambert (1999), Deakin et al. (2002) and Melchert (2007). The importance to address sustainability at this level seems fairly intuitive due to the vast influence of governmental institutions, its importance is thus hardly a matter of contention. The study of sustainability related issues at a lower level than that of politics, as in examining the role of local public client organizations, does not occur in lieu of studying the political level but rather in addition to it. It is vital to ensure that sustainability issues are properly managed by the public recipients of said policies just as it is important for the policy makers themselves to formulate sensible requirements. Authors such as Ugwu and Haupt (2007) and Bröchner et al. (1999, p. 371) have examined the usefulness of the performance concept vis-à-vis sustainability and in the case of the former found that indicators for sustainability performance constitute an important first step in bridging the gap between global sustainability aspirations and local micro-level decision-making; and in the case of the latter that "there is an inescapable need for competence among those who formulate, monitor and follow performance requirements." This echoes the broader call that has been made for improving the capabilities of the client organization (Adam et al., 2014; Manley, 2012). In light of this inescapable need for competence, questions need to be raised in terms how capable the construction client is in meeting the sustainability requirements that are often dictated by politics without jeopardizing project delivery. This study attempts to address this inquiry. What is of particular interest is the degree to which public client organizations either develop or procure systems/staff to ensure that the criteria for social, environmental and cultural sustainability are maintained and how the consequences of different approaches are understood and managed.

2. Research method

The study is based on a set of interviews targeting public clients in Sweden and it investigates how sustainability requirements are managed in large public construction projects. What is of particular interest is the degree to which public client organizations either develop and organize or procure systems/staff to ensure that the criteria for social, environmental and cultural sustainability are maintained and that the consequences of different approaches are managed. In order to investigate this, a large public Swedish client organization was studied, henceforth referred to as PubClient. The study consisted of interviewing the manager responsible of energy and environmental related concerns. The results of the one-hour interview took place in one the facilities of PubClient and were then transcribed and analyzed. Additionally, three supplementary phone interviews were conducted for three different client organizations active in the Swedish construction industry. The objective of these phone interviews was to provide additional information and also assess to which degree the results obtained from PubClient were relevant in other public construction client organizations. Although a small sample of interviewees, the respondents were all representatives on a management level in a large city and thus covered the main organizations in this particular context. There is a risk of low validity of the data, however, as one key aspect of the data is descriptive the complementing telephone interviews can be seen as triangulation of the main interview data.

2.1 Overview of PubClient

PubClient procures and manages the construction of public facilities and the refurbishment of facilities on behalf of the municipality. With a combined floor space exceeding two million square meters and a total land area exceeding five million square meters, PubClient stands as one of the nation's largest public construction organization with a yearly expenditure hovering around one billion SEK. PubClient objectives include a variety of tasks, the main ones can be reduced to five:

i. Ensure good property management, which includes the management of land, buildings, installations and maintenance.
ii. Provide appropriate business premises and good service.
iii. Develop energy-saving measures.
iv. On behalf of the municipal government and customers, plan and build/rent new facilities or rebuild existing ones.
v. Administratively coordinate the Municipality's common building processes.

Aside from stating energy saving measures as one of its chief objectives, PubClient has consistently worked to initiate environmentally conscious procedures in all of its projects. This is due to a number of reasons, chiefly that they as a public organization should "do good" as they build and run their own maintenance with a long time perspective. Beginning from 2009-2010, all of PubClient's newly built facilitates were required to be of the low-energy consumption variety. This follows a larger trend in the country of building facilities that utilize less energy and that are more environmentally friendly. However, what sets PubClient apart in this area is not merely its scrupulousness in following government stipulated regulations but its insistence to follow internal regulations that are even more stringent than those demanded by the government. As such, the organization has received accolades for its role in actively working with sustainably issues in all of its affairs.

3. Sustainability as a concept

The modern concept of sustainability is based on the Brundtland commission report of 1987. It cemented the importance of sustainability in social and environmental affairs and gave birth to the commonly accepted definition of sustainable development as the development "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Toman, 2006, p. 3).

Not long thereafter, the rising discourse on sustainability began to find its place in the area of construction. It also began to alter the established nomenclature, terms such as “green” building, became readily available and began to be associated with a number of positive outcomes, from lower overhead costs to higher employee productivity. This development can trace its origins to the idea of “sustainable construction”, a term coined in conjunction with the first world conference for sustainable construction held in Tampa, Florida in 1994 (Miyatake, 1996). It was there where Kibert (1994), the convener of the conference, suggested that sustainable construction consisted of six principles: I). Reducing resource consumption. II). Improving resource reuse. III). Begin using renewable or recyclable resources. IV). Safeguard the natural environment. V). Maintain a healthy, nontoxic environment and VI). Strive towards achieving quality in construction.

Like much of the discourse surrounding sustainability, the term sustainable construction has been contested. Tough widely adopted by the construction community, as exemplified by the works of Ding (2008), Hill and Bowen (1997) and Kibert (2012) it has not been without detractors. Much of the critique rests on the apparent incompatibility of the phrase “sustainability” on the one hand which carries the connotation of something infinitely replenishable and the term ‘construction’ on the other hand which is by its very nature finite (Goodland, 1995). In order to avoid potential semantic disputes of what sustainability actually refers to and how it ought to be conceived in the context of construction, we opt for the definition put forward by Presley and Meade (2010) where sustainable construction is used to describe not only the construction phase of the actual projects but also all of the aspects surrounding it such as those imposed on social systems, transportation, waste management and so forth. The term ‘green building’ is used interchangeably, as is conventionally the case (Kibert, 2012; Presley & Meade, 2010; van Bueren & Broekhans, 2013).

3.1 Systems for complying to sustainability criteria

A range of different methods/systems have been developed to allow construction organizations to build in accordance with sustainable construction. These frameworks, such as the one developed by Presley and Meade (2010) is geared primarily toward contractors as a way to evaluate their sustainability performance by taking into account both strategic and activity-based criteria using well-established practices such as activity-based management, balanced scorecard, and multi-attribute decision models. Similarly, various organizations have begun issuing certifications ensuring that its holder have met certain criteria for the energy consumption of the building project as well as its water use, material use and indoor environmental quality. In Sweden, FEBY provides one such framework. Other certifications include, among others: Green Star (Australia); LEED Canada (Canada); DGNB Certification System (Germany); IGBC Rating System (India); Comprehensive Assessment System for Building Environmental Efficiency (Japan); Green Star NZ (New Zealand); Green Star SA (South Africa), BREEAM (UK), and LEED (US) (Azhar, et al., 2011). In a similar vein, Environmental Management Systems (EMS) have become a significant tool for achieving sustainable development in construction. As important as it may be, one should be weary of treating it as a panacea. Although EMS have been linked with a positive influence on environmental outcomes, it is also apparent that abiding by an EMS alone is not sufficient in guaranteeing optimal environmental performance (Lam, et al., 2011). Aside from its apparent use as a way to improve environmental performance, these systems are also employed in order to maintain compliance with environmental regulations, curb environmental costs, reduce risk and train employees. Typically, an EMS contains guidelines on policies, goals, systems for handling information, task lists, emergency plans, audits, regulatory requirements, and annual reports (Christini, et al., 2004). Although numerous EMS have been proposed, none have had an impact as great as the ISO 14000 series. This series of standards emerged as a by-product of the General Agreement on Tariffs and Trade (GATT) negotiations and the 1992 Rio de Janeiro summit on the environment (Kein, et al., 1999). The ISO 14001 constitutes the standard for developing an EMS, the rest of the standards in the series offer guidance and supporting documentation. In total since the end of 2013, over 300,000 certificates for ISO 14001 had been granted in 171 countries of which China, Italy and Japan stood out as the most prolific receivers of certificates (ISO, 2013).

4. The clients' responses

The importance of upholding sustainable ideals, especially with respect to the environment has become of paramount importance for construction clients. In the case of PubClient, the interviewee insisted that public client organization need to be at the forefront of the sustainability issue leading the way for the other actors in the industry. The client, and the public client in particular has the opportunity to play a significant role in advocating for the benefits of green construction, both through regulatory mechanisms as well as through raising awareness of 'best practices' with green construction. The challenges in upholding sustainable construction lies partly in the vastly different skillset, resources and capabilities that are required when adhering to green construction principles (Mokhlesian & Holmén, 2012). However, for PubClient, this viewpoint was somewhat contested:

> A project manager is supposed to know lots of other things, why shouldn't they be able to know these questions [i.e. sustainability]? It's not that much... It's not like you need to be a chemist or anything. It's fairly basic capabilities that one needs. But one has a bit of... I like to say that sometimes the "environment ghost" is looming in the corner and as soon as it is about the environment, everyone is all: I can't do this! But then you start to talk about it: but it's about these things! O, but I think I've got this, is this all that is to it? I think that in my field, it [i.e. sustainability] must become a natural part of everyone's roles, to know these areas. (*Development Manager of Energy and Environment for PubClient*)

The main contention here being that although environmental issues may demand a different skillset, nonetheless, project managers are inherently expected to have a varied skillset. Why then should sustainability not fall under this already wide umbrella?

The challenge of capability improvement becomes an even greater concern when taking into consideration the emergence of the performance approach. This approach essentially shifts governmental regulations from specifying technical requirements for products and materials to instead specifying the desired outcome of those products. The performance approach has been described as conducive to increasing the propensity for innovation in that it allows contractors a higher degree of freedom in how they wish to meet the stated requirements (Pries & Janszen, 1995). The reason why the development of capabilities becomes a great concern in regards to the performance approach is due to heightened need for competence in expressing, interpreting and monitoring the requirements that have been stated in terms of performance. This argument is echoed by Bröchner et al. (1999) who further add that the performance approach demands both acquiring and managing technical, environmental and administrative knowledge. Additionally, test methods and acceptance criteria need to be defined, a process that requires competence. The construction client can thus tackle the issue of sustainability from different angles, depending on the level that is of interest. Essentially, these measure can be grouped into either external actions that relate to parties outside of the inherent organization or internal actions that seeks to address the organization's own internal procedures.

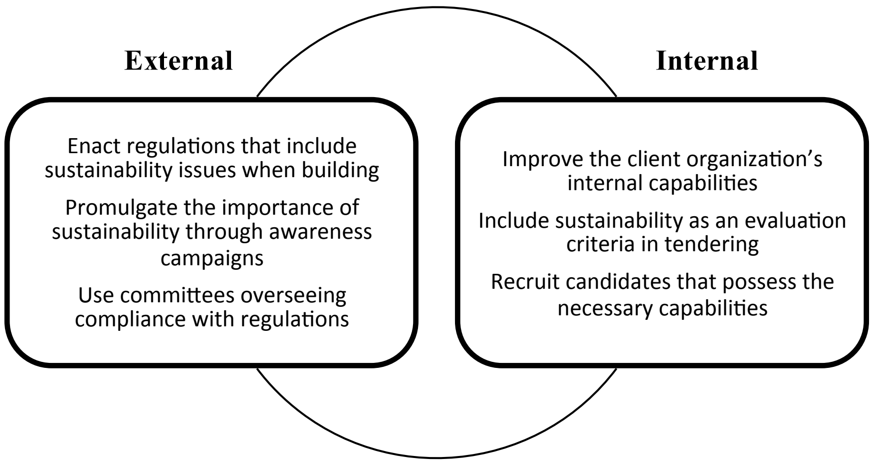

Figure 1: Approaches to safeguarding sustainability requirements, external and internal.

Bröchner (1999) as well as Mokhlesian and Holmen (2012) among others make the point that competence is at the heart of a successfully implemented environmental system. Building on this notion, one might take it further and state that the given EMS that the client organization uses is merely a reflection of its competencies. The more competent the organization and the individuals who partake in it, the more pertinent the environmental systems ought to be for its intended purposes. Therefore, it would seem that the optimal solution would be one that incorporates the different systems that are available to the client. It is not a singular holistic approach, but rather a diversified strategy that employs different systems where they are appropriate. This line of thinking goes against what seems to be the prevalent paradigm for clients in the Swedish construction sector where sustainability is often regarded as a monolithic issue, as made evident by the common structure of having widely different areas such as energy efficiency, toxicity, safety, social sustainability and cultural sustainability in the same division.

The latter two are particularly difficult to grasp as they seem to involve a subjective dimension which is more difficult to comprehend.

> It is as you say, a lot more difficult [to manage social/cultural sustainability]. It seems to be about primarily perceived values that are much more difficult to grasp than if one has used this type chemical or not, that's more black and white. (*Development Manager of Energy and Environment for PubClient*)

> You have no metrics [on social/cultural sustainability] what so ever. It is a bit of trumpery, really! The energy issues are a lot easier […] it is easier to place a metric on it. (*Environment and Energy coordinator for the Municipality*)

A proposed response to this is to specify separate personnel that deal exclusively with those issues or the more preferred option of creating an environment in which these sustainability considerations become an accepted part of the project manager's role.

> I feel that everyone still needs a lot of support in regards to environmental and energy related issues and [they] regard it as a separate issue whereas I would argue that it is a natural part of any type of role. In the long term, I would say that we need far less support for capabilities in those areas. As project managers, most environmental issues should be obvious. (*Development Manager of Energy and Environment for PubClient*)

This shift in mentality would essentially reduce or do away with specialized organizational units that deal with these issues. Instead opting for a solution where the project managers are expected to possess the capabilities needed to safeguard sustainability requirements themselves. This can also be viewed in light of the past changes that has occurred in the construction industry in regards to environmental concerns. Initially, such questions were often met with resistance by actors in the industry who questioned the soundness of more sustainable ways of building.

> The trend is essentially the same in the construction industry or the real estate industry. Although the public sector had even prior to this had it easier in discussing these types of questions, I think that there is a huge difference today. For example, energy-efficient construction, when we started there were many who did not believe in it at all, [claiming] you would construct bad buildings. That debate is surely not as prevalent. […] Now, I'd say that there's a great upswing regarding all these environmental issues for everyone. No one thinks it's weird to talk about biodiversity anymore which if you were to mention it in 2008, it was almost a bit nonsensical. But certainly in public organizations, I do not think that there is a single public [organization] that we have contact with, a property owner, who is not working with these questions and considers them important. (*Development Manager of Energy and Environment for PubClient*)

There are two notes that relate to this quote, firstly that although public organizations may be working with these issues, it would seem that the private sector has a more organized way of working as evident by one interviewee saying:

> Large [contracting] companies have worked with sustainability questions in a more structured way. (*Sustainability strategist for a municipal company*)

Secondly, that the state of the sustainability issue went from being something that is questioned to something that is obvious and part of every task in the organization. What occurred beyond this, however, shows a rather peculiar shift. Once environmental concerns had become a natural part of the organization, it was no longer viewed as a differentiating attribute of that organization. Initially, PubClient's project managers were fully cognizant of the importance of keeping sustainability in mind in all matters as this was a core issue that permeated much of the organization.

> There are a lot of new project managers [of ours] who can barely understand that we build the most energy efficient buildings in Sweden! We have very clear instructions and requirements [internally] and so on which they adhere to, but they do not get an understanding for what it is and what it really means. (*Development Manager of Energy and Environment for PubClient*)

From this, there seems to be an indication that as the organization becomes more capable in working with sustainability related issues, the more fluent it is in formulating stipulations and requirements to adhere to sustainability requirements. However, once the organization has worked with these issues for a sustained amount of time, they become part of the everyday mode of operation as opposed to something novel. This shift may then result in the members of the organization working with these issues in a perfunctory fashion without much forethought in why the work is carried out in the way that is.

Another reoccurring theme in the interviews was the tendency to regard the sustainability issue as one that could be easily managed if there was more awareness of the issue. The interviewees mostly rejected the notion that there was a lack of capability in the organization for how to work with the sustainability. There seemed to be an insistence on downplaying the technical skills required to work with sustainability related issues. Instead, they would point to a lack of awareness as the primary issue that needed to be addressed.

> Yes, I think so (i.e. that the organization is capable to handle sustainability issues). However, I do think that if one wants to get more results then there is a need for more people to work with these matters […] I mean it's not a difficult science […] I believe that the capability exists, that's my experience at least. If you look at [client organizations] in the city, I think there is tremendous capability […] we have knowledge, I think everyone knows what it is about. I don't think we can get more knowledge, it is about finding more in the organization and really go through with it and receive enough resources and

> money to be able to go through with it. (*Environment and Energy coordinator for the Municipality)*

Instead of viewing the challenge of sustainability as a capability issue, perhaps it should be viewed as a questions of resource allocation. In order to work with this issue in an efficient matter, more resources, basically, need to be allocated to it. Or, by embedding sustainability in everyday work it becomes a discreet capability, it becomes something that is simply a part of the everyday work's starting point.

5. Concluding thoughts

Sustainable construction is essentially an umbrella term that contains a wide range of different activities that aim to improve the production and the outcome of construction projects in a way that ensures that long term effects are considered. Not only with respect to the environment but also to society. Although issues such as waste management, noise reduction and preserving the biodiversity of a local ecosystem could all fall under sustainable construction, these issues have few things in common both in their technical details as well as their strict relevance to construction. This invites one to ask: does it make sense to feature social sustainability, cultural sustainably and environmental sustainability under the same department? Much of environmental sustainability can be measured in hard figures, particularly with respect to pollution, and could essentially fall under quality assurance, whereas social and cultural sustainability cannot be measured easily and are handled using more qualitative assessments.

This study would also suggest that although the capability required to manage sustainability issues does not necessarily need to be extensive, there is however a need for increasing the resources required for managing sustainability in a more efficient manner.

The construction industry's fragmented structure dictates that any change that occurs needs to do so in the entire supply chain of actors for it to have any fruitful effect on the industry as a whole. It would similarly seem that a multifaceted approach for managing sustainable construction would too require that the different actors be involved. Environmental issues are treated as constraints, a necessary evil that must be addressed instead of a factor of equal importance to that of financial concerns and project delivery. At the same time, it is important not to downplay the shift towards a more sustainability-driven thinking that has slowly but unrelentingly found its way into the practices of the construction industry. From energy efficient houses to methods of production that involve burning fewer amounts of fossil fuels. This is all commendable and few would argue the contrary. The point of interest lies in finding ways to continue the trend of incorporating and embedding sustainably to the operations of the organization. However, what this study shows is that when the client organization does so and working with sustainability issues becomes part of the established modus operandi, there is a risk that the members of the organization work with these issues in a perfunctory way without understanding what they are doing and why they are doing it. If this is a development that should be regarded as troubling or merely the expected culmination of incorporating sustainability in all affairs remains to be seen. What can be said however is that the increased incorporation of sustainability will significantly alter the way in which that organization operates and the way that it is structured.

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Engaging End-users for Sustainable Repurposing and Improved Occupancy

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Abstract

Vacant commercial facilities are an increasing concern in many developed countries. Despite the low occupancy rates in existing facilities, new commercial facilities that better accommodate the needs of modern end-users are constantly developed. In addition to financial concerns, under-utilized spaces are a great environmental burden, as buildings account for approximately one third of the global energy demand. One of the most effective ways to reduce the greenhouse gas emissions associated with buildings is to increase space-efficiency, namely, reduce the use of space. Repurposing existing facilities for a new use or a different end-user, does not suffer from the embodied energy and material use associated with new construction and major refurbishments. However, it can be argued that even a repurposing project may lead to significant waste of financial, natural and human resources if the project is unsuccessful, i.e., the facility remains under-utilized after the attempted adaptation. This study examines two Finnish repurposing projects with special focus on stakeholder management and engaging end-users. Both projects are investigated starting from the early design phase. The data comprises stakeholder interviews, and observation in a planning workshop. As the researchers actively participated in the workshop, the research is also partially action-based. This paper presents a model for identifying and engaging end-users to a repurposing project. The key finding is that, active participation in the design phase leads to a sense of ownership of the space, which in turn is thought to promote the efficient use of space and improve occupancy. End-user engagement and higher occupancy together would support all three dimensions of sustainability: social, environmental, and economic.

Keywords: repurposing, end-user engagement, project management, stakeholder management, sustainability

1. Introduction

Vacant commercial facilities are an increasing concern in many developed countries. For instance in the Helsinki Metropolitan Area the occupancy rates reached a record low level of 82% in 2014 (KTI 2015). Despite the low occupancy rates in existing facilities, new commercial facilities that better accommodate the needs of modern end-users are constantly developed. Moreover, new construction carries with it significant embodied greenhouse gas (GHG) emissions. Therefore, in addition to financial concerns, under-utilized spaces are a great environmental burden, as buildings account for approximately one third of the global energy demand. One of the most effective ways to reduce the GHG emissions associated with buildings is to increase space-efficiency. Numerous companies have adopted this measure in their sustainability program, in the form of reorganizing facility portfolios. The popularity of the measure is largely due to the relationship between cost-efficiency and space-efficiency, but the reduction in GHG emissions is also evident.

Repurposing existing facilities for a new use or a different end-user, is gaining support globally and is considered a more sustainable option than new construction (Bullen 2007; Bullen and Love 2009, 2010; Langston et al 2007). Repurposing does not suffer from the embodied energy and material use associated with new construction and major refurbishments. However, it can be argued that even a repurposing project may lead to significant waste of financial, natural and human resources if the project is unsuccessful, i.e., the facility remains under-utilized after the attempted adaptation. In line with the Toyota Production System (TPS) definition (Liker 2004), a failed project is considered 'waste' (Silvius and Schipper 2014). Therefore, and for the purpose of this study, a repurposing project is considered sustainable if it succeeds in engaging the intended end-users and, consequently, improving occupancy levels. Based on previous literature, a sustainable project requires proactive stakeholder management and engagement early on in the project (Aaltonen 2010, Bai et al. 2013). Consequently, this study looks at repurposing projects from the point of view of stakeholder engagement in the design process.

This study examines two Finnish repurposing projects, which both place special emphasis on end-user engagement in the project design phase. The primary data sources comprise stakeholder interviews, and observation. As the researchers actively participated in the workshop, the research is also partially action-based. A model for identifying and engaging end-users to a repurposing project is presented. The study finds that, active participation in formulating a joint vision and participating in the design phase leads to a sense of ownership of the space, which in turn promotes the efficient use of existing commercial buildings. However, based on the findings, end-user engagement in the early phases of the project is not enough, but engagement should continue throughout the project and during operations also.

The remainder of the paper is structured, as follows. The next section introduces the theoretical background for the research. The following Section 3 describes the study design, including a description of the cases, data collection and analysis. The findings of the empirical analysis are presented in the fourth section. The fifth section discusses the findings further, and the sixth and final section provides conclusions and suggestions for future research avenues.

2. Theoretical background

This paper utilizes two separate streams of research as a theoretical background for the study. First, literature on sustainable adaptive reuse of buildings is introduced. Second, the paper draws on previous work that has integrated sustainability into project management.

2.1 Sustainable adaptive reuse of buildings

Repurposing of facilities, where existing facilities are renovated for a new use or a different end-user, is gaining support globally and is considered a more sustainable option than new construction (Bullen 2007; Bullen and Love 2009, 2010; Langston et al 2007). Bullen (2007) identified several sustainable outcomes of an adaptive reuse process, including: reducing resource consumption, reducing energy use and emissions, extending the useful life of a building, cost-efficiency compared to demolition and rebuilding, reclaiming embodied energy, and revitalizing existing neighbourhoods, to name but a few (Bullen 2007).

Langton at al. (2007) discuss the obsolescence of a building and bring up six different types: physical, economic, functional technological, social, and legal obsolescence. The cases studied in this paper best suit the description of the functional obsolescence, where the buildings are no longer needed for their original purpose, and social obsolescence. Social obsolescence was particularly visible in the case of the new learning environment, where behavioural change had lead to changes in space requirements. When buildings become obsolete, Langston et al (2007) argue, they require either demolition or refurbishment. Bullen and Love (2009) develop a viability process model to aid the decision making process of building owners on whether to demolish or refurbish the buildings. The overall conclusion is that the decision should always be based on the individual characteristic of the building, and that no consensus exists whether adaptive reuse is always the most sustainable option (Bullen and Love 2009).

This paper utilizes the theoretical framework recognising the sustainability of reuse of existing facilities. Nonetheless, neither of the case projects represent the type of major renovations that are described in the previous sustainable adaptive reuse literature. The presumption is that, minor repurposing projects are always innately sustainable, as they require even less energy, materials and other resources than major refurbishments. It should be further noted that better occupancy rates and space-efficiency along with avoiding new construction make the repurposing of buildings sustainable regardless of whether sustainability per se is a stated goal of the project. In other words, the motivation behind a repurposing project need not be achieving sustainability, but underlying motivations are in fact, most often economic.

2.2 Sustainability in projects

Recently, issues related to sustainability have received only minor attention in project management literature. Much of the discourse is emphasizing the role of stakeholder management, linking proactive stakeholder management to sustainability. Unlike sustainability, stakeholder management has received increased attention in project management literature in recent years. Special attention has been placed on the significance of proactive stakeholder management early on in the project, and stakeholder identification (see e.g. Aaltonen 2010). This approach is also found to promote project sustainability (Bai et al. 2013).

Both stakeholder management and sustainability management are crucial in large built environment projects, which inherently carry great environmental, social and economic impacts. Eskerod and Huemann (2013) argue that currently project managers falsely engage in "managing-of-stakeholders" rather than "managing-for-stakeholders". The former simply attempts to make the stakeholder adjust to the project, while the latter is considered more sustainable as it proactively considers the diverse needs of the different stakeholders.

Silvius and Schipper (2014) define nine dimensions of sustainability in projects: Balancing the triple bottom line, balancing short-term and long-term orientation, balancing local and global orientation, considering values and ethics, considering transparency and accountability, stakeholder participation, risk reduction, eliminating waste, and consuming income rather than capital. They also list identification of the key stakeholders, stakeholder involvement, communication, project handover, and selection and organization of the project team as one of the relevant impact areas of projects. Successful handover and organizational learning are also seen as key components in sustainable project (Silvius and Schipper 2014).

Using the terminology and philosophy developed by Liker (2004) for the Toyota Production System (TPS), Silvius and Schipper (2014) consider a failed project to be 'waste'. Waste of materials and resources is of course inherently unsustainable. Therefore, and for the purpose of this study, a repurposing project is considered sustainable if it succeeds in engaging the targeted end-users. Bai et al (2013) have developed a six-stage process for achieving sustainability in project through stakeholder management. The six suggested stages are: 1) identification 2) relating stakeholders to sustainability targets, 3) prioritization 4) managing 5) measuring performance 6) putting targets into action. The six stages approach requires that the project set measurable sustainability targets. It is therefore not applicable as such, as this study argues that a repurposing project is innately sustainable.

3. Study Design

The research approach is qualitative and explorative, with two cases studies. Case study research with a small number of cases allows studying phenomena rigorously and in-depth in their real-life context. For this research, both studied cases provide rich information on the phenomenon under study. The main source of data comprises interviews with key informants from both cases, participating in a planning workshop and development meetings, and archival data of the two projects. The in-depth, semi-structured interviews ranging between 60 to 90 minutes in length included questions about project stakeholders and the development process. Despite the extensiveness of the interview data, also archival data such as email correspondence were used as additional data sources. Moreover, observations by the researchers complement the data and provide also investigator and method triangulation. Finally, utilizing two separate cases for the study provide an opportunity to compare the cases and provides a richer empirical data base. Limiting the number of cases to two allows for in-depth analysis of both cases

This study examines two Finnish repurposing projects with special focus on stakeholder management and end-user engagement. The first case study is a private health care and wellness campus in Helsinki. The project was initiated because a major occupant is re-locating offsite. The vision of the property owner is to revitalise the campus by leasing the excess vacant space to several smaller, commercial tenants. The facility is a heritage building with conservational value, and even though restrictions do not apply to the interior or space design, only minor refurbishment is planned. Potential future occupants were invited to participate in a workshop and submit ideas for the new campus. The other case is a learning environment on Aalto University campus in Espoo, Finland. Several campus facilities suffer from low occupancy rates and are potentially subject to major renovations or demolitions. Simultaneously, new ways of working and learning continue to make traditional classroom settings obsolete. The second case project combines the need for new type of learning environments to the need to improve space efficiency on campus. The repurposing project transforms an old machine hall into an innovative networking and learning space for students. This exceptional project utilizes co-design techniques with students to create an innovative space.

Table 1: Description of the two cases

Case / *Theme*	*Case Energy Garage*	*Case Wellbeing Campus*
Facility type	*Alternative learning environment on campus*	*Full-service health and wellbeing campus*
Project type	*Developing a new learning space, refurbishing unused space*	*Improving space efficiency, energizing campus with new tenants*
Data sources	*Primary data source* • *19 stakeholder interviews (recorded and transcribed)* *Other data sources* • *80 archived documents including email correspondence* • *Observation during meetings and other site visits*	*Primary data source* • *Workshop* *Other data sources* • *14 stakeholder interviews (recorded and transcribed)* • *Observation during meetings and other site visits*

Based on previous literature, special focus of analysis was placed in the early project phases and how the first contact with stakeholders was managed. The distinct processes of the two selected cases are mapped, analysed and compared particularly from the perspective of stakeholder management.

4. Findings

The findings are first presented separately for each case, through introducing a project outline with detailed descriptions and quotes about events. Then, the findings are synthesized to form a suggested model for end-user engagement in a repurposing project.

4.1 Case Energy Garage

The development path of the learning environment Energy Garage has been described in detail in previous research (Kyrö and Artto 2015). Different phases, each with a different focus and different key stakeholders, arose from the analysis. The project has its origin in a research initiative, which in 2013 was decided to re-focus on students and learning. The project shifted from a faculty-driven research initiative to a student-led social learning environment.

Even though the project was initiated at the top management of the university, the project had a goal of bottom-up management. The university wanted to provide financing and support, but not micromanage the project. Instead, students were invited to be active members of the design team and a student was selected as a project manager. As one member of faculty put it: "*adults were left out of the design process.*" An experienced designer of learning spaces led the design efforts, however. Four interactive design meetings were organized. The lead designer stated, that her role was to be *"facilitating, instead of planning for the students"*. After the start of operations, students had the main responsibility of day-to-day management of the space. Additionally, a board consisting of student and faculty representatives meets every quarter to discuss user needs.

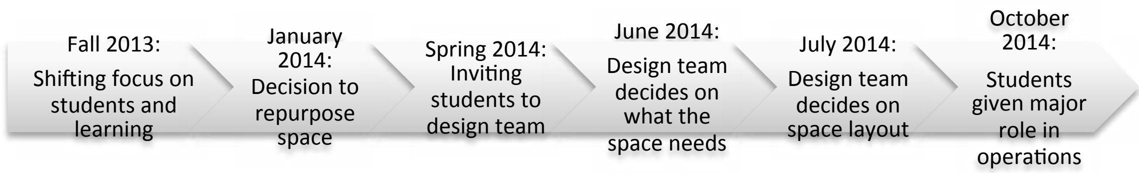

Figure 1: Timeline of Case Energy Garage repurposing project

The benefit of this kind of a co-design process was identified to be an enhanced sense of ownership experienced by the design-team. However, students are a problematic end-user group as they tend to graduate and move on, quickly. New students may have completely different ideals of an innovative learning environment.

4.2 Case Wellbeing Campus

The second case takes a different approach to the campus development, and utilizes a new form of an ideating workshop to catch the attention of potential new end-users and gain fresh insight. Ideating was sought with a distinct and novel workshop method. Potential end-users were first invited for a workshop on campus. Invitations were sent to private, public and third sector actors both from the health and wellbeing sector. Altogether 13 participants were present at the ideating workshop, aided by five facilitators and three persons assisting in documenting the workshop for future research use.

During the workshop, participants were first asked to recall a recent pleasant memory related to health and wellbeing. This was thought to focus the participants to the workshop theme in a positive way. For the remainder of the workshop the participants were divided into three separate groups. Each group member first considered which actors and activities they would prefer to locate on the campus, and present their suggestions to the group. At this point the participants were not allowed to select the organization they were presenting as a future campus end-user. During the second phase the group was to combine the best suggestions from each member to come up with a new unique set of actors and activities on campus. Once the activities were agreed upon, the next phase required the group to design the campus layout on a general level by placing the different activities on campus. Finally, the groups were asked to come up with a name and slogan for the campus. During the entire workshop the participants were reminded that they were not restricted by any existing physical of economic constraints of the campus. The freedom to innovate produced a range a truly special ideas for the future use of the campus.

The innovative workshop method produced a number of ideas for the campus development, and a few were selected for further implementation. The strength of the workshop method, the ‘no restrictions’ principle, also entails a challenge, as the unique, innovative ideas cannot be executed as such. However, the method was extremely successful in capturing novel ideas. As the instructions distributed to all workshop participants read: *“You will be able plan the campus with your peers in a good atmosphere and without any restrictions… Together we will create a business model concept of dreams. The results can later be compared to more traditional or implemented plans”*

Consequently, the ideas have been taken into account when planning the campus with existing tenants present. Moreover, the participants of the first ideating workshop remain stakeholders of the campus development project, albeit in a minor role.

4.3 Cross-case analysis

Next, some key features of the two projects are identified and listed in Table 2. Also the handover of the projects, which is known to be of significance to overall project sustainability, is discussed.

Table 2: Findings from the two case projects

Case / *Theme*	*Case Energy Garage*	*Case Wellbeing Campus*
Target	*Create a new learning environment for the students* *Improve occupancy*	*Energize the campus with new activities and end-users* *Improve occupancy*
Approach	*Proactive end-user (student) engagement starting from the early design phase* *Bottom-up management approach*	*Proactive inclusion of potential future occupants (public, private, third sector) in the early design phase*
Process	*Co-design team meetings*	*Single ideating workshop*
Strengths	*End-users experience ownership of the project and space*	*Innovative, 'out-of-the-box' ideas emerge*
Challenges	*Students as an end-users group change; the design team no longer represent the end-users at the operations phase*	*Financial constraints limit possibility to realize ideas* *Workshop participants do not represent end-users as such*
Handover	*Continued engagement of student groups during operational phase, e.g. membership in the board*	*Internal workshops with final end-users to refine the ideas to more realistic ones*

As seen in the table, the projects differ somewhat in their respective process, and therefore strengths and challenges. The strength of a long-standing, co-design process involving a group of selected end-user representatives meeting several times, is the enhanced sense of engagement and ownership of the space that the group was identified to feel. On the other hand, the innovative ideating workshop method, where participants were specifically told to leave all physical and economic constraints, produced a number of great, out-of-the-box ideas. However, as many ideas will not be realized, the process might lead to lowered sense of empowerment of the participants. It is noteworthy that both project faced the challenge of a change in the actual end-users compared to the originally planned. Due to this, the importance of stakeholder engagement also later on in the project is highlighted.

5. Discussion

This study sought out to increase understanding on how the repurposing of building could bring about environmental, social and economic sustainability. The results indicate that the most significant challenges are connected to the identification of the right stakeholders. Interestingly, both cases witnessed a change in the end-users compared to what was planned. Previous literature suggests that stakeholder engagement its crucial at the project frond end. However, based on these findings, engaging end-users early on in the planning phase is not enough if the end-users change and the management does not respond to the change. Instead, sustainable repurposing projects require stakeholder engagement throughout the project lifecycle. The importance of continuous, lifecycle management has previously been discussed earlier in the context of shopping centre facilities (Artto et al. 2015).

Based on the findings, a model adapted from the six-stage process for achieving sustainability in project through stakeholder management, inspired by Bai et al. (2013), is developed. The suggested model for repurposing projects comprises five separate phases, as follows.

1) **Identification of desired end-users.** This stage was handled differently in each case project, but nonetheless received significant emphasis on both. The identification was based on careful analysis of the desired future use of the space *(e.g. modern learning environment or energizing campus ecosystem)*
2) **Engaging potential end-users to the project.** This stage is particularly crucial for the further success of the projects primary goal, namely, improving occupancy at the end of the repurposing project. Despite different approaches in each case study, both cases place special emphasis on engaging the end-users through inviting them to participate in the joint planning activities.
3) **Formulating a shared vision with potential end-users.** Both cases were promoting a certain vision of the future space already before the joint planning activities, however, both openly allowed jointly ideating a new vision. This stage aids the sense of empowerment and ownership of the space.
4) **Co-design of activities and space.** End-users were also engaged in the actual design of the physical phase and activities that should be included. In both cases, this stage requires compromising between the different actors.
5) **Engaging final end-users to operations.** This stage is a requirement for the continued sense of ownership and end-user satisfaction. For both case studies, problems were identified as the final end-users differ from the potential end-users who participating in the previous phases.

The five stages are presented as a continuous project lifecycle in Figure 3.

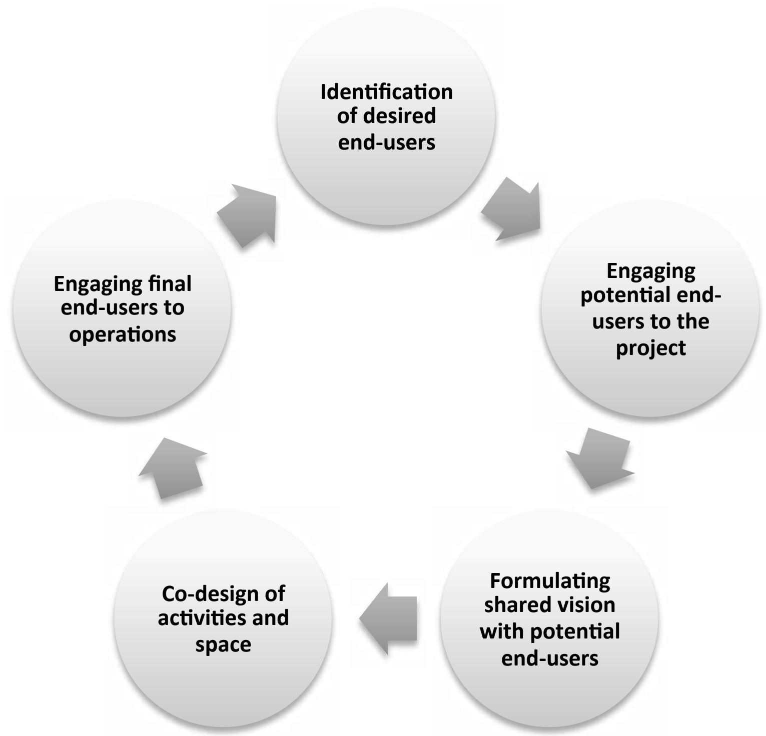

Figure 3: End-user engagement model for repurposing projects

The practical contributions may be used by real estate professionals in planning for repurposing projects, and utilized in the design process introducing these co-design principles. As new learning environments and campus retrofitting projects are becoming more and more common (Eriksson et al. 2015), the practical contributions are particularly current and relevant.

6. Conclusions

This paper has introduced the common goals of, and enhanced understanding of the concepts of stakeholder engagement, repurposing, and sustainability. Engaging stakeholders and managing sustainability have previously been linked, as have repurposing and sustainability, but all three combined provide a more thorough view of sustainable repurposing project.. It should be noted that improved occupancy rates and space-efficiency make the repurposing of buildings sustainable regardless of whether sustainability per se is sought after in the projects. In others words, the motivation behind a reuse project need not be achieving sustainability. This paper draws on empirical data of two exploratory case studies, and makes no attempt at statistical generalisation. In the future, analysing a number of case studies with available quantitative occupancy data after repurposing projects would provide interesting findings. The proposed, integrated stakeholder engagement model could be validated through these types of mixed method studies. Another potential future research avenue would be to study the relationship between sustainable repurposing and city planning policies.

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Veteran Workforce Development: How Veterans can make a Positive Impact on Workforce Development in the Construction Industry

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Abstract

Many different sources have reported on the looming shortage of labor for the construction industry. Simultaneously, veterans who are returning from deployments and transferring into a civilian career are facing significantly higher unemployment rates than the general population. This paper proposes that these issues can be partially solved by forming a working relationship between the two populations. To find relevant information and opinions on this topic, interviews were conducted with three different groups. These three groups were contractors, veterans who are currently working in construction, and groups or organizations who are working to promote the partnership of the construction industry and the veteran population. Since the data gathered was mostly opinions and experiences, qualitative data analysis techniques were used to find trends in the data. Comparing and contrasting these different groups gave an informative insight to the issue. This paper concludes that while there are many challenges to overcome, the veteran population is a sustainable source for future employees for the construction industry, which can, in part, help to lessen the forecasted shortages for both skilled labor and construction professionals. However, there are multiple steps that need to be taken before veterans will have the opportunity to easily transfer their skills into the construction workforce. Some of these are cultivating lasting relationships between contractors and local military bases, provide opportunities for veterans to learn about and connect with contractors, and offer targeted veteran training programs that allow veterans to gain trade specific skills before they leave the military.

Keywords: veterans, workforce development, construction industry, United States,

1. Introduction

In 2011, in the United States, it was estimated that there will be approximately 300,000 veterans exiting the military in the next year, and this number will continue to grow in the years to come (VetPop 2011). These men and woman who have served the country are returning home to another battle, the adjustment to civilian life. Veterans who have fought in post September 11, 2001 wars (known as Gulf War II – era veterans) face an unemployment rate that is roughly three percentage points higher than the average (Army Times 2013).

The construction industry in the United States, on a whole, is experiencing a shortage of labor (AGC, 2013). This shortage applies to both construction professionals and trade workers. As the US economy is recovering from the downturn that began in 2007, construction projects are once again in high demand. Almost three quarters (74%) of construction companies report having trouble hiring qualified workers to meet the demand for their increasing work (AGC, 2013). This is an issue that is not just a current one, but one that will persist long into the future if new avenues of finding laborers and employees are not established and continually sustained.

This paper proposes that these two issues can be solved simultaneously. Veterans need sustainable careers and construction firms need trainable, responsible workers. Yet, there still seems to be a disconnection between the companies and these potential employees. This study investigated if and why veterans were a good fit to work in construction and what is currently being done to pair these two populations together and what can be done in the future to increase awareness on both sides of the issue. This research aimed to explore the opportunities in, benefits of, and barriers to construction as a civilian career for recent veterans and to investigate how this population could help to solve workforce issues in the construction industry. The objectives of the research were to (1) assess the need for renewed and continual workforce development in the construction industry, (2) discover what skills, experiences, and training veterans of the U.S. Military have that have been and would be applicable in the construction industry and (3) to discover what efforts are currently being made to pair contractors with veterans and to suggest future actions to this end.

The study used qualitative research methods and techniques. Interviews were selected as the main method of data collection because of the personal nature of the issue at hand. The collected data was analyzed by summarizing, coding, narrative and comparative analysis methods.

2. Literature Review

2.1. Construction Workforce Issues

In 2013, the Associated General Contractors of America (AGC) released the results of a nationwide survey that revealed issues companies were having with finding suitable workers. Over eighty percent of the firms surveyed answered that they had expanded their professional or craft workforce in the past year and that they had trouble or are still having trouble filling those positions (AGC, 2013). This survey determined that 65% of the firms considered the quality of the available construction crafts workers was below average or poor whereas 77% of the firms considered the quality of general construction professionals as either average or less. Contractors are pushing more for higher productivity rates from their craft workers. This higher demand for quality and productivity is being opposed by the lack of proper training pipelines for future construction workers (Pace, 2003).

According to a leading management consulting and investment banking company for the engineering and construction industry (FMI), in a detailed 2010 report on construction trade demand, the estimated number of jobs that needed to be added by 2014 to fulfil the estimated amount of work was 1.5 million. Another source, the Construction Labor Research Council (CLRC) predicted that a minimum of 185,000 new construction jobs will have to be added annually in the next decade to keep pace with the demand for construction services. It was also predicted in 2010 that by 2014 almost twenty percent of the current construction workforce would retire or be on the verge of retiring. All of this comes at a time when the market for construction is finally climbing out of a six year recession (NCCER, 2013).

All of these facts point to, what is commonly referred to as, the "skills gap." This skills gap highlights the growing break between the construction workforce and the skills and training that are needed for one to join the workforce and the general population. High school aged kids and other young people are not receiving or are not interested in receiving the proper training to enter a construction trade as a career. Over fifty percent of high school graduates are now attending college. Very few are attending trade schools. This shift in the US culture is leading to less funding for the secondary career and technical schools, which in turn leads to fewer workers and less ways for a hopeful employee to receive proper training (AGC, 2014).

The AGC released a workforce development plan in 2014 which outlines a number of ideas on how to combat the aforementioned problems about labor shortages and a lack of proper training programs (AGC, 2014). One section of this plan discusses how giving training opportunities to veterans can be a great source of future workers. There are already many programs in place that could help veterans gain the needed skills to enter the construction workforce, if they receive more funding and are grown into a national effort. The AGC also mentions that extending the Work Opportunity Tax Credit, which helps cover certain costs of hiring veterans for companies, would encourage more companies to actively seek out the veteran population as a potential market for future employees.

2.2. Veteran Unemployment Status

Bureau of Labor Statistics publishes the data for unemployment rates for veterans. The statistics for the unemployment rate for vets by period of service show that while many periods have lower rates than nonveterans, the Gulf War era II, which is defined as veterans who have served post 9/11/2001, is the youngest generation of vets and has the highest unemployment rate. The Gulf War era II generation is also comprised of a much larger population of women than previous veteran generations.

2.3. Veterans in Construction

The idea of pairing veterans with construction companies is not new, but it is one that still has plenty of potential to help both sides. There are multiple organizations and programs that have this goal in mind: V2C, Helmets to Hardhats, VIP, Veterans Build America, and V.I.C.E. or Veterans in Construction Electrical are just a few such programs (Jones, 2013). However the effectiveness of many of these programs is hard to quantify. If they truly are making a difference in the labor force as a whole has yet to be determined.

"Helmets to Hardhats" has been helping veterans find jobs in the construction industry since 2003 but recently lost its funding from the federal government thus greatly impacting its effectiveness (Cronin, 2013). V2C is a much smaller and much newer program. It has been developed and run thus far with no funding. The founding members of the program have essentially volunteered their extra time to run V2C, but they feel that to begin making a larger impact, funding must be procured soon (Jones, 2013).

VIP is the most different program from the previously mentioned ones. This is because VIP does not simply try to pair veterans with jobs, it actually provides the necessary training to become an apprentice in the plumbing and pipefitting industry for free. This program is twenty weeks long and guarantees job placement upon completion of the program. The program includes eighteen weeks of intensive training that takes place while the veteran is still stationed on base and then two weeks of transition assistance to assure the veteran a smooth shift back to a civilian life and career. All of these services are provided free to the veterans and paid for by the local UA (United Association of Plumbers, Pipe Fitters, Welders and HVACR Technicians). This program started on Joint Base Lewis-McChord in Lacey, WA and has spread to multiple other bases including Camp Pendleton, California and Camp Douglas in Wisconson (Terven, 2011).

The percentage of veterans working in construction is significantly less than other industries such as: automotive/mechanic, aviation, government, health-related services, security, and transportation (Abt, 2008). There is limited data on the make-up of the construction labor force and what percentage of workers and professionals are veterans.

A survey by the *Military Times* entitled "Best for Vets 2013: Employers" ranked the top 53 employers for veterans. Of the 53 companies listed none were from the construction industry. There are two contractors listed on the 2014 list of "Best for Vets: Employers." The decision was based on data such as percentage of employees who were veterans, percentage of veteran executives, and percentage of recruiting budgets dedicated to veterans. This survey suggests that the construction industry as a whole could improve its outreach towards veteran.

3. Research Methodology

The study was conducted using qualitative research methods and techniques. Interviews were administered to collect the data from three different groups consisting of twelve people in total.

The collected data was analyzed using qualitative methods such as summarizing, coding, narrative and comparative analysis. The answers from each group were examined individually, as a group, and comparatively across all groups.

Group One- General and Specialty Contractors. This group consisted of a representative or group of representatives from selected construction firms in the Southeast of the United States. These firms and individuals were chosen using convenience sampling methods.

Group Two- Veterans. This group was comprised of people who were currently working for a company that was involved in the construction industry and also had previously served in any of the branches of the United States military. This group was selected using both convenience and snowball sampling methods.

Group Three- Programs that are currently working to pair the veteran population with the construction industry. This group contained people in leadership positions in a group or organization whose goal is to pair the veteran population with the construction industry through a variety of different methods. These organizations and individuals were chosen using convenience sampling methods.

3.1. Interview questions

Group One was asked eight questions, Group Two were asked ten questions and the third group responded to six questions in total. Following questions were asked in the interview:

a) Interview Questions for Group One (Construction Company representative)

1. Does your company have or participated in any special hiring/training program for veterans? If so, please explain. If not, would you consider creating and or joining one?

2. Does your company actively participate in any kind of workforce development program? If so, please explain.

3. What are some positions that veterans currently hold or have historically held in your company?

4. In your experience, have veterans had more, less, or a comparable amount of applicable training than non-veterans who you have hired for similar positions?

5. Has your company experienced any difficulties in finding and or hiring veterans onto your workforce? If you have, please explain.

6. Has your company experienced any direct or indirect benefits of hiring veterans i.e. government relocation assistance or other paid expenses? If so, please explain.

7. Is there any specific factor that is keeping your company from actively recruiting and hiring veterans?

8. For your company, what would make the process of recruiting and hiring veterans a simpler and more regular occurrence?

b) Interview Questions for Group Two (Industry Veterans)

1. Were you involved in construction in any way during your time in the military?

2. Did you receive any construction related training while in the military?

3. Why did you get into construction?

4. Did you have any connections in the industry? If not how did you get in touch with construction companies?

5. Did you participate in any program or organization that helped veterans find jobs in construction or other fields?

6. Do you believe that the training you received from the military prepared you for a civilian career after you had finished your service?

7. Do you know of anyone that you served with who is now working in the construction industry?

8. What was your knowledge of and perception about construction before you started to work in the industry?

9. Did you consider any other careers outside of the construction industry?

10. Would you recommend a career in construction to a fellow recent veteran?

c) Interview Questions for Group Three (Veteran Program Representatives)

1) How/why did your program get started?

   a) Why do you think vets and construction are a good match?

2) What is the goal/mission of your program?

   a) Has it evolved at all?

   b) If so. Why?

3) What kind of progress has your program made and how has it changed?

4) What has been the biggest impediment to the mission of your program?

5) What is the biggest factor(s) that will help promote the partnership between vets and construction?

6) Where will your program go from here?

4. Results and Analysis

4.1. Data Trends

In this section of data analysis, the collected interviews were transcribed into written form. The interview transcripts were then comprehensively read multiple times. Trends in answers to the questions were identified and recorded as codes. The tables are reported below from each group with the codes as found in the text. This paper defines a trend as a topic that was mentioned by two or more (40%) of the interviewees in a certain group. The interviewees wording did not have to exactly match another's to be considered a code or trend, rather it was the topic of idea spoken which determined the trend. There are three fields in each of the tables below:

- Description—a brief description of the idea or topic that was repeated by multiple interviewees

- Mentions—This is the number of times the identified topic or idea was mentioned by the interviewees, this includes multiple mentions by a single interviewee, but at least two separate interviewees had to mention the idea before it was considered a trend

- Marker—this is the highlighted color of the trend (Table ,1 2, and 3)

Table 1: Contractors' responses

Marker	Respondents	Mentions	Description
	5	17	Veterans are hard to contact as a group
	4	10	Veterans have the type of work ethic or attidue we are looking for in an employee
	5	8	We would like to hire more veterans
	3	5	Veterans have the leadership skills we need in our workforce
	2	3	Veterans thrive in teamwork enviornments

As demonstrated in Tables 1, 2, and 3, there were many trends found throughout the collected data. One of major takeaways from this form of analysis is that one of the main hindrances in advancing the relationship between the construction industry and the veteran population is the difficulty in finding, or lack thereof, established lines of communication between these two groups. A separate trend discovered in all three groups was that of how military training prepares veterans for their civilian careers. While most interviewees agree that the trade specific training is absent, the soft skills that military service men and women develop such as, work ethic, attitude, trainability, leadership, and teamwork combine to make veterans a great candidate for any job in construction.

Table 2: Veterans' responses

Marker	Respondents	Mentions	Description
	5	14	I gained skills in the military which helped me later when I got a civillian job
	4	13	I had a Family or Friend Connection in the Construction industry
	3	11	Construction is hard work
	4	8	I did not particpate in construction while in the military
	5	6	Construction is a hard field to get into if you do not have any connections with a company

Table 3: Responses from veteran construction programs

Marker	Respondents	Mentions	Description
	2	6	Online job sites are not the answer, there needs to be a more tangible solution
	2	6	The Military and Government are hard to work with
	2	5	These types of programs are good for the veteran community
	2	5	Veterans are hard to contact as a group
	2	3	Construction is a fragmented industry
	2	2	Veterans have the type of work ethic, attidue, and leadership skills we need in our workforce
	2	2	Veterans are trainable

4.2. Comparative Analysis

The diagram below (Figure 1) illustrates how the data trends from all three groups align with each other. This diagram shows that there were many interrelated issues mentioned by two or even all three groups. By representing the data in this way it is easy to spot the main issues and ideas for the entire collection of interviewees.

As illustrated above, one trend that stood out from all interview groups was the topic of communication. This theme was brought up by the interviewee in almost every interview. Every time communication was mentioned the tone was negative. The difficulties of trying to reach out from one population to the other or the lack of communication between populations were pointed out as the biggest obstacles in the way of the goal. All contractors had experienced indirect benefits of hiring veterans through their attitudes about work, and their abilities to thrive in team oriented environments. This idea was to back up all of the veterans' belief that the leadership and teamwork skills they developed during their time in the military were the cornerstone to their successful careers in the construction industry. The notion of veterans having the skills needed to be successful in the construction business was further reinforced by the fact that all three programs in this study were started by veterans who believed the same thing so strongly that they decided to do something about it, in a big way.

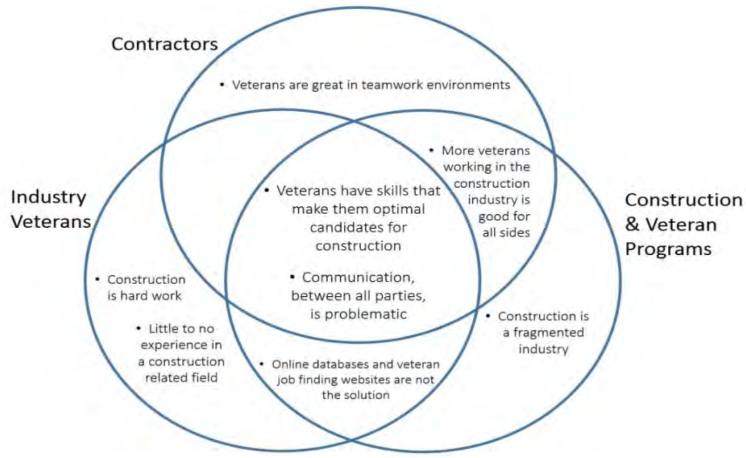

Figure 1: Conceptual alignment of data trends

The most prevalent difference between the group of contractors interviewed and the group of veterans interviewed was their outlook on veteran employability in the construction industry. Although all parties agreed that there are many similar skills needed and many parallels in the lines of work, the veterans were split evenly between recommending a career in construction to a fellow veteran, while contractors were unanimous in their desire to employ more veterans. While this result cannot be extrapolated to the populations as a whole, it certainly points out a gap that must be filled if the construction industry truly wants to recruit more veterans in the future.

5. Conclusions and Recommendations

There is no doubt that workforce development in the construction industry is a topic that needs to be addressed. Amid forecasts of labor shortages and the public's rapidly deteriorating attitudes about working in the construction trades, no contractor is denying this need. However, what the strategy will be to truly develop the workforce remains largely to be determined. Several different national contractors and industry groups have proposed plans of how to accomplish this task. As revealed through the interviews performed for this study, this issue cannot be solved with a singular solution or by a one contractor. Conversely, it must be handled through multiple avenues of attack and via an industry wide effort. The conclusions and recommendations of this paper alone are not enough to solve the construction labor shortage, nor are they intended to do so. To be successful, the following tactics must be accompanied with a heightened sense of awareness from all contractors and industry participants and a comprehensive, realistic plan of action from collaborative industry groups, unions, construction nonprofit groups, and individual contractors.

Ultimately, hiring a veteran is a business decision and as with any business decision, it is about return on investment. Veterans have been proven to have the intangibles needed to succeed in the construction industry in positions from trade apprentices all the way to senior management and owners. With the addition of increased awareness of the construction fields, opportunities to make personal connections with contractors, and readily available training programs, the veteran population could prove to be a renewable source of future employees for the construction industry for years to come. More importantly, these training programs and other opportunities will provide reliable avenues for service men and women to develop the skills and connections needed to smoothly transfer from active duty service into a prosperous civilian career. As a result of the research in this paper, the authors make following recommendations for the construction industry:

1) Begin the process of building a relationship with the veterans before they become veterans.

The construction industry is a fragmented industry with thousands of individual contractors spread across the country. Very few of the contractors have the time and or resources to individually establish a working relationship with the military. Likewise the veteran population, once separated from the military, is disjointed and near impossible to reach as a whole. Because of the conditions of these two populations it is important for a significant number of contractors, acting through local industry groups, such as the state chapters of the Associated Builders and Contractors, begin the process of building a relationship with the veterans before they are discharged from their final military stationing.

2) Recruit people with connections on both sides to become a liaison

This can be done firstly by recruiting someone with a strong network of connections in the military bases in the local community to be a part of this initiative. These connections are critical because, similar to construction, knowing who to talk to is half of the battle.

3) Establish a presence on local military bases

With the aforementioned connections in place it will be easier to establish a presence on the base. The idea is to get veterans to begin thinking of construction as a viable career. The most obvious groups of veterans to begin this campaign towards are those with construction related experience from the military i.e. the Navy Construction Battalion, or the Army Corps of Engineers. This group may prove to provide the best immediate return on investment, however, as revealed through this study veterans who were not assigned to these units can and will still make great employees for any contractor.

4) Offer construction specific career fairs and information sessions

To begin reaching out to these groups and establishing a credibility with the base command, groups should begin with relatively low cost, high yield strategies such as construction specific career expos. V2C has already begun this process and hopefully the rewards to all parties will be evident. Once these types of events have been successful it will become easier for individual contractors to reach out to these bases when they want to recruit more veterans. This strategy will diminish the largest complaint of both the contractors and veterans interviewed, which is the high level of difficulty experienced in trying to reach out and make personal contact with the other population.

5) Start a military specific training program

VIP has established a very effective training program specifically for veterans to gain the skills necessary to enter the welding and pipefitting trade. They have set up these programs to be run on base for active military personnel who are about to be finished with their military service. This is the optimal time to train the service men and women because of multiple reasons. Firstly, these men and women are highly trainable at this stage in their military careers and can absorb the trade knowledge and gain the necessary skills efficiently. This allows for training programs to be condensed, saving everyone involved time and money. Secondly, as they are still employed by the federal government, their living expenses and housing arrangements are fully taken care of by the military. This means that the veterans do not have to try and support their families by working a night job or by taking unemployment benefits form the government. This gives the veteran the ability to fully concentrate on the training program, which again saves everyone involved time and money.

The program that VIP has created is an accelerated eighteen week training regimen that is completely free to the veteran. The UA pays for the training which amounts to $15,000 per person. At the end of the program every veteran is guaranteed a job in the industry and also must join the UA. That amount of money may seem daunting at first, but not when one considers the thousands of dollars in union dues the graduates will pay back to the UA and the tens and possibly hundreds of thousands of dollars of work the graduates will produce in quality craftsmanship over the lifetime of their careers. It is important that the framework for this strategy continue to be developed and expanded into as many construction trades as possible. As of now, the UA is the only group with such a training program and the program is only available on a limited number of USMC bases. Unions and other trade groups, as well as general construction industry groups must find ways to finance, implement, and expand these types of training programs.

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Evaluating Urban Living Labs for Modernisation and Social Upgrading of Suburban Areas in Finland and Sweden

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Abstract

Across Europe, some 200 million people live in suburbs in great need of modernization and social uplifting. The JPI Urban Europe SubUrbanLab project has examined how these suburbs can be modernized and socially uplifted together with the residents and other stakeholders using the Urban Living Lab approach.

This paper proposes a plan for the evaluation of six Urban Living Labs. The Urban Living Labs were real life development actions implemented in two suburban areas using different Urban Living Lab methods: Alby in Sweden and Peltosaari in Finland. The evaluation plan is divided into two sections 1) evaluation of the Urban Living Lab methods and 2) evaluation of the implemented modernization and social upgrading actions.

The evaluation of methods provides insights into the appropriateness of using an Urban Living Lab approach for involving users and stakeholders in less valued suburbs. This evaluation is designed to include the whole process of developing, planning, implementing and following-up an Urban Living Lab. The evaluation of actions is carried out using both quantitative (e.g. CEA, physical indicators) and qualitative (e.g. online questionnaires and interviews with residents, municipal representatives, practitioners and other experts) methods. The evaluation focuses on how the implemented actions have contributed to these suburbs' attraction, sustainability and economic viability.

Keywords: modernisation, urban living labs, neighbourhood, people involvement

1. Introduction

Across Europe, some 200 million people live in suburbs in great need of modernization and social uplifting. The JPI Urban Europe SubUrbanLab project (2013-2016) has examined how these suburbs can be modernized and socially uplifted together with the residents and other stakeholders. The project developed and set up six Urban Living Labs (ULLs): three in Alby, Sweden and three in Peltosaari, Finland. These ULLs were arenas for co-creation of innovative urban solutions: a means to develop new forms of experiences on involving the residents and stakeholders into development in an urban context. The long-term goal is to turn these suburbs into more attractive, sustainable and economically viable urban areas.

2. Urban Living Labs methods

Urban Living Labs are development environments that integrate residents and other stakeholders to develop and test new solutions in their daily life. The users of the new services or solutions are active partners in the whole development process, which happens in the real urban context. Urban Living Labs utilize various co-design methods for understanding the needs, generating solution ideas, presenting ideas and evaluating the solutions in practice. In addition, citizen participation methods are used for participation in decision making and taking action. Voytenko et al. (2015) defined the characteristics of urban living labs based on a study of the ongoing research projects in Europe as follows:

- ULLs are placed in geographical area
- ULLs represent a specific form of experimentation, including processes of innovation and learning
- Participation and user involvement
- Leadership and ownership

In this project we have defined an Urban Living Lab as a forum for innovation and dialogue that integrates the residents and other stakeholders to develop and test new ideas, systems and solutions in complex and real contexts in order to solve challenges in the urban area (see e.g. Friedrich P. et al. 2013). The research and development are intertwined in a "living laboratory" – in the middle of people's everyday living environment. An ULL includes the following features (Friedrich P. et al. 2013, Ståhlbröst & Holst 2013):

- it integrates researchers, public organizations, residents and companies to co-develop new solutions;
- the users of the developed services or solutions are active partners in the development work during the whole process;
- the solutions will be developed and evaluated in the real use context;
- besides producing the concrete solutions, the aim is to learn and exchange knowledge among the partners;
- the activities are encouraging and rewarding for all participants;

Before starting Urban Living Lab activities, several things have to be checked and planned. First of all, understanding the context is important. This understanding can be obtained by interviewing people from different backgrounds, observing the environment and familiarising oneself with earlier reports written about the area and its challenges. The next tasks is to define the goals for the development project based on the needs of different target groups, identify the residents and other stakeholders who should participate in the project and involve them in defining the aims, clarify the roles in the Urban Living Lab and define a transparent decision making process. Finally, the methods for the specific actions and the communication process should be planned.

Friedrich P, et al. (2013) have defined general boundary conditions and methods for successful Urban Living Lab implementation based on existing literature on citizen participation and consumer behaviour change. Additionally, municipality employees, active residents and participants in previous citizen participation projects were interviewed in the target areas of the project: Botkyrka municipality in Sweden and the city of Riihimäki in Finland. A summary of the defined methods with short descriptions (when necessary) and their suitability for face-to-face or online use is presented in

Table 1. More detailed descriptions for each method are presented in Friedrich P. et al. (2013).

Table 1: Participatory methods grouped based on their purpose and art of implementation

Purpose	*Method (description)*	*Face-to-face*	*Online*
Understanding people and issues	*Interviews (both open-ended and individual follow-up questions)*	*x*	*x*
	Observation	*x*	
	Questionnaires	*x*	*x*
	Focus groups (structured discussion groups led by a facilitator)	*x*	*x*
	Diaries (e.g. blogs telling stories and sharing observations around a certain topic)	*x*	*x*
	Cultural probes (a specific diary method consisting of inspirational material packages and tasks)	*x*	*x*
Generating ideas	*Workshops (including variations such as "rotating table", "dialogue café", "Open Space")*	*x*	*x*
	Walkshop (a workshop implemented by walking)	*x*	
	Brainstorming	*x*	*x*
	Idea competition		*x*
Presenting and evaluating solutions	*Scenarios (textual stories of possible futures)*	*x*	*x*
	Storyboards (a visual story of a planned service or solution, e.g. in a form of a comic)	*x*	*x*
	Films (further developed form of storyboards)	*x*	*x*
	Mock-ups (light weight prototypes illustrating aspects of the solution as a tangible object)	*x*	
	Field tests (testing new services/solutions in the real world context)	*x*	

Participating in decision making	*Dialogue meetings / forum (moderated meetings around a certain topic)*	*x*	*x*
	Citizen panels (regular meetings for selected participants to give input and feedback on a certain service/solution)	*x*	*x*
	Chat (real time on online discussion after or instead of a face-to-face meeting)		*x*
	Voting	*x*	*x*
Taking action	*Citizen parliament (a forum where the citizens take action themselves)*	*x*	
	Mini pilots (citizen driven projects sponsored by the municipality)	*x*	
	Change agents (voluntary citizens informing and activating their peers to change their behaviour)	*x*	

Online focus groups, workshops, panels etc. should be arranged in existing online forums that the target groups already use instead of introducing new tools that need to be advertised to the participants according to Brandtzæg et al. (2012). Also face-to-face methods should utilize already existing networks.

3. Implemented Urban Living Labs

Six Urban Living Labs as real life development actions were defined and implemented in Alby and Peltosaari districts during 2014-2015 as a part of the normal living and operation of neighbourhoods. Within the Urban Living Labs, residents and other stakeholders were involved using different Urban Living Lab methods in developing and implementing innovative solutions to increase the social, economic and environmental sustainability in these areas in great need of modernisation and social uplifting.

The first Urban Living Lab in Alby, “Shape your world”, provided children and young adults (age 12-18) with the opportunity to increase their knowledge and understanding of sustainable development and urban gardening while participating in renewing their urban environment.

The second Urban Living Lab in Alby, “New light on Alby Hill”, focused on how using new LED technology and light installations can transform a walkway on Alby Hill, an area that the residents earlier have perceived as insecure, into a more attractive and safe area.

The third Urban Living Lab in Alby, “Vacant Space Alby”, involved a broad range of stakeholders, including residents, in the design and planning of temporary activities (time span 10 -15 years) to be implemented on a vacant 18 000 m2 space in central Alby. The stakeholders were involved in design of activities, based on local needs, using workshops and web-based co-creation tools.

The first Urban Living Lab in Peltosaari, “Energetic co-operation”, focused on finding ways in collaboration with residents and the housing company for decreasing the energy use of rental apartment buildings. Discussion events with residents and other stakeholders were arranged to find out energy saving ideas and best ways to share information about energy efficient living.

The second Urban Living Lab in Peltosaari, “Sustainable decisions”, brought together decision makers and municipality representatives to find out ways for taking into account better and more actively the city’s energy and climate targets in the everyday decision making. Workshops were arranged for activating dialogue and co-development, and ideas for improving practices were gathered.

The third Urban Living Lab in Peltosaari, “Together more”, involved residents in the planning and development of their environment and provided local activities and meeting places for the residents. The goal was to improve the appreciation of the area and to increase the communal feeling among the residents. Several types of activities were piloted and residents were invited to discussion events to influence the plans concerning the area.

4. Evaluation of the implemented Urban Living Labs

4.1 Goals and evaluation process

The goals for each Urban Living Lab were formulated in a dialogue between different stakeholders and project partners, depending on the planned scope of the work. It has been important that both the involved project partners and the stakeholders have common expectations and goals for the Urban Living Lab from the beginning. Nevertheless, the individual goals of different stakeholders and partners need to be recognized. The goals defined for each Urban Living Lab concern both the modernization actions and the participation of residents and stakeholders.

The evaluation of the implemented Urban Living Labs is twofold: First, each ULL is evaluated regarding its contribution to environmental, social and economic sustainability in the area where the Urban Living Lab has been implemented. Secondly each Urban Living Lab is evaluated with respect to how it has lived up to the definition of an Urban Living Lab (the Urban Living Lab principles). The evaluations of each Urban Living Lab are hence focused around the following two parts:

1. Evaluation of the Urban Living Lab’s contribution to environmental, social and economic sustainability
2. Evaluation of fulfilment of general Urban Living Lab principles (Urban Living Lab definition)

The evaluation plan for each Urban Living Lab is specific to that particular Urban Living Lab, as the Urban Living Labs are focused on different actions, using different methods and set in different contexts with different users.

4.2 Evaluation of the Urban Living Lab's contribution to environmental, social and economic sustainability

The evaluation of contribution to sustainability depends on the goals of the particular Urban Living Lab but also on the local goals or views on social, environmental and economic sustainable development in the particular suburb. The evaluation of sustainability mainly takes its point of departure from goals set up for each Urban Living Lab and sustainability as seen from the context of the particular suburb, but will also discuss contribution to sustainability from a broader point of view. Some aspects of sustainability were not covered by local views/goals on sustainability or by the specific Urban Living Lab goals, but they will also be evaluated. As an example, the evaluation of contribution of sustainability will, as far as this has been possible, evaluate the economic viability (economic sustainability) for the Urban Living Labs.

In the evaluation of contribution to sustainability, both quantitative (e.g. CEA, physical indicators) and qualitative (e.g. online questionnaires and interviews with residents, municipal representatives, practitioners and other experts) evaluation methods will be used, depending on the specific Urban Living Lab. The evaluation focuses on how the implemented actions have contributed to the attraction, sustainability and economic viability of the target areas Alby and Peltosaari.

The evaluation can be based on a focus group or reference group that, after the project has been finished, discusses how the Urban Living Lab has contributed to local sustainability goals. For social sustainability, a before-and-after-survey can reveal changes over time concerning e.g. interest to contribute to the local society and commitment to sustainability. All Urban Living Labs will also, as far as this is possible, be evaluated with respect to the Urban Living Labs contribution to increased social cohesion and increased commitment among residents and other stakeholders to sustainability.

Relevant evaluation questions concerning the social issues and attraction are e.g. what kind of role do the implemented actions play in order to attract people and businesses to the suburbs? Have the actions increased the willingness of people to live in these suburbs? Do more businesses want to invest or get established in these suburbs due to the actions undertaken? Have the actions increased the willingness to cooperate with local stakeholders? Do the Urban Living Labs bring lasting and deepened commitment among residents regarding environmental matters and sustainability? How do the Urban Living Labs increase social cohesion? Are the developed Urban Living Labs mature to continue actions after the SubUrbanLab project ends? Are the responsibilities between different stakeholders clear for further collaboration?

Relevant evaluation questions concerning the environmental sustainability and economic viability are e.g.: How have the implemented actions contributed to environmental, social and economic objectives e.g. leading to improved environmental performance and creating new local jobs? Have the actions been implemented in a cost-efficient way? What is the added value, (even monetary) of Urban Living Labs in getting the benefits?

Economic viability refers to how cost-efficient the Urban Living Lab has been, e.g. compared to more traditional ways of implementing the same actions. Where possible, the project will use cost-effectiveness analysis (CEA) in order to evaluate the cost-effectiveness of the different implemented Urban Living Lab actions and to compare the different alternatives. Here the VTT-CEA tool (Tuominen et al. 2015) will be used for evaluating energy efficiency investments done in the case areas. The evaluation of cost-effectiveness is done to measure the performance and effectiveness of a project. From a public policy point of view, the main argument for evaluating the costs and benefits of projects is for ascertaining whether public support for the project is a sound investment.

4.3 Evaluation of the Urban Living Lab methods (participation of residents and other stakeholders)

The evaluation of methods provides insights into the appropriateness of the selected Urban Living Lab methods for involving users and stakeholders in less valued suburbs. This evaluation is designed to include the whole process of developing, planning, implementing and following-up an Urban Living Lab.

In practice, Urban Living Labs can make use of different co-design methods both face-to-face and online to involve all relevant stakeholders in the process of planning, designing, developing and evaluating new solutions. The evaluation of the Urban Living Lab approach will therefore especially focus on how residents and other stakeholders have been integrated to solve challenges in the urban areas or, in other words, how the knowledge, experience and input from the involved residents and stakeholders have been used in the whole process of the Urban Living Lab - when setting up and developing the Urban Living Lab, when planning the Urban Living Lab and when implementing the Urban Living Lab. Other aspects of the Urban Living Lab approach, such as the learning between partners and how invited participants have experienced their participation, will also be discussed.

To be able to evaluate this, documentation, such as meeting minutes, is vital during whole process of all Urban Living Labs. Interviews with and questionnaires among participating residents and stakeholders have also been important methods to be able to evaluate their involvement.

Inhabitants and other stakeholders were engaged to the implemented development actions through different participatory methods such as online Owela tool developed by VTT (Friedrich 2013), face-to-face meetings, workshops, interviews, questionnaires, field tests and mini pilots. The implemented Urban Living Labs used mainly traditional face-to-face-methods, such as workshops, discussions, surveys and questionnaires as these turned out to be suitable ways of co-creation with the target groups. Face-to-face meetings and discussions with the residents were focal in raising interest and creating commitment whereas use of digital tools for participation was not regarded natural by many of the residents.

Relevant questions concerning the evaluation of methods are for example: Were the relevant people able and willing to participate through the method? Was the group involved in the activity sufficiently representative of the targeted stakeholders? Did the contributions gained using the method have an impact on the activity? Did the method support interaction and mutual learning among the participants? Did the method provide equal opportunities to participate for different kinds of people? Could the method be adjusted based on the needs of the activity? Was the method laborious and/or complicated for the organizers or participants?

4.4 Preliminary evaluation results of two Urban Living Labs

The evaluation work is ongoing during the time of writing this paper. Here some preliminary evaluation results of the second Urban Living Lab in Alby, "New light on Alby Hill" and the second Urban Living Lab in Peltosaari, "Sustainable decisions" are presented (Karlsson et al. 2016b).

Alby Urban Living Lab "New light on Alby Hill" focused on how using new LED technology and light installations can transform a walkway on Alby Hill, an area that the residents earlier have perceived as insecure, into a more attractive and safe area. The sustainability objectives of this Urban Living Lab were: 1) Renewing the urban Environment, 2) Modernising Alby's identity and 3) Trying out new working methods at the municipality.

Several methods were used to evaluate the contribution to sustainability. Questionnaire surveys targeting the users of the pathway were carried out before and after the implementation of the new lightning. The energy use before and after the implementation was calculated including also the reduction of GHG-emissions. A focus group interview was carried out with the representatives of the municipality, private housing company Mitt Alby, Collage of Arts and the research partner IVL to discuss the contribution to sustainability objectives on different levels. A Cost Effectiveness Analysis (CEA) was conducted to examine the economic sustainability. All phases of the Urban Living Lab were continuously documented and reported in project reports "Selection of Urban Living Labs in Alby and Peltosaari" (Karlsson et al. 2015) and "Establishment and implementation of Urban Living Labs in Alby and Peltosaari" (Karlsson et al. 2016a) to be utilized in the evaluation process.

The contribution of the Urban Living Lab to social sustainability is here presented as an example. The contribution to social sustainability was evaluated by estimating the increase in the sense of security and participation and engagement.

The increase in the sense of security was evaluated using the results of the questionnaires. According to the results the new lighting on the pathway increased the sense of safety to some extent, especially amongst the women. The amount of women feeling unsafe or sometimes unsafe using the pathway during dark hours was reduced from 79% to 55%. The pathway was experienced to be better and lighter with the new lighting system but a high proportion of the respondents still felt sometimes insecure despite of the new lighting.

The residents' involvement and participation was evaluated to be high in the project. The number of people participating in the project either through the Residents Council, by submitting images for the competition, by voting on their favourite picture or by participating in the opening ceremony was counted to be 160 people, but there has been some overlapping (for example both contributing pictures and voting). The specific Urban Living Lab website was visited by nearly 400 people. The residents on Alby Hill were also informed about the project via info leaflets and there has been also other information sharing utilizing e.g. posters and the municipality´s website. According to the results of the questionnaires, the amount of respondents feeling that they can influence changes in their outdoor environment raised from 31% to 52%.

Peltosaari Urban Living Lab "Sustainable decisions" brought together decision makers and municipality representatives to find out ways for taking into account better and more actively the city's energy and climate targets in the everyday decision making. Workshops were arranged for activating dialogue and co-development, and ideas for improving practices were gathered. The sustainability objectives relevant for this Urban Living Lab were: 1) Support decision making on energy efficient and sustainable investments and 2) Develop and experiment with new practices in the municipality to enhance collaboration and communication.

The methods used to evaluate the contribution to sustainability were e.g. questionnaires and surveys to participants before and after the seminars. The contribution of the Urban Living Lab to environmental sustainability is presented here as an example. The impact of the workshop was evaluated by the number of people reached through the workshops. Besides the persons actually participating in the workshop, the invitations and the presentation materials distributed after the workshops reached a much wider group of people. The workshops were considered worthwhile participating and especially discussions were highly valued. The workshops were also regarded as a good way to enhance interaction and communication. The results of the questionnaires and surveys showed that the energy efficiency and life cycle perspectives are not well integrated into the current decision making in the municipality, despite of the goals and commitments of the city. This fact further emphasises the need for developing new ways to take these issues better into account in the future. Based on the discussions with the representatives of the City of Riihimäki some impacts of the workshops have already been noted, such as:

- Life-cycle projects will be taken to be considered in some upcoming investments
- PV panels will be included in some future alternatives
- Representatives of other departments have been invited to some meetings to enhance the flow of information in the organisation.

5. Discussion

This paper has concentrated on the evaluation plans of different Urban Living Labs. The impacts of each Urban Living Lab differ from each other and therefore impact evaluation has to be planned separately for each Urban Living Lab but also common elements have been identified. It is also challenging to evaluate the impact of one single Urban Living Lab as the city has several ongoing activities and sustainability goals having similar kinds of effect. Also, many impacts can be noticed and/or measured only after several years, as for example changes in attitudes and processes, which happen slowly and are simultaneously affected by several external factors. It is however difficult to identify at that point how an ULL has affected that development.

Key success factors for Urban Living Labs are the early and continuous involvement of the affected people, clear goals and expectations, and experimenting in real context instead of discussing. The methods must be adapted to the goals and participants. On the other hand, an intrinsic part of the ULL approach is that course of an activity may change during the process, based on the contributions and decisions among the participants. This further complicates the evaluation since the goals may be adjusted during the process. At its best, people can participate in the Urban Living Lab activities as a part of their other activities and see the effects of their participation shortly afterwards. The participants should have the ownership to the project, create content and express themselves (Brandtzæg et al. 2012).

There are different ways to realise Urban Living Labs depending on the stakeholder group, boundaries, and existing groups/networks in the neighbourhood. It is important to identify different types of existing development projects, networks and stakeholders, with which to link the Urban Living Lab actions as utilizing relations to other activities brings win-win advantages. Urban Living Lab should be planned to support broader development targets and projects in the municipality or area.

From a public policy point of view evaluation methods are needed for assessing a project's level of success and for being able to compare the project to its alternatives. Currently decision makers clearly need more evidence on the impacts and benefits of co-creation and co-design. How can we measure the impact and value of the learning process and show that the monetary investment has been profitable? The common factor in all Urban Living Labs is thus estimating the impact of co-creation, which lacks methods and indicators.

The preliminary evaluation results emphasize the need for careful planning of the measures and methods for evaluation but also the necessity to update them during the course of work, due to adjustments and changes for the scope of the work that often take place as a result of the contributions from the stakeholders.

Furthermore the results indicate that the value of using Urban Living Lab approach needs to be considered more extensively than the generally used quantitative measures, such as costs and number solutions that are taken into use. Benefits of engaging residents in developing and piloting solutions often follow from "avoided costs", such as early identification of non-working solutions or potential bottlenecks, improved acceptance of a new solution among the users, and faster start-up and active use of a solution. Additionally the approach intrinsically supports learning and self-efficacy among the participants and improves co-operation between the partners, and thus provides benefits that are not necessarily expressed as specific goals of the activity but nevertheless are valuable. Successful engagement as such should be weighted as a valuable result.

The preliminary evaluation results also emphasize that the motivation for using Urban Living Lab approach should be based on different kinds of criteria than simple cost-efficiency of implementing concrete actions. Engaging people and co-development processes require resources and take time but on the other hand the outcomes of all Urban Living Labs of the study were significantly affected by the participation: similar results could not have been achieved without the Urban Living Labs. Maybe even more importantly, the Urban Living Labs were seen to have numerous "secondary effects" on the participants and the area that would not have been accomplished without Urban Living Lab approach. Examples of these are learning, enhanced opportunities for self-expression, increased awareness of relevant issues in the area, improved collaboration between partners and feeling of being able to influence.

The set of evaluation questions formulated in this study provide a good basis for conducting systematic evaluation of an Urban Living Lab. Further development of methods and ways for assessing benefits of different scales in parallel are however still needed to be able to demonstrate convincingly the profitability of Urban Living Lab approaches.

6. Conclusions

The overall conclusions of the paper are following:

- It is vital to be able to demonstrate the benefits of Urban Living Labs and thus approaches for evaluating impacts systematically are needed
- The SubUrbanLab project with six different Urban Living Labs provides a good basis for developing a general evaluation "framework"
- This paper proposes division of evaluation into different categories and suggests questions that can be used as a basis for evaluating Urban Living Labs

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The paradoxical nexus between corporate social responsibility and financial performance in international construction business

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Abstract

This study aims to develop and test a paradoxical link between corporate social responsibility (CSR) and corporate financial performance (CFP): CSR may be detrimental to financial performance in the short-term term (e.g. by adopting carbon reduction schemes, or taking account of fair trade) but will be conducive to improving performance in the long term (e.g. by developing reputation, or improving business relationships). Using panel data of international construction companies derived from various sources, the hypothesis is confirmed. The traditional notion that CSR will have an immediate and unchanging impact on CFP is probably flawed. In the international construction business, a short-term, negative effect of CSR on CFP is witnessed, but a positive effective of CSR on CFP can be developed if effectively involved in CSR programme for long. It takes time to materialize CSR in terms of financial performance. This research helps explain the CSR dilemma, whereby business executives' hesitate to fully engage in CSR for long, given their pressure to effectively maximize profitability for shareholders. The research thus provides support to business executives who should be relieved from short-termism when devising proper CSR strategies in international business.

Keywords: Corporate social responsibility, Corporate social performance, Corporate financial performance, CSR-CFP relationship, International construction

1. Introduction

Since the phrase corporate social responsibility (CSR) was coined by Bowen and Johnson (1953), it has been and remains the subject of contentious debate. Friedman (1970), for example, famously argued that socially desirable goals, if at the expense of profitability, should be disconnected from a company's fiduciary responsibilities; "if managers used corporate resources for any cause other than profit maximization, it would constitute a form of theft". On the other hand, Porter and Kramer (2006; 2011) advocated 'creating shared value', which involves creating economic value in a way that *also* creates value for society. They advocated raising societal issues from the periphery to the core of a business. The two schools seem form a debate spectrum with Friedman on the one end while Porter on the other, although both share the same component to emphasize profitability of a business. The majority of the debaters tend to take an eclectic position in the spectrum by accepting that nowadays companies have an obligation to assume social responsibilities while pursuing business success (Lu *et al.*, 2014). This school of CSR thought reflects the changing social and political climate around the world, indicated by the decline of *laissez-faire*, the increase of government intervention, the vogue for stakeholder theory, the deepening of globalization, and the emergence of sustainable development (Green, 2009).

CSR has increasingly become the Quadruple Bottom Line (QBL) by broadening the traditional Triple Bottom Line (TBL), which requires societal, environmental, and economic reporting in business. This echoes with Porter and Kramer's (2006) observation that CSR has emerged as "an inescapable priority for business leaders in every country". Yet, the extent to which a company actually engages itself in this CSR trend is vigorously disputed. At times, business executives are allegedly myopic in assuming social responsibility (Painter-Morland, 2006). CSR needs to have a genuine economic foundation to be sustained in a competitive business world (DTI, 2002). Without evident benefits for companies, CSR may not continue to flourish as CSR programs are costly and detract from companies' limited financial resources (Wang *et al.*, 2008).

To provide this CSR legitimacy, researchers have endeavoured to search for a link between CSR and corporate financial performance (CFP). This CSR-CFP link has become a non-trivial issue that is widely debated amongst management theorists and business executives. Margolis and Walsh (2001) identified 95 empirical studies on the CSR-CFP relationship published since 1972. Orlitzky *et al.* (2003), in their milestone review, critiqued that Margolis and Walsh's (2001) study used the so-called 'vote-counting' technique, whereby studies are simply coded as showing significantly positive, negative, or statistically non-significant results, and conclusions are likely to be false. They used meta-analysis, viewing it as a more robust statistical method, and reported with greater certainty that CSR is positively correlated with CFP. Empirical research on the CSR-CFP relationship continues, irrespective of the call for a moratorium on it made by Margolis and Walsh (2001). Lu *et al.* (2014) identified 84 relevant empirical studies on the CSP-CFP relationship published during 2002 and 2011.

One notable research trend is that researchers have gradually recognized the CSR-CFP nexus as not being static but changing in a non-linear fashion, e.g. U-shaped curvilinear relationship (Barnett and Salomon, 2006; Park and Lee, 2009). The causality between CSR and CFP may occur in a certain time lapse. It is a significant advancement to consider time lags in the CSR-CFP nexus research, since decision-makings and resource allocation are time-consuming in practice. Though this kind of view is partly reviewed by Orlitzky et al (2003), convincing empirical studies remain few and far between. Inoue and Lee (2011) reveal that each decomposed CSR aspect had a different effect on both short-term and future profitability of companies in tourism-related industries. There seems to be two hypotheses, one positing the short term effect between CSR and CFP, and the other concerning the long term relationship. While contemporary researchers have acknowledged both hypotheses, no one, to the best of our knowledge, has attempted to integrate the two into a refined theory capable of accounting for their seemingly paradoxical dynamics.

The aim of this paper is thus to offer and test a refined theory on the dynamic and sophisticated relationship between CSR and CFP by considering time lags. The main hypothesis is that a paradoxical link exists between CSR and CFP: *CSR is detrimental to CFP in the short-term but will be conducive to CFP in the long-term.* The distinction between the expected short-term and long-term effects of CSR on CFP enables the falsification of the theory. The research in this paper has profound academic and practical values. Academically, the research provides fresh answers to the moot question regarding the CSR-CFP link. It helps divert researchers' attention from the allies-and-adversaries dichotomy to the paradoxical dynamics between CSR and CFP. It may lead to a breakthrough towards a refined theory of the CSR-CFP nexus. Practically, it could help explain some CSR dilemmas, such as executives' hesitation to fully engage in CSR despite the rhetorical exhortations of its benefits; back to the board room, they are under pressure to effectively maximize profitability for shareholders in short-term. The research provides support to business executives to be relieved from short-termism when they devise proper CSR strategies to achieve business success.

2. Constructs and measures

2.1 Corporate Social Responsibility (CSR)/Corporate Social Performance (CSP)

There is no agreed-upon definition on what is meant by CSR. Dahlsrud (2008) identified 37 definitions of CSR. Carroll and Shabana (2010) advised that there are many other academically derived definitional constructs. Carroll (1979) proposed four kinds of social responsibilities constitute total CSR: economic, legal, ethical, and discretionary (philanthropic) responsibilities; the CSR firm should strive to make a profit, obey the law, be ethical, and be a good corporate citizen. Carroll (1979) further suggested depicting them as a pyramid, which has been known by many scholars as the CSR pyramid. While a consensus of CSR definitions remains an issue, other similar concepts such as corporate social performance (CSP) have emerged. Many empirical papers reviewed by Margolis and Walsh (2001), Orlitzky *et al.* (2003), and Lu *et al.* (2014) actually examined the relationship between CSP and CFP. Although some researchers (e.g. Margolis *et al.*, 2007) use CSP and CSR interchangeably in empirical studies, others attempt to distinguish the two concepts (Lu *et al.*, 2014). According to Carroll (1991), CSR emphasizes obligation and accountability to society, while CSP emphasizes outcomes and results. Maron (2006) suggested that CSP is a way of making CSR applicable and putting it into practice. Beurden and Gössling (2008) pointed out that CSR is not a variable and therefore it is impossible to measure; CSP, on the other hand, though difficult to measure too, can be surrogated by the use of proxy measurable variables.

The proliferation of definitions makes it difficult to measure CSP. The challenge is to identify and measure CSR initiatives that are prevalent amongst companies. Carroll's (1979) CSR taxonomy provides the theoretical guideline from which CSR initiatives can be identified. Many companies also issue CSR disclosures, in which they explain their dedication to CSR and highlight successes. By following all these, CSR initiatives can be identified and measured. It is also noticed that studies that explored the empirical CSR-CFP link often circumvented the measuring problem by adopting a pragmatic approach. They used aggregated CSR indices that were established by other parties, such as the Council on Economic Priorities (CEP) index, the Kinder, Lydenberg, Domini (KLD) index, and the FTSE KLD 400 Social Index, or the World's Most Admired Companies, annually published by *Fortune* magazine, as a CSR index.

2.2 Corporate Financial Performance (CFP)

Performance means different things to different stakeholders. Nevertheless, in contrast to the pluralism of CSR/CSP, measures of CFP in academic research have largely converged into the trichotomy of CFP proposed by Orlitzky *et al.* (2003), namely, 1) market-based, 2) accounting-based, and 3) perceptual CFP measures. Market-based measures of CFP, such as price per share or share price appreciation, reflect the notion that shareholders are a primary stakeholder group (Cochran and Wood, 1984). Beurden and Gössling (2008) added more market-based measures in their review work, including stock performance, market return, market value to book value, and others. Alternatively, accounting-based measures consist of profitability measures, asset utilization, such as return on asset (ROA) and asset turnover, and growth measures. Cochran and Wood (1984) aruged that accounting-based indicators, such as the firm's return on assets (ROA), return on equity (ROE), or earnings per share (EPS), capture a firm's internal efficiency in some way. Lastly, perceptual measures of CFP ask survey respondents to provide subjective estimates of firms' financial performance (Conine and Madden, 1987). Amongst the three generic CFP measures, the accounting-based measures are objective and audited, market-based measures are partly objective, and perceptual are largely subjective based on the survey respondents' perceptions (Lu *et al.,* 2014). Given that both CSP and CFP are already broad constructs that are difficult to be measured, Lu *et al.* (2014) suggested a general principle of using more objective CFP measures and secondary data in future empirical studies. The selection of CFP measures is also subject to data accessibility, and their suitability to the characteristics of an industry within which companies are operating.

3. Hypotheses

To reiterate, the aim of this paper is to investigate the causality of CSP on CFP. Instead of trying to identify a static and linear positive, neutral, or negative causal effect between CSP and CFP, the main premise in this paper is that a paradoxical link exists between CSP and CFP. There are, in effect, two hypotheses: one that posits a short-term, negative effect of CSP on CFP, and the other that proposes a lagged, positive effective of CSP on CFP:

H_1: The link between CSP and CFP in the long-term is positive.

H_2: The link between CSP and CFP in the short-term is negative.

The intention is to identify how CSP affect CFP in the short and long-term. The hypotheses can be conceptually illustrated in Fig. 1.

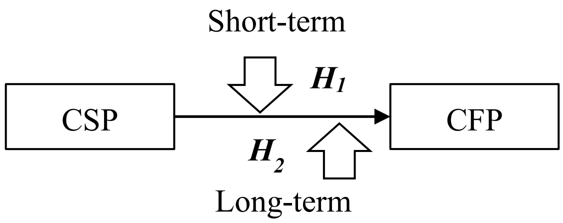

Fig. 1 Illustrated Conceptual Model

The hypothesized paradoxical relationship between CSP and CFP in this paper is different from those studies exploring a curvilinear (U-shaped) or an inversely U-shaped curve between CSP and CFP (e.g. Barnett and Salomon, 2006). For example, although Barnett and Salomon (2006) recognized that the basic issue concerns whether the costs of social responsibility are offset or exceeded by financial returns over some period of time, they hypothesized and tested the curvilinear relationship between CSP and CFP by using an ordinary least squares test without considering the lead-lag effects. The research is also different from those studies looking at the nexus between sustainability and financial performance, or in entertaining words 'when does it pay to be green'. The difference lies in the fact that the terms, CSR or sustainable development, are different, although when operationalizing the concepts, managers tend to treat them as similar, if not entirely identical (Lu *et al.*, 2014).

4. International Construction Business

The hypothetical paradoxical link between CSR and CFP will be tested within the context of 'international construction business (ICB)'. According to Ngowi *et al.* (2005), international construction is defined as the part of construction business that is undertaken by companies working on projects outside their home country; it concerns when a company resident in one country performs work in another country. Once seen as a local activity, the construction business today is fast becoming an internationally interdependent marketplace (Yang and Lu, 2013). To give an example of the scale of this business, *Engineering News-Record* (ENR) statistics show that the ENR Top 250 International Contractors (TIC 250) lodged US$511.05 billion in contracting revenue in 2012 from projects outside their home countries, along with US$813.55 billion in revenue from domestic projects (Tulacz, 2013). Advanced technology, fast transportation, convenient communication, effective knowledge transfer, integrated markets, and trade liberalisation have all helped construction companies transcend traditional national boundaries and enter the international arena (Yang and Lu, 2013).

When looked at in the context of CSR debate, probably no industry offers up as many paradoxes as construction CSR (Lu *et al.*, 2015). On the one hand, the construction industry has an inherent social responsibility; it materializes the built environment, making an important contribution to the national economy, and providing a large number of jobs (Hillebrandt, 1984). On the other hand, construction is intrinsically 'irresponsible'; it competes with the natural environment and can have an adverse impacts upon it, including land degradation, greenhouse gas emissions, resource depletion, waste generation, and various forms of pollution (Ofori, 1993). The conjunction of these paradoxes has brought CSR to the fore. CSR it is now growing in prominence as a core issue confronting the construction industry and its organizations (Murray and Dainty, 2008).

The above paradoxes relating to CSP-CFP nexus are particularly evident in international construction. CSR practices travel with international construction companies (ICCs) and influence other countries with the increasing globalization of construction business. Indeed, in analysing top ICCs' CSR disclosure trends and future prospects, Lu *et al.* (2015) discovered that the firms spent great deal of efforts on CSR when they conducted international business. Yet, the difference of cultural/institutional background between the home and host countries further complicated the paradoxes. ICCs from economically developed countries are normally required "central compliance". The ICB is certainly a positive development in terms of value creation, knowledge exchange, and resource configuration and optimization. However, the ICB is also criticized as being relatively irresponsible, given the embodied energy and the carbon emissions associated with mobilizing resources across continents. It thus provides an interesting lens through which the paradoxes of CSR can be fruitfully investigated.

5. Data, Samples, and Measures

The data used to test the hypotheses was collected from several sources. The initial sample came from the Environmental, Social and Governance (ESG) Intangible Value Assessment (IVA) index tracked by the Morgan and Stanley Capital International (MSCI). MSCI offers kinds of products and services indexes, such as the IVA indexes, to provide research and ratings of corporate management of environmental, social risk factors, and other CSR activities. Companies from industries related to construction were selected according to the Global Industry Classification Standard (GICS) developed by the MSCI. This included ICCs such as Hochtief AG from the construction and engineering industry, CRH plc from the construction materials industry, and Cummins Inc. from the construction and farm machinery industry. The MSCI began to rate ICCs in 2002. The amount of firms rated was small at the beginning bit it increased steadily. Our starting sample represents a balanced panel of 34 ICCs from 2006 to 2013, i.e. 34 ICCs over the period of 2006-2013 have been consistently rated in terms of their CSR performance by the MSCI and the data was realised via the ESG IVA index.

Secondary data was collected from various sources for measuring ICCs' CFP. Basic financial data for each firm were gleaned from their annual reports or financial reports. These reports were retrieved from their websites or other databases like Morningstar.com and Bloomberg.com, since most of the ICCs are publically listed companies in various stock exchange markets and they have to reveal data and maintain the integrity of the data to its shareholders to comply with the law. When we matched the financial data with the MSCI ESG data, we lost four firms due to missing data. This left us a final usable sample that is a balanced panel of 30 ICCs from 2006-2013.

CSP is used as a measurable substitution of CSR. The majority of CSP-CFP studies uses CSP databases developed by third parties, so does this study. MSCI rate firms' CSP based on three criteria: environmental, social, and governance pillars. For the environmental pillar, the MSCI considers carbon emissions, toxic emissions and waste, and opportunities for clean technology as the key issues. Corruption and instability, and health and safety are regarded as the key issues for the social pillar criterion. Key indicators of the governance pillar criterion include audit, board structure, shareholder rights, compensation, and transparency. The weights of key issues in each GICS sub-industry are set according to the industry's relative contribution to the externality of each issue, as well as the time frame to internalize these costs. According to the MSCI industry report of the construction industry, for example, the Construction & Engineering industry ranks above the 90th percentile of all sub-industries in terms of employee accident and fatality rates, which is thus categorised as a High Contribution (MSCI, 2015). Firms receive weighted average scores every year based on the performance scores and weights of the three criteria. The score range for a firm's CSP is within 0-10.

CFP measurement remains the subject of contentious debate in CSP-CFP nexus research. Orlitzky *et al.* (2003) list various CFP measures in 52 studies, and the widely used profitability measures include ROA (return on assets), ROE (return on equity), profit margin, EPS (earnings per share) etc. They converge the CFP measures into three broad subdivisions, namely market-based (investor returns), accounting-based (accounting returns) and perceptual (survey) measures. Following Lu *et al.*'s (2014) suggestion to use more objective CFP measures and depending on data availability, we selected accounting-based indicators, such as the firm's return on assets (ROA), return on equity (ROE) or earnings per share (EPS) and market-based indicators, such as the stock return (SR) or price-earnings ratio (P/E). Following many researchers, such as Waddock and Graves (1997), Barnett and Salomon (2012), we finally choose the ROA as the major CFP measure in this paper.

Control variables are needed for the CSP-CFP nexus analyses, given that CSP will not explain all the variations in CFP across companies. Andersen and Dejoy (2011) summarized that size, industry, risk, RD and advertising expenses are the most commonly used control variables in explaining the CSP-CFP relationship. Lu *et al.* (2014) found that capital structure is often adopted as control variable in the paper under their review. All the firms in the sample are from the construction industry so industry as a control variable makes little sense. Mainly for practical reason, firm size and capital structure are selected as the control variables in this study. Market capitalization of stocks is usually adopted as the measure of firm size. The stocks of large, medium and small companies are referred to as large-cap ($10 billion plus), mid-cap ($2 billion to $10 billion), and small-cap (less than $2 billion). We define debt/equity ratio as the firm's total debts divided by equity to control the capital structure of the firm. This ratio can reveal the managers' preference of financing as well as measuring the risk of the firm. In this regard, risk is also considered a control variable in this study.

6. Results and Analyses

The panel data model is analysed by R software (R Development Core Team 2008), which is an open source statistical analytical software program. The "plm" package in R software is chosen for the panel data analysis.

6.1 Stationarity test

Before the panel data analysis, the first step is to test the stationarity of the variables. A stationary process has the property that the mean, variance and autocorrelation structure do not change over time. If the data of the variable contains a trend, the results of regression could not be fully credibility without isolating the effects of the trend. Stationarity of the variables is tested by a unit root test (Maddala and Wu, 1999), which is one of the common ways to perform the task. Maddala-Wu unit root test model is chosen for this study. Maddala and Wu (1999) proposed that use of the Fisher (p_{λ})

test which is based on combining the p-values of the test-statistic for a unit root in each cross-sectional unit. In *R* software, *purtest* implements several testing procedures that have been proposed to test unit root. The results are shown in the Table 1.

Table 1 Stationarity test of the panel data using the Maddala-Wu unit root test model

	Maddala-Wu unit root test						
Variables		***Chi Square***	***Degree of freedom (df)***	***Order***	***method***	***p-Value***	***Results***
CFP	*ROA*	*52.5334*	*2*	*0*	*trend*	*3.913e-12*	*Stationarity*
CSR	*CSP*	*49.4894*	*2*	*0*	*trend*	*1.793e-11*	*Stationarity*
Control Variable	*D/E ratio*	*29.7743*	*2*	*0*	*trend*	*3.425e-07*	*Stationarity*
	MC	*28.7758*	*2*	*0*	*trend*	*5.642e-07*	*Stationarity*

Notes: 1. ROA=return on assets; D/E ratio=debt/equity ratio; and MC=market capitalization. 2. Alternative hypothesis of test is stationarity.

The results in Table 1 show that Maddala-Wu unit root test with the method of trend is used and the null hypothesis is non-stationarity. Since the p-values for all the indicators are smaller than 0.001, they indicate that the variables in the panel are stationary and ready for the further analysis.

6.2 Results of long-run equilibrium relationship

To test *Hypothesis 1*, panel data models are used directly to estimate the equilibrium relationships between CSP and CFP in the long-term. The equation for testing the long term equilibrium relationship between CSP-CFP is shown as follows:

$$CFP_{it} = CSP_{it} \times \beta + DE_{it} \times \alpha + FirmSize_i \times \gamma + Z_i \times \theta + \varepsilon_{it} \qquad \textit{Eq. (1)}$$

(i=1, 2… 30; t=2006, 2007… 2013)

where the subscript i indicates individual firm, t represents the time (years), CFP_{it} is the dependent variable (using ROA as the indicator), CSP_{it} is the independent variable, DE_{it} and $FirmSize_i$ are two control variables, DE_{it} is the Debt/Equity Ratio while $FirmSize_i$ is represented by Market Capitalization, β, α and γ are the coefficients of CSP_{it}, DE_{it}, and $FirmSize_i$, $Z_i \times \theta$ is the heterogeneity term, Z_i could be a constant term or a group-specific constant term or a group-specific random element, θ is the coefficient of Z_i, and ε_{it} is the error term.Various available panel data analysis models are compared using the results of the three tests (Lagrange Multiplier Test, f test, and Hausman Test) mentioned above. By strictly following Kunst's (2009) comparison method, the fixed model is tested to be better for estimating the impact of CSP on CFP, i.e., ROA in the long run. Results of the long-run equilibrium relationship using the fixed model are shown in Table 2.

Table 2 Results of long run equilibrium effects of CSP on CFP

Dependent variable: ROA (fixed model)				
	Estimate	*Std. Error*	*t-value*	*p-value*
CSP	*0.0056*	*0.0019*	*2.9000*	*0.0041***
D/E ratio	*-0.0009*	*0.0021*	*-0.4008*	*0.6890*
MC	*0.0013*	*0.0004*	*3.1651*	*0.0018***
R-squared: 0.1004 Adj. R-squared: 0.0866 F-statistic: 7.7014				
*p-value: 6.663e-05 Signif. Codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '`'*				

CSP is found to have a positive and statistically significant (p-value= 0.0041) impact on ROA in the general model with β equal to 0.0056, which means CSP in general would improve the financial performance, represented by ROA. Therefore, the general equation for the long-term equilibrium relationship between CSP and ROA (Eq. 1) can be written more specifically in *Eq.(3)*. The p-value of the long term model equals to 6.663e-05, which is much smaller than 0.001, showing good results in testing *Hypothesis 1*. The hypothesis that CSR will be conducive to improving corporate financial performance in the long term is thus supported.

$$ROA_{it} \sim 0.0056 * CSP_{it} + 0.0013 * FirmSize_i \qquad Eq.(3)$$
$$i = 1,2,\dots,30, t = 2007,2008,\dots,2013, CSP \in [1,10]$$

6.3 Results of short-run effects test

To test *Hypothesis 2*, interactive effects of CSP in each year are added into the panel data analysis, which indicate the effects of CSP in specific year on CFP. The equation is shown as follows:

$$CFP_{it} = CSP_{it} \times \beta_0 + \sum Factor(year) \times CSP_{ij} \times \beta_j + DE_{it} \times \alpha + FirmSize_i \times \gamma + +Z_i \times \theta + \varepsilon_{it} \qquad Eq.(2)$$

(i=1, 2… 30; t=2006, 2007… 2013; j=2007, 2008… 2013)

where the subscript i indicates individual firm, t represents the time (years), j represents the years using interactive effects (all years except 2006, which is regarded as the basis year), CFP_{it} is the dependent variable (using ROA as the indicator), CSP_{it} is the independent variable, $Factor(year) \times CSP_{ij}$ is the interactive items of each year times CSP, DE_{it} and $FirmSize_i$ are two control variables, DE_{it} is the Debt/Equity Ratio while $FirmSize_i$ is represented by Market Capitalization, β_0, β_j , α and γ are the coefficients of CSP_{it}, the interactive items, DE_{it}, and $FirmSize_i$, $Z_i \times \theta$ is the heterogeneity term, Z_i could be a constant term or a group-specific constant term or a group-specific random element, θ is the coefficient of Z_i, and ε_{it} is the error term. Various available panel data analysis models are compared using the results of the three tests (Lagrange Multiplier Test, f test, and Hausman Test). The fixed model is tested to be the best for estimating the impact of CSR on CFP (i.e., ROA) in the short term. Results of the short-run effects test using the fixed model are shown in Table 3.

Table 3 Results of short-term effects of CSP on CFP

Dependent variable: ROA (fixed model)					***Dependent variable: ROA (fixed model)***				
	Estimate	*Std. Error*	*t-value*	*p-value*		*Estimate*	*Std. Error*	*t-value*	*p-value*
CSP	*0.0053*	*0.0021*	*2.5326*	*0.0121**	***Factor(2011)*CSP***	*-0.0017*	*0.0010*	*-1.7219*	*0.0866`*
Factor(2007)*CSP	*-0.0002*	*0.0010*	*-0.2249*	*0.8223*	***Factor(2012)*CSP***	*-0.0024*	*0.0011*	*-2.2157*	*0.0278**
Factor(2008)*CSP	*-0.0002*	*0.0010*	*-0.2171*	*0.8283*	***Factor(2013)*CSP***	*-0.0034*	*0.0011*	*-3.1438*	*0.0019***
Factor(2009)*CSP	*-0.0030*	*0.0010*	*-2.9855*	*0.0032***	***D/E ratio***	*-0.0026*	*0.0021*	*-1.2531*	*0.2116*
Factor(2010)*CSP	*-0.0023*	*0.0010*	*-2.2350*	*0.0265**	***MC***	*0.0015*	*0.0004*	*3.5127*	*0.0005****
R-squared: 0.1887 Adj. R-squared: 0.15725 F-statistic: 4.6518									
p-value: 5.7636e-06 Signif. Codes: 0 ‘’, 0.001 ‘**’, 0.01 ‘*’, 0.05 ‘`’***									

As shown in Table 3, all the interactive items, representing CSR in each year, show the negative impacts on ROA, which means CSR implementation in short-term is detrimental to CFP. Thus, *Hypothesis 2* is supported.

7. Discussions and Conclusions

Owing to its theoretical and practical significance, the intellectual debate on the nexus between corporate social performance (CSP) and corporate financial performance (CFP) is incessant. It is hardly new for existing studies to recognise the positive, negative, neutral or even the non-linear, dynamic, and multidirectional relationships between CSP and CFP. However, it seems that no one has attempted to integrate the CSP-CFP nexuses into a refined theory capable of accounting for their seemingly paradoxical dynamics. Originated on the both sides of the Atlantic, CSR has travelled with construction business when it traverses traditional national boundaries into the international arena. International construction companies nowadays use it as a ‘soft power’ for market penetration. This paper, by focusing on the international construction business sector, found that indeed CSR is slightly detrimental to CFP in the short term but will be conducive to CFP in the long term. At the beginning, CSR programmes are in the nature of competing scarce resources possessed by the firms, such as capital, entrepreneurship, manpower, time, and management efforts while the benefits might not be able to be cultivated in short term. After a certain period of time, the CSR programmes, though competing scarce resources too, may bring long-term benefits, e.g. after experienced the learning curve, by developing reputation, or improving business relationships.

The research provided a fresh perspective to the moot question regarding the CSR-CFP link. With the introduction of time into the equitation, the traditional negative and positive relationships are now conceived as complementary rather than opposing. It goes beyond the allies-and-adversaries dichotomy towards a theory of paradoxical dynamics between CSR and CFP. The research can also enrich the classic discussions of firm’s boundary. Particularly, new institutional economics asserts that certain economic tasks, if add to the transaction cost, should be excluded from the boundary of a firm, and they should be performed by the market (Coase, 1930; Williamson, 1991). Given the fact that CSR does consume firm’s resources, many scholars thus believe that CSR should be excluded from the boundary of a firm. Many have misunderstood Friedman, assuming he was against CSR as he famously argued that socially desirable goals, if at the expense of profitability, should be disconnected from a company's fiduciary responsibilities (Friedman, 1970). This research shows that with discretional management, CSR could reduce transaction cost, e.g. by developing a harmonious relationship with stakeholders so as to guarantee key resources, or by developing a reputation. Business executives should focus no more on "whether conducting CSR or not" but on how to properly manage CSR as the allies of CFP.

A significant practical use of this research is that it provides to business executives to be relieved from short-termism when they devise CSR strategies to achieve business success. Most contemporary firms are set up and governed based on old firm theories, such as profit maximization, and shareholders' profits are protected by law while stakeholders' benefits, though important too, are bound by 'social contracts'. With these firm-related ideology, it is a natural thinking for shareholders to emphasize maximizing their profit effectively and efficiently. In a competitive business world, this is translated to the perpetual burden of business executives to justify their CSR strategies with higher CFP. This research suggests that CSP may not immediately lead to higher financial performance. Instead, at the beginning, CSP may jeopardize a firm's financial performance. Shareholders should take a long-term stance to their CEO's CSR strategies.

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Building energy retrofits, occupant health and wellbeing

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Abstract

Occupant questionnaire data were collected both before and after retrofitting of 38 Finnish multifamily buildings and eight control buildings. One adult per apartment (an average of about five apartments per building) was asked to fill in a questionnaire about occupant perceived housing satisfaction, health and wellbeing, as well as occupant behaviour. A total of 234 occupants (response rate 94%) answered to the first questionnaire (baseline), and 187 (75%) answered to the second questionnaire (follow-up). In this paper, we aim to describe occupants' perceptions on their housing and self-reported health symptoms, and to assess the effects of retrofits improving energy efficiency of the buildings on occupants' perceptions if indoor environmental quality and health.

Keywords: apartment buildings, indoor environmental quality, noise, thermal comfort

1. Introduction

Collecting information directly from the occupants is an important part of building and indoor environmental quality (IEQ) assessments. Overall, collecting information from the occupants using structured interviews or questionnaires can be useful when assessing ways to improve occupants' satisfaction with their housing conditions, and also in larger scale population studies where sample size is sufficient for group level (statistical) analyses. Limitations of occupant surveys include that they provide subjective measures prone to bias (e.g., misclassification, self-selection bias), and dependent errors (Rothman et al. 2008).

There exist a few energy retrofit intervention studies, which have included assessments of health outcomes. In UK, a review of the impacts the Warm Front program provided evidence of that the home energy improvements conducted were accompanied by appreciable benefits in terms of use of living space, comfort and quality of life, physical and mental well-being (Gilbertson et al. 2006). In Germany, Frankfurt housing intervention study concluded that renovation and insulation activities did not appear to be in conflict with the health of residents (WHO 2008).

Outside Europe, a cluster randomised study was conducted to evaluate effects of insulating existing houses on health in New Zealand. It was reported that insulating houses led to a significantly warmer, drier indoor environment, and resulted in improved self-rated health, self-reported wheezing, days off school and work, and visits to general practitioners as well as a trend for fewer hospital admissions for respiratory conditions (Howden-Chapman et al. 2007). In addition, a recent study from the US assessed low-income housing development renovated in accordance with green healthy housing improvements, reporting improved self-reported general health among adults (Jacobs et al. 2015).

This paper focuses on results from housing and health questionnaires collected from Finnish apartments as a part of INSULAtE-project (www.insulateproject.eu).

2. Material and methods

Study buildings were drawn from several regions in Finland (Tampere, Hämeenlinna, Imatra, Helsinki, Porvoo, and Kuopio). Participating multi-family buildings were chosen among buildings with planned retrofits improving energy efficiency during the project (2010-2015). In addition, some control buildings, which had no plans for retrofitting, were included. Recruited apartments were selected from volunteering occupants, who did not receive any compensation for their time participating in the study. The study plan was evaluated and approved by the National Institute for Health and Welfare's Ethical Research Working Group in Finland.

About 80% of the buildings were constructed between 1960 and 1980, and majority of them had mechanical exhaust ventilation (<10% had natural ventilation). Most common retrofitting activities included changing windows, adding heat recovery to the ventilation systems, adding thermal insulation to the building envelope, and changing heating systems.

Information about housing and health was collected from the occupants by questionnaires developed based on previous studies (Turunen et al. 2010). The questionnaire comprised of 49 questions related to the building and living environment; physical, biological, and chemical conditions; hygiene; occupant behaviour, health and well-being; and background information. One adult per apartment was asked to fill in the questionnaire on two occasions: first at the baseline (corresponding to the situation before retrofits in the study buildings) and second (follow-up) questionnaire usually about one year later (corresponding to the situation after retrofits in the study buildings). A total of 234 and 187 people (response rates 94% and 75%) answered to the first and second questionnaires, respectively. In addition to the questionnaires, comprehensive IEQ assessments were performed by trained investigators, who conducted measurements in each apartment (data not shown). Table 1 shows some background characteristics of the respondents and their apartments.

Table 1: Questionnaire respondents' background characteristics.

	Control buildings					*Study buildings*				
	1st		*2nd*			*1st*		*2nd*		
	N	*%*	*N*	*%*	*P*	*N*	*%*	*N*	*%*	*p*
Gender, female	16	52	6	55	.87	127	63	101	63	.98
Smoking in the dwelling, never	27	90	10	91	.93	187	94	142	90	.15
Furry pets	6	20	3	27	.62	27	14	22	14	.90
Exercising several days per week										
Near dwelling	23	79	6	55	.22	125	65	98	67	.90
On the way to work	12	57	6	76	.89	43	39	25	34	.34
Elsewhere						52	43	50	53	.40
Percent of income spent for housing					.12					.42
< 15 %	8	26	1	10		42	22	26	17	
16–25%	10	32	4	40		62	33	39	26	
26-35%	1	3	2	20		37	19	40	27	
36–50%	7	23	1	10		33	17	30	20	
51–65%	4	13	0	0		10	5	10	7	
> 65 %	1	2	2	20		7	4	4	3	
Tenure status					.69					.28
Own	13	42	4	36		138	68	111	70	
Rent	17	55	7	64		65	32	46	29	
*Other**	1	3	0	0		0	0	1	1	
Balcony	21	68	7	64	.80	110	54	86	53	.88
Covered balcony	12	39	4	36	.89	**96**	**47**	**99**	**62**	**.01**
Mechanical exhaust	9	29	6	55	.13	62	31	49	30	.98
Mechanical supply	10	32	3	27	.76	**16**	**8**	**34**	**21**	**.00**
Trickle vents in bedrooms	8	26	2	18	.61	**31**	**15**	**66**	**41**	**.00**
Wood burning fire place / oven	3	10	2	18	.45	1	1	1	1	.87
Sauna	17	55	4	46	.59	**86**	**42**	**85**	**53**	**.05**

	Mean	SD	Mean	SD	P	Mean	SD	Mean	SD	p
Age mean	*47.5*	*18.6*	*49.6*	*16.1*	*.75*	*57.9*	*19.4*	*58.2*	*17.4*	*.88*
Years lived in the current dwelling	7.8	10.1	11.3	11.2	.37	13.0	12.5	13.2	12.5	.87
Number of persons in the dwelling										
Adults (18-65 yrs)	1.1	0.6	1.1	0.6	.79	1.4	0.6	1.4	0.7	.91
Children (7-17 yrs)	0.4	0.7	0.8	1.0	.39	0.8	0.9	0.8	0.8	.87
Children (<7 yrs)	0.1	0.3	00.0	0.0	.66	0.5	0.7	0.5	0.7	.99

*includes: employers' housing, right of residence apartment, and others

P-values shown in the tables are referring to the statistical testing of group level differences between first and second questionnaires using chi-square test. The test does not take into account the dependency between the samples, i.e. the fact that in most cases the respondents were same at the baseline (1st questionnaire) and follow-up (2nd questionnaire). Therefore, the test results are only used for screening purposes. With respect to selected variables, where significant differences were found on the group level, the results were further analysed using General Estimating Equations (GEEs). These multivariate models were fitted with unstructured covariance structure and binominal link-function. In the models, individual responders and buildings, as well as time of questionnaire were identified by the ID-, building-, and time -variables, and respondents' gender and age were included.

We also tested the differences between the control and study buildings using chi-square test, but these results should be treated with caution due to small number of respondents from control buildings. At the baseline (1st questionnaire), a larger proportion of the respondents in the study buildings were females, and kept furry pets indoor less frequently than the respondents in the control buildings. On the other hand, the respondents in the control buildings were significantly more often tenants, they were younger, and had lived in their current apartment a shorter period of time, and had less children living in their apartments. Mechanical air supply and wood burning fireplace were more common in the control buildings. At the follow-up (2nd questionnaire), the differences between study and control buildings remained significant for tenure status and number of children living in the apartments. In addition, the respondents from the study buildings reported exercising more frequently.

Based on the preliminary screening, the respondents from the study buildings reported higher proportion of apartments having covered balcony, trickle vents, and mechanical supply air after retrofits (2nd questionnaire) as compared to the baseline (1st questionnaire), which changes are corresponding with the targeted energy retrofit actions. Also saunas were significantly more common in the study buildings after retrofits.

3. Results

Results related to occupant self-reported thermal conditions are shown in Table 2. Occupants from the control buildings reported significantly less opening windows daily in the living room as compared to the occupants from the study buildings at the baseline (1st questionnaire), and a similar (non-significant) trend was seen in the winter. At the follow-up (2nd questionnaire), occupants from the study buildings reported significantly higher temperatures during heating season as compared to the occupants from the control buildings.

Table 2. Thermal conditions.

	Control buildings					*Study buildings*				
	Pre		*Post*			*Pre*		*Post*		
	N	*%*	*N*	*%*	*P*	*N*	*%*	*N*	*%*	*p*
Typical temperature during heating season					.35					.33
<18°C	0	0	1	9		3	2	0	0	
18-20°C	9	30	4	36		33	17	19	12	
20-22°C	16	53	4	36		108	55	96	61	
22-24°C	5	17	2	17		46	23	39	25	
>24°C	0	0	0	0		7	4	4	3	
Thermal conditions in summer										
Suitable warm	15	48	8	73	.16	111	58	92	57	.93
Too cold	0	0	0	0	-	2	1	3	2	.48
Too hot	14	45	6	55	.59	103	51	68	42	.11
Draughty	0	0	0	0	-	5	3	6	4	.48
Cold floor surfaces etc.	0	0	1	9	.09	5	3	2	1	.40
Thermal conditions in winter										
Suitable warm	17	55	6	55	.99	130	64	105	65	.82
Too cold	15	48	3	27	.22	45	22	36	22	.97
Too hot	1	3	0	0	.55	17	8	13	8	.92
Draughty	5	16	3	27	.42	58	29	34	21	.10
Cold floor surfaces etc.	8	26	8	36	.50	53	26	39	24	.68
Open windows daily in kitchen for temperature control										
Summer	10	32	7	64	.07	102	50	65	40	.06
Winter	1	3	2	18	.10	29	14	18	11	.38
Open windows daily in bedroom for temperature control										
Summer	17	55	8	73	.30	141	70	99	62	.11
Winter	7	23	4	36	.37	79	39	59	37	.66
Open windows daily in living room for temperature control										
*Summer**	9	29	5	46	.32	**110**	**54**	**66**	**41**	**.01**
Winter	2	8	2	17	.26	37	18	22	14	.24
Did not attempt to adjust thermostats in the past 12 mo.	18	58	4	40	.32	85	43	70	44	.86

* Further analysed with GEEs

In the study buildings, the respondents reported slightly higher indoor temperatures after retrofits as compared to the situation before retrofits, but the group level differences were not significant. Similarly, reporting too hot summer temperatures was less frequent among respondents from study buildings after retrofits, as well as reporting of draught during winter.

There was a significant pre - post retrofit difference among respondents in the study buildings in reporting opening windows daily for temperature control in summer in their living room. The difference remained significant in the GEE model including respondents' age and gender. The trend was similar for other rooms and also during winter in the study buildings, whereas an opposite trend was seen among the respondents from the control buildings.

Table 3 shows results related to dampness and mould, odours, lighting, and noise. At the baseline, respondents from the control buildings reported significantly less frequently odours related to food, and daily noise disturbance related to traffic or industry, as compared to the respondents from the study buildings. At the follow-up, respondents from the study buildings reported odour related to tobacco smoke significantly less frequently.

Table 3. Indoor environmental quality.

	Control buildings					*Study buildings*				
	Pre		*Post*			*Pre*		*Post*		
	N	*%*	*N*	*%*	*p*	*N*	*%*	*N*	*%*	*p*
Condensation on windows										
Summer	7	23	3	27	0.75	24	12	22	14	.60
Winter	14	45	7	64	0.29	75	37	52	32	.36
No know water damage	24	77	9	82	0.74	151	77	123	79	.48
No moisture or mould damage in the bedroom	26	93	9	100	0.56	184	100	151	100	.37
Odours										
Food	1	3	2	18	0.11	46	25	25	17	.07
Tobacco	**3**	**10**	**5**	**46**	**0.01**	**28**	**15**	**11**	**7**	**.03**
Mould	1	4	1	9	0.48	3	2	1	1	.41
Building materials	1	3	0	0	0.53	2	1	3	2	.50
*Stuffiness**	4	14	2	18	0.73	**33**	**19**	**12**	**8**	**.01**
Sewage	4	13	2	18	0.70	**31**	**17**	**13**	**9**	**.03**
Lighting defects										
In the dwelling	4	13	1	9	0.71	21	11	16	10	.82
In the hallways	3	10	2	18	0.50	18	9	10	7	.37
Outside	4	15	3	27	0.37	36	19	28	18	.89
Daily noise disturbance related to										
Dwelling (occupants etc.)	4	14	2	18	0.76	12	6	17	12	.08
HVAC systems	6	21	3	30	0.58	22	12	26	18	.10
Neighbours	10	35	4	36	0.91	46	24	42	28	.41
*Traffic, industry etc.**	2	7	2	18	0.31	**52**	**28**	**26**	**18**	**.03**

* Further analysed with GEEs

Reporting of odours appeared to become less frequent after retrofits in the study buildings. The group level differences were statistically significant for odours of tobacco, stuffiness, and sewage smell. The differences for stuffiness remained significant in the GEE model including respondents' age and gender. Daily noise disturbance related to the dwelling and HVAC systems appeared to become more frequent, whereas disturbance related to traffic or industry was reported significantly less frequently. These differences were statistically significant in the GEE models including respondents' age and gender.

As indicated in Table 4, occupants from the control buildings were more satisfied with indoor air quality (IAQ) and maintenance at the baseline, and they reported less upper respiratory symptoms and eye symptoms. They also related symptoms to home environment less often than the occupants from the study buildings. They missed days from work or school less frequently. At the follow-up, the differences between the control and study buildings appeared to diminish.

Table 4. Satisfaction with housing and health symptoms.

	Control buildings					*Study buildings*				
	Pre		*Post*			*Pre*		*Post*		
	N	*%*	*N*	*%*	*p*	*N*	*%*	*N*	*%*	*p*
Plans to move	8	26	6	55	.08	57	28	32	20	.07
Satisfied with dwelling	18	58	5	46	.37	82	41	82	52	.23
*Satisfied with IAQ**	14	45	4	36	.56	**42**	**22**	**65**	**41**	**.00**
Satisfied with maintenance	12	41	4	36	.56	**65**	**33**	**63**	**40**	**.02**
Health symptoms[a]										
General symptoms	4	13	3	27	.27	56	28	42	26	.75
*Upper respiratory symptoms**	6	19	3	27	.58	**75**	**37**	**44**	**27**	**.05**
Lower respiratory symptoms	3	10	1	9	.96	45	22	23	14	.06
Eye symptoms	**3**	**10**	**4**	**36**	**.04**	64	32	43	27	.32
Skin symptoms	9	29	4	36	.65	60	30	42	26	.46
Arthritis	6	19	2	18	.93	51	25	45	28	.54
Muscular pain	4	13	2	18	.67	40	20	34	21	.74
Diarrhea	2	7	1	9	.77	7	3	4	3	.59
Difficulties to sleep	7	23	3	27	.75	46	23	37	23	.94
Symptoms are related to home environment	**4**	**15**	**5**	**50**	**.03**	60	34	55	37	.53
Respiratory infections[b]*	8	26	3	27	.92	**62**	**32**	**34**	**22**	**.04**
Doctor visits	6	19	3	27	.58	56	29	30	20	.05
Antibiotics	6	19	3	27	.58	58	30	34	23	.10
Missed work or school	5	17	2	18	.91	33	21	17	13	.06

*[a] Daily / weekly [b] within the last 12 months * Further analysed with GEEs*

The respondents in the study buildings were significantly more frequently satisfied with IAQ and maintenance than before retrofits, and they were less frequently planning to move, whereas an opposite trend was seen in the control buildings. Respondents in the study buildings reported significantly less weekly upper respiratory symptoms and a similar trend was seen for lower respiratory symptoms. Reporting of respiratory infections, doctor visits and missed work or school days were also reduced. The differences with respect to satisfaction with IAQ and upper respiratory symptoms remained significant in the GEE models including age and gender.

4. Discussion

Drawing conclusions based on questionnaire data requires careful analyses and interpretation. Occupant self-reporting is subjective and prone to reporting bias. There are, however, some ways to increase objectivity: e.g. using questions that specifically ask about matters that can be validated, such as doctor diagnosed diseases, and missed work/school days due to illness.

Due to numerous factors that influence human health and well-being, a large enough sample size is needed to draw conclusions about the empirical relationships between housing conditions and occupant health. The required sample size is primarily based on the need to have sufficient statistical power. There are many methodological difficulties inherent in assessing the health effects of housing that need to be carefully considered. For example, response rates are often low, which can limit the possibility to draw conclusions and generalize the results.

On the group level, our sample size appears to be sufficient to detect relatively large differences (>10% difference in the prevalence values) between the sub-samples. However, group level comparisons may be inconclusive, as there are many confounding factors that have to be taken into consideration. It appears that our sample size with respect to questionnaire data may be limited with respect to drawing definite conclusions on the potential effects of energy retrofits on occupant health and wellbeing, but it could be used to develop tools to follow-up effects of national programmes and policies that are aiming to improve energy efficiency of buildings, particularly with respect to occupants' satisfaction. Future analyses will also provide additional information about associations between occupants' self-reported and measured IAQ, which can be used for validation purposes.

National Institute for Health and Welfare has also conducted so called "National housing quality, health and safety survey", where questionnaire data have been collected from random samples of 3000 household-dwelling units in 2007 and 2011 (Anttila et al. 2013, Pekkonen & Haverinen-Shaughnessy 2014). The results of the survey can be useful as reference material, regarding to housing and health conditions in Finland.

5. Conclusions

INSULAtE-project has developed a comprehensive assessment protocol aiming to demonstrate how improving energy efficiency in buildings impacts on indoor environmental quality and health outcomes. The protocol includes occupant questionnaires, which could be utilized when assessing the effects of improving energy efficiency of the housing stock. Changes were observed in occupant satisfaction with the dwelling and IAQ, perception of odours, daily noise disturbance related to HVAC systems and traffic or industry, as well as respiratory symptoms and missed work or school days, which could be related to the retrofits, although further studies are needed to verify the associations.

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Perspective of Social Usability in the Change Processes of an Academic Workplace

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Abstract

The goal of this paper is to provide an overview of the defensive and supportive projections of users towards perspective of social usability during the change processes of an academic workplace. The significance a university's staff attributes to relational aspects during the change process of a workplace was studied at the University of Jyväskylä, in a situation where a faculty and a research institute were moving into a new building. The workplace process was carried out through co-designing. An interview survey of the key persons (N=12) was conducted. These persons acted as mediators of information between employees, architects and designers. The results revealed several tensions relating to social usability and the importance of experiencing safety and trust during the process. Also professional identity is reflected during the workplace change. End-user satisfaction is closely related to the individuals' experiences of relational factors attributed to communication and collaboration. It is especially important in the change process of a workplace. Moreover, it is very culturally sensitive both to express and interpret who knows the needs of the users "best". Therefore, it is a very complex phenomenon: attempts to improve the culture of working needs those who lead the way of change. Otherwise it is too tempting to remain stagnant within a comfort zone. The agents of change partially exist inside the working community, but for the most part, the need for change can be found from the group consisting of the built environment professionals, the employer and the owner of the property.

An academic community is naturally accustomed to influencing its professional field but is much less so when dealing with factors beyond that field. Keeping this in mind, we must note that the arena of influencing the built environment that should reflect your professional expertise is a new one. Therefore, an academic community may at first have problems influencing these environments in an expedient manner. Research-based knowledge and a deeper understanding of the processes that build mutual trust are crucial. Therefore, a better base of knowledge and understanding of social processes is required.

Keywords: usability, user experiences, change within an academic workplace, co-creation

1. Introduction

Even though they carry the considerable weight of tradition, universities and academic workplaces are in a state of transformation. They must reflect and support the skills and attitudes needed in the 21st century. The requirements and need are not easily defined without the perspective of a future-orientated user. According to den Heijer (2011) the most important considerations that the campus of the future should incorporate/reflect are e.g. less individual territory and more shared space as well as considerations in terms of place independency: due to developments in ICT, people can work wherever is best for them. Various generic models are suggested for academic offices for example as 'studies, quarters, clusters, hubs and clubs' but that an appropriate workplace solution should be developed 'based on an in-depth understanding of the work activities of the people involved' in the workspace (Harrison and Hutton, 2014, 163).

Especially when considering the scenarios of the work and work environments of the future, the space should be seen as a multi-dimensionally structured one, containing social, emotional, physical and intellectual features. Existing spaces seldom support all these levels of work in the future. The future of academic workplaces needs dynamic communities that offer participative and collaborative spaces for knowledge sharing, creativity and learning. (See Jääskelä, Klemola, Kostiainen and Rautiainen, 2012; Rautiainen and Kostiainen, 2015.) Therefore, a fresh evaluation of usability of places from the perspective of social usability, meaning the usability of the social place, is worth to investigate: how the diverse features and artefacts of a built environment support emotional experiences and relational processes. The aim of this paper is to explore the defensive and supportive projections of users towards the perspective of social usability during the change processes of an academic workplace.

2. Theory

2.1 Perspective of Social usability

The International Council for Building Research and Documentation (CIB) working group on the usability of workplace (W111) has been exploring concepts, methods and tools, developed in the evaluation of all kinds of consumer products, applied to the built environment (Alexander, 2006; 2008; 2010). The intention has been to identify and evaluate how to design and manage the relationship between activities and space. Usability in the built environment is context dependent and related to user experience, social relations amongst users and to the interaction between users and facilities. Usability has found to be strongly related not only to relationships between people and physical settings, but also to clarify strategies for the organization regarding work and the use of facilities. Usability is 'a cultural phenomenon that can only be improved through better understanding user experience, considered as situated action in a specific context' (Alexander, 2008, 6). Usability is social by its nature and the perspective of social usability focus on user experience and understanding the relationship between individual, place and social community connected to the context. Language and communication are important factors in studying the user experience and understanding the social layout of the place (Airo 2014; Airo, Rasila and Nenonen, 2012).

2.2 The social dimension of work

Finnish organizations and university campuses are increasingly building multifunctional spaces (e.g. Future Campuses, 2011; Ruohomäki, Lahtinen, Haapakangas and Reijula, 2014). When considering the perspective of social usability of the workplace – especially the sense of community, knowledge sharing and meanings given to it – it is noticed in previous research that multifunctional spaces increase social interaction (Davis, Leach and Clegg, 2011; De Croon, Sluiter, Kuijer and Frings-Dresen, 2005; Vos and van der Voordt, 2002) and perceptions of forthcoming workplace changes also seem to focus on spaces where collaboration is supported (Ruohomäki et al, 2014, 709). The social dimension of the work and the meaning of interaction, collaboration and competence in communication become clear when we examine how work is performed in today's knowledge-intensive work culture. Academic work that is based on shared expertise, knowledge processing, networking, mobility and globalisation, poses a serious challenge to the meaning and relevance given to a social dimension of the work: communication and collaboration are not merely a tool – they are rudimentary requirements for work.

Jobs require comprehension and control of processes that are fundamentally communicative: collaboration is how work is done - e.g. work is done through teams or networks, or is performed interactively. Knowledge and understanding is created and shared and the work result - instead of concrete products or performance – is increasingly in the form of pooled ideas, and is the outcome of collaboration (e.g. specialised problem solving). Work no longer speaks for itself (work is not a material product), and an employee must be able to uphold the "results" of his or her work, often consisting of abstract ideas or shared processing of data (see Kostiainen, 2003). The origination, distribution and approval of common meanings - and learning what is new - are based on interaction, so that work performance requires multi-faceted familiarity with and confidence in collaborative processes both nationally and globally (e.g. Curtain, 2000; FinnSight 2015, 2006). However, collaborative orientation to work does not 'transfer' with employees from old environment to new or form an essential part of the work employees do, unless its meaning becomes relevant to them. Although interaction is permanently part of employee routine, it is too often taken for granted that people at work can communicate or collaborate, and is rarely given profound consideration. Therefore a fresh perspective of social usability of the workplace and its evaluation - meanings university staff attribute to collaboration and knowledge sharing – is called for in the studies concerning the forthcoming changing of the workplace.

3. Method

3.1 Research questions and data description

Previous research on usability has used case-studies in order to define the concepts of usability and to support the process of usability research (e.g. Alexander, 2008, 7-8). This case-study aims to improve the understanding about defensive and supportive relational processes and defining concepts related to the perspective of social usability of workplace. This study seeks to answer the following questions:

1) What are the defensive and supportive projections towards relational processes and experiences during the design-phase of the new work space?
2) What phenomena could explain the perspective of social usability?

An interview survey of the key informants (N=12) was conducted. The study included a total of ten interviews (two pair-interviews) with people from the University of Jyväskylä. The interviewees were chosen as module co-ordinators by the facility team consisted of faculty administration and construction team. All module co-ordinators had been involved in the planning of their own module (dice) - the section of the new building where the particular group of employees were placed. They were acting as key persons who were mediators of information between employees and architects and designers.

The interviews were carried out as semi-structured qualitative interviews using an interview guideline with about 25-30 questions divided into seven themes: (1) the overall expectations as well as expectations related (2) to work, (3) to the new building and space, (4) to collaboration, (5) to wellbeing and enthusiasm, (6) to the image of their own organization and (7) experience of possibility to influence. Questions were framed as open as possible. All interviewees were asked the same questions, but ordering the questions was flexible and followed the progression of the conversation. Additional questions were asked dependent on what interviewees brought into question. Each interview lasted about one hour and were recorded. Blakstad et al (2010, 23) states that in order to gain useful information about the usability of the building it is important to relate the users' experiences to certain space or place and to specific physical surroundings. In this case study, the new building was under construction and some of the future users had had an opportunity to visit the construction site. In the interview situation, all interviewees had a copy of a floor plan where they and their colleagues are going to move within one year. Just before the interviews the employees had got information about their placement in the new building.

3.2 Data analysis

The thematic analysis frame of Braun and Clark (2006) was used in data analysis. The data was analysed step-by-step consisting of three interactive sub processes. The first, data reduction phase consisted of generating initial codes where the process of systematic coding (Miles and Huberman, 1994) was applied. The second phase of the analysis was searching for themes and all the codes were collated into potential themes. Also the comprised themes were reviewed against the first phase initial codes' themes. Finally, defining and naming themes and the drawing of conclusions were implemented (see Table 1). In the first, data reduction phase the qualitative interview data was reduced into a manageable form by generating initial codes by using an ATLAS.ti analysis program. The codes were used as the units of organizing the qualitative data in a way that the initial codes were formed through the re-reading of the data. The data was coded according to defensive, supportive and neutral projections concerning social usability. After categorizing the data into these three dimensions the qualitatively different ways of experiencing the phenomena either positively, negatively or neutrally were the more detailed units (e.g. sentence or phrase) of analysis (see Marton, 1994). As a result of the first analysis phase altogether thirteen sub-code categories were created to which interviewees' experiences were interpreted as connecting (see Table 1).

Table 1: The phases of analysis

<table>
<tr><th colspan="3">Phase 1: Generating initial codes</th><th>Phase 2: Searching and reviewing themes</th><th>Phase 3: Defining and naming themes</th></tr>
<tr><td>Supportive projections</td><td>Defensive projections</td><td>Neutral projections</td><td>Thematic tensions between experiences and expressions</td><td>Interpretation, identifying the central findings</td></tr>
<tr><td>Social orientation, collaboration</td><td></td><td></td><td rowspan="13">Need for change – the claim/concern of stability

The sense of ownership – the sense of detachment

Efficiency – inefficiency

The sense of being heard – the sense of being dismissed

The sense of being valued – the sense of being valueless

Rationality – sensibility

Social – privacy</td><td rowspan="13">Experience of safety (high – low)

Experience of trust (high – low)

Professional identity (individual – collective)</td></tr>
<tr><td>New possibilities, innovations</td><td></td><td></td></tr>
<tr><td>Clean and healthy work environment</td><td></td><td></td></tr>
<tr><td>Enthusiasm</td><td></td><td></td></tr>
<tr><td>Privacy, peace and quietness</td><td>(Lack of) privacy, peace and quietness</td><td></td></tr>
<tr><td>The sense of ownership</td><td>(Lack of) ownership</td><td></td></tr>
<tr><td>Stability</td><td>Stability</td><td></td></tr>
<tr><td>Status, hierarchy</td><td>Status, hierarchy</td><td>Status, hierarchy</td></tr>
<tr><td>Informing, instructions</td><td>Informing, instructions</td><td>Informing, instructions</td></tr>
<tr><td>Work practices</td><td>Work practices</td><td>Work practices</td></tr>
<tr><td></td><td>Various fears, anxiety</td><td></td></tr>
<tr><td></td><td>Placement</td><td>Placement</td></tr>
<tr><td></td><td>Physical space, layout</td><td></td></tr>
</table>

The first phase analysis revealed that the same matters, occasions or events could have both supportive and defensive as well as neutral projections. Although the interviewees experienced certain matters either largely positively or negatively it was apparent that in the same interview the same matters could be expressed both defensively or supportively. As a consequence of this finding, the thematic tensions between experiences and expressions were studied in the second phase of analysis. Analysis revealed in total seven thematic tensions. Finally, in the third phase defining and naming the meta-themes was the systematic process of interpretation, identifying the central findings, the conclusion drawing of the organized data. Three meta-themes behind the thematic tensions were identified as experience of safety (high-low), the experience of trust (high-low) and the professional identity (individual-collective). These cross data findings – the thematic tension between experiences and expressions (Chapter 4.1) and interpretative meta-themes (Chapter 4.2) are reported in the results.

4. Results

4.1 Social usability as supportive and defensive tensions

The interview survey of the key informants who were mediators of information between employees and architects and designers revealed several tensions relating to social usability in the process. These tensions could be named to following themes: 1) Need for change – the claim/concern of stability, 2) the sense of ownership – the sense of detachment, 3) efficiency – inefficiency, 4) sense of being heard – sense of being dismissed, 5) sense of being valued – sense of being valueless, 6) rationality – emotionalism and 7) social – privacy.

Need for change – the claim/concern of stability. The analysis of the data raised either the need for change or the claim of stability. Also those who wanted some changes expressed their concern about excessive stability. They saw that the possibility to change is maybe not utilized in its possible entirety. Both desire for change and fear for change are essential elements which generate experiences of feeling comfortable at future work and work space. Therefore it is important to take these opposing orientations into consideration. The need for change and the concern of stability are shown in the next exemplars:

> ”I also believe that they are sort of burdened by tradition. I think that they should gather an outside perspective on things and switch things up accordingly. It should be the basis for trying new things bravely. We should try to find ways to save some space if it helps in keeping a few more people employed at the location. I don't think the concept of saving always has to mean that things are taken away from you. It can also be the spark for trying out new and different things.”

> ”I probably somehow disagree with the notion that the work of a researcher requires a peaceful atmosphere for thinking. If we consider the kind of phenomena that we're researching and the direction we're heading to, I think we need […] a sort of shuffling of ideas. A kind of collision of minds. Meetings where different ideas are tossed around. Then after such meetings, there are places for you to kind a withdraw to […] where you can mull over your own thoughts. But the thought of going through an entire process like that in isolation, that 'I came up with this research idea, I'm going to look into it, I will advance and I will develop'...no way, such thinking belongs in the past.”

> ” I don't think it's going to become any better or worse than what we've had here or anywhere else.”

> ”If I had to say one word, for me it would be, like, an opportunity to do something differently. But unfortunately I have to ask that has it also been a wasted opportunity? I mean, it's still somewhat possible, but it also carries the danger of getting too comfortable and safe.”

The sense of ownership – the sense of detachment. The data also revealed a tension between the ownership and sense of detachment. Users' expectancies mirror the idea that the users themselves mould the new space to be their own. Some of them could already express that 'this is my place here' (pointing out one spot from the floor plan) or this is going to be 'our get-together space'. Experiences related to at least some level of ownership create the feeling of safety. Next citations exemplify the joint or personal feeling of ownership:

> ”On the other hand, I feel we're not even expecting to get everything, like a physiotherapy station […]. So our wishes display the atmosphere that we would want there. […] If there won't be an egg chair, then there'll probably be an exercise ball or something else then. There's a drive present, that we're going to make this great.”

> "At least my own feelings about the building are really positive. My kids are utterly tired of hearing about it when we drive past it. Like look, there's mommy's house! The entire building is so beautiful already.”

Other hand, there are also uncertainty originating from the sense of detachment and 'free-floating'. Within the co-design process all the users were not always certain were their planning the space for themselves or for some more undefined user. Also, the placement of users lived during the process and experiences of ending up with someone else's ready-made plan was frustrating. Moreover there is lots of speculation whether there is an own or a changing working place or whether it is possible to bring any material of their own and personal things or not. Moreover there is uncertainty whether the forthcoming working community is familiar or re-formed of stranger people. The elements of the sense of detachment emerge in the next quotations:

> ”So in a way, for quite a while it was designed for the needs of people who are not here anymore. We are no longer interested in what was being taken there but now we are going to live with the decisions that they made on our behalf.”

> ”Somehow I feel that there won't be a kind of personal space for me or anyone else. The reality will probably be that, considering how few people we have overall, in the end we will designate personal desks for everyone. So those will be the personal spaces where you can bring your own photograph or potted plant if you feel like doing so. But during the planning phase the overall picture we have received has been quite impersonal, that everyone is going to switch places constantly and you don't really have this little space of your own.”

Efficiency – inefficiency. One essential tension expresses the desire to be efficient and productive in the new work space. This tension was mainly connected to the discourse involving the private rooms or the working area in an open space. Especially the conditions where people do not have their own space were seen a great threat to efficiency. The following statements exemplify this approach:

> ”But if we look at the nature of this job, we have people who are doing eight to ten hours of work daily at their own work station in their office. I think it is a difficult proposition to place those individuals into an open space like this and expect that the efficiency of their work doesn't suffer.”

> ”Well, there are a lot of doubts connected to these developments. If everything that has been suggested during the planning phase is implemented, I believe that overall well-being will suffer. That not having a

> space of your own will immediately increase stress levels. […] In any case, this change of scenery, this big moving project will at first disrupt the working rhythm people have developed. I guess after six months or so we may begin seeing these factors settle down."

Also, an opposite impression can be seen which is considered productive ways of doing work. For part of the users, the threat of working alone or placement in a private room would be more ineffective. The next exemplar illustrates this point of view:

> "So how much do we know about ergonomics. How much do we know about creativity, producing new ideas and the importance of cooperation? I think it's a genuinely dreadful thought that I should go into a box, inside four walls, to work by sitting in that same spot."

The sense of being heard – the sense of being dismissed. One of the most discreet tensions addressed the problem the sense of being either heard or dismissed in different phases of the co-design process. Some of the users find that their ideas and thoughts have been taken into consideration very well. Also the awareness of different experiences seems to be shared especially in informal discussions. The next quotation reveals the comparison of different experiences of being heard:

> "And a trusting feeling, there's this notable feeling that this group […] trusts that they will be heard in comparison to these others. I mean, if we haven't been heard, we have designed this die but it doesn't turn out in practice according to those designs, somehow this feels different. I could of course be wrong, but maybe we have a more decided feeling of being heard here."

The experiences of being dismissed are usually connected with assumptions that the decisions are fixed on in advance and there are not any possibilities to influence. Moreover users think that they have been promised certain solutions (e.g. private room) or things (e.g. extra walls) and these promises are not heard and taken into proper consideration. The following statements exemplify these thoughts:

> "Somehow I feel that there's not much use discussing anything here. These things have already been decided. [--] I think at least in our dice the final conversations will revolve mainly around fighting for who gets to be in a smaller room and who in a bigger open space, etc. Or maybe fighting is too strong a word, but people will try to make their cases for needing exactly a certain type of work space."

> "Then the negative feelings that relate to our dice or that may not even be connected to any of the dice in particular, but to my feeling of how poorly we've been listened to. Even though we were promised the opposite. We assumed that we would have a bigger influence on this process and we are disappointed because we didn't."

The sense of being valued – the sense of being valueless. Also the sense of being valued or valueless is one of the crucial features when evaluating the social usability of work space. Part of the users feel extremely privileged in the situation of having a brand new building and allowing to be part of the exceptional co-design process. Experiences of being valued are expressed in the following statements:

> "Well, I feel it is like, once in a lifetime. A brilliant, but probably also a very rare, opportunity to be designing your own future work spaces."

> "I think that at least having this great building, at such a beautiful location, it makes me feel that it'll be nice to invite in guests from other universities or such places. That the building is a great business card of sorts, that we can proudly display to others."

The sense of being valued or valueless can be fastened on an individual level as well as on a professional level or it can be fastened on status. Part of the users find it highly dismissing if their own work or opinions seem not to be valued during the process:

> ”What has kind of happened here, in my view, is that the work of the designers has been shifted onto us. That we could somehow nicely refine the most important questions and deliver them to the architects so that their valuable working hours wouldn't be wasted. […] Thinking about this inversely, this may mean that our working hours aren't the most valuable ones around.”

> ”This process has somewhat clarified the fact that the statements of some are valued more than the statements of others, because they tend to follow the basic ideas that the architects have set out. Those statements tend to be valued more than the ones that have criticized those basic ideas. […] It's obvious that some people are listened to more than others, I feel it's blatantly obvious.”

Rationality – sensibility. The data did not reveal any extreme expressions of happiness or satisfaction towards the new working space or its social climate. When users brought out some positive aspects or features even then they described the awareness of critical atmosphere and siege mentality at the same time. Quite a rational and moderate attitude was usual when describing the new work space and the ways of working there:

> ”I think that this is a common mission for us all. […] I relay the information and wishes and organize what is needed, but if folks are not going to get on board, I don't feel like it's my responsibility to lure people in. We're all grown-ups here. […] Whoever comes in, comes in [to the design meetings] and their opinions will be included in the decision-making process. Everyone else will simply adapt.”

> ”People have had a long while to digest this move to [the new building]. They have seen the blueprints, they know approximately what awaits them and thus should know how to ready themselves. I don't believe there will be any notable problems beyond that.”

Where there was not a noticeable enthusiasm in users talk there was considerable amount of negative toned emotions towards the new working space and the interpersonal relations there or even towards the location of the property itself:

> [Is there something inspiring there?] “It's terribly depressing if you say no, but in my mind it's just a space we occupy. I don't think there's anything particularly inspiring in that.”

> [What is the negative feedback centered on?] ”It's centered on the other staff members. People seem to fear the thought of an open workspace, figuratively sitting like chickens on a roost where everyone can see and hear what you're doing with no personal peace for your work. Maybe this fear is based on not knowing what this transition to something new will lead to, leading at first to negative feedback.”

> ”The property that [the new building] is built on is absolutely horrible, what with all the motorways crisscrossing around it. When you take a look at any of the university buildings, none of them are on such an inferior property.”

Tensions between social – privacy. Further, the tension between social and privacy was evident in users' expectations. Especially the entrance hall and lobbies on each floor were expected to function as various social encounters, more than their own working spaces. The wish for various social happenings and the chance for fruitful random and casual encounters were expressed:

> ”I think people should arrange all kinds of events in the main lobby, such as christmas parties or something more regular. It could work as a great meeting place, so I think it could also work as an event space for the townspeople.”

> ”I was actually allowed to visit the building back in August and in my view, the shared spaces and the ground floor and the entrance, right by the cafeteria and the large lecture hall, I think they're going to be brilliant. The entrance looked really nice. And I absolutely loved the cafeteria!”

> ”This dice in itself isn't all that important. What's much more important is the space in between the dice. I can imagine that in that space lots of happy or even random gatherings can take place. ”

The tension between social and privacy was often expressed through the talk of quietness and peace. The privacy-talk was mainly attached to the wish to have a decent peace to work. The concern of losing the ability to concentrate was very evident at the expense of those possibilities the new building could offer. There was even a very strict demand for being silently which causes also distress:

> ”There's a lot of talk about arranging the workspace culture in a way that gives people silence when they need it. I would have personally maybe wanted more discussion about how to co-exist while also frequently talking to our colleagues. [--] Silence, silence and calmly and silently like mice within the walls and you should never say anything or make any sounds. Even if you start eating your lunch, you should try to make sure you don't rustle any papers or otherwise cause noise in the process.”

> ”The biggest issues have revolved around peace for working. I think the demand for this kind of peace and silence has drowned out attempts to innovate and bring in new ideas and viewpoints concerning our jobs.”

4.2 Social usability as an experience of safety, trust and professional identity

As a result of the third analysis phase three meta-themes behind the supportive and defensive thematic tensions were identified: 1) experience of safety (high-low), 2) experience of trust (high-low) and 3) the professional identity (individual-collective). These phenomena and their relations can in part be attached to explain the concept of social usability. The relations between these meta-themes can be placed at a fourfold table as seen in Figure 1.

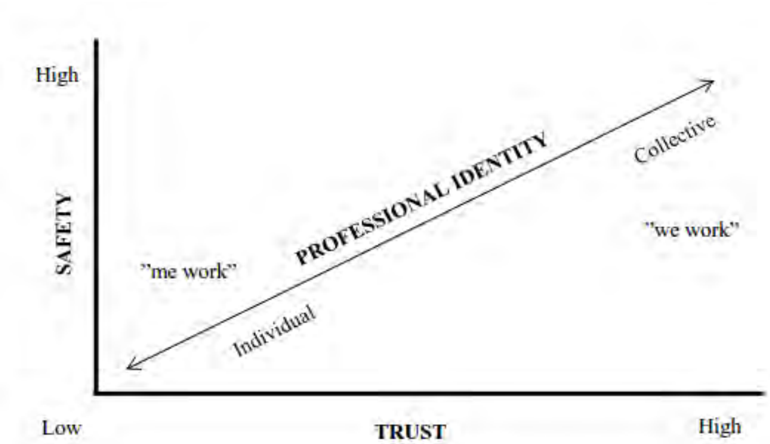

Figure 1: Relations between experiences of safety, trust and professional identity

It seems that during the change process of an academic workplace the experiences of individual workers can fluctuate in the continuums of experiencing low trust to experiencing high trust as well as experiencing low safety to high safety. The trust (e.g. experience of being heard and valued) is not only experienced at an individual level but it is a shared feature – what you hear and assume others to think and behave moulds also subjective experiences. Further, experience of safety seems to be attached to relational factors, how and to what degree an individual expects he or she is able to preserve ones privacy as well as factors connecting with ownership to ones' work and various personal things. Experience of low trust and low safety can be erupted into high defensive emotionalism. Moreover this can have a link to the fear of low productivity which emphasis is apparent in an academic work. At the same time, the professional identity can be seen either more individual or collective or the desire to be more one or the other remains either quite stable or varies depending e.g. on the new placement and its possibilities. Experience of high trust and high safety can predict desire to work more collectively.

5. Discussion

In the workplace change process it is very culturally sensitive both to express and interpret who knows "best" the needs of users and therefore it is a very complex phenomenon. In the transition phase and especially just before the concrete change – in our case before moving into a new building – the suspicious and defensive projection tend to be overpowering compared with supportive and trusting projection. However, being aware of this emphasis attempts to improve the working culture needs those who lead the way of change, otherwise remaining in the comfort zone is too tempting. The transition from customary or traditional work culture towards something new is not easy and it is crucial to understand how users are able to make the sense of the change (Bean and Eisenberg, 2006, 210). Employees' expectancies and prejudices tend to colour their mental image of forthcoming work space (whether physical, social or virtual in nature), have an impact on motivation and wellbeing and therefore non-instrumental, especially social needs must be better understood, defined and operationalized (e.g. Airo, 2014; Kojo and Nenonen, 2012; Hassenzahl and Tractinsky, 2006). During the change process it can be considered if a place and perspective of social usability can be understood as an interactive product: interactive processes should be planned carefully both before, during and after the workplace change.

We need to notice that an academic community is naturally accustomed to influencing its professional field but is much less so when concerning factors beyond that field. Keeping this in mind, we must note that the arena of influencing the built environment that should reflect your professional expertise is a new one. Therefore, an academic community may at first have problems influencing these environments in an expedient manner. Partly the agents of change exist inside the working community, but for the most part the need for change is displayed by built environment professionals, employer and the owner of the property. In academic settings there is a long tradition to be or to move in ready-built environments. Nevertheless when there is a possibility to influence not only in ones' professional field but also in the built environment which should reflect your professional expertise it is a new arena to express the expertise. Therefore understanding the processes building mutual trust are crucial.

6. Conclusions

The results revealed several supportive and defensive tensions relating to the perspective of social usability during the change process of an academic workplace. Eventually, the experience of trust and safety and the perception of being heard and valued during the change process seem to be essential.

Experiences of trust and safety mirror the satisfaction among the users and support the trend that more qualitative indicators are needed in real estate business (e.g. den Heijer, 2011; Kärnä et al, 2013).

End-user satisfaction is closely related to the individuals' experiences of relational factors attributed to communication and collaboration in the workplace (Airo, Rasila and Nenonen, 2012; Kivimäki et al, 2000) and especially in workplace change processes (Laframboise, Nelson and Schmaltz, 2003; Qian and Daniels, 2008). Further, experience of trust and safety can enhance the collective professional identity, which is seen to support the skills and attitudes needed in the 21st century. In all, research-based knowledge and deeper understanding about the processes building mutual trust are crucial.

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Review of end users' role in facility management in university environment. A basis for a complementary approach to enhance interaction between end users and professionals

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Abstract

The aim of this literature review is to explore ground for including institutional and socially constructed understanding of the end users' role in facility management processes. This is applicable especially in strongly institutional settings, such as universities.

In facility management of universities, economic efficiency and effectiveness, such as utilization rates and appropriate use of premises, is a recognized object for development. The usual attempts are to survey end users' needs and satisfaction, or to establish interactive bodies and processes between facility management, organizational management and the end users. However, the interaction between the facility managers and the end users is still a challenge.

This research is carried out by a literature review of current study about the role of end users in facility management. The literature review is focused on university buildings' internal end user groups, students and staff, but includes a wider overview of service buildings in general.

First, previous study shows needs for development and implementation of practical methods of interaction between facility management and end users. Secondly, there is a lack of recognizing the need for inclusion of end users in the everyday practices. Thirdly, there is an insufficient understanding of the end users as definitive stakeholders, that have their own concepts and understanding of the facilities they work and study in. Fourthly, in dynamic university campus environments, the connection between the facility management and its' added value function in academic outcomes is recognized, but hard to measure.

Since facility management can be defined as a type of workplace management, a different interpretation of the environment should be considered on the side of the technical and the service-business-oriented view. Socially constructed understanding of the institutional settings is already a common approach in the field of organizational studies. This approach can facilitate interaction and improved understanding between the professionals and the end users. Higher level of mutual understanding can contribute to the value adding function of the facility management.

Keywords: end user, facility management, interaction, university

1. Introduction

The aim of this literature review is to explore ground for including institutional and socially constructed understanding of the end users role as stakeholders in facility management processes. This is applicable especially in strongly institutional settings, such as universities. The literature review concentrates on current research papers on the end users' role in facility management.

Chapter two presents end users' role in whole cycle of construction design and use. The objective is to find out how end user involvement in this cycle is presented in the literature. Facility management has a value adding function for the core operation. The end user is one key actor for this value adding function.

Chapter three reviews current research of end user role in facility management in university environment. Research of the subject can be divided in two groups: first the research concerning end user satisfaction, and secondly the research concerning campus management processes.

Chapter four reviews research papers concerning current practice in the facility management research, as well as a few recent academic openings that aim for understanding users' original definitions in the field of facility management.

Chapter five discusses the findings and introduces the idea of socially constructed and institutional understanding as a complementary approach in the field of facility management research. Chapter six present conclusions of this literature review.

2. End users' role and involvement in facility management

2.1 End users in design and using phases

In facility management of service buildings, economic efficiency and effectiveness, such as utilization rates and appropriate use based on core functions and individual and social needs, are often a challenge. The practical developmental actions are for example to survey end users' needs and satisfaction, or to establish interactive bodies or processes between the professional facility management, the user organization management and the end users. The common factor between these different tools is the need to increase interaction. However, often not the whole process from design to actual end use is covered. The using phase and the actual outcome of the design process is not necessary the object of concern. (Hansson et al. 2010, 37.)

In Scandinavian countries, based on the democratic welfare-state-ideology, hearing of citizens is a part of official processes in land use and urban planning. In the house building industry this is not regulated and thus not a practice. However, in the design phase of buildings, end users seem to be involved increasingly. Reasons for this are both practical and political. There is a genuine need to obtain information as the base for technical solutions. Another reason is to overcome differences in values and interests, as well as resistance for change, to reach commitment of the parties involved (Pemsel et al. 2010, 24). Literature presents a number of different methods to include end users in a design process. It is still uncertain, how well these methods are used, and also, how well they can be adopted in real life projects (Pemsel et al. 2010, 24; Hansson et al. 2010, 37). Many of the methods are also criticized for not offering guidance for how to act upon the outcome from the method (Hansson et al. 2010, 13). Different methods tend to seek increasing communication between the stakeholders, and to improve the understanding of end users' real needs and requirements. However, they are built on quite complex systems and based on data gathering and analysis (ibid.) Methods seem to be built on professional base of knowledge and concepts of the industry.

In previous research about end user inclusion in both public building projects, as well as in private office building environment, the writers argue that a traditional cost-based property management doesn't still acknowledge end users' level of awareness of for example sustainability factors or long-term maintenance cost (Nousiainen & Junnila 2008, 275; Wihlborg & Laurell 2011). In public building projects end user inclusion in the process in early states benefits society's cohesion and decision-making processes (Wihlborg & Laurell 2011, 367). End users knowhow and interest seems to be underestimated.

Social and cultural barriers between the professionals and the end users cause communication failure and hinder the effectiveness of the planning tools used, even though some methods are based on interaction (Pemsel et al. 2010, 25). The end users are still seen merely an obstacle, than a stakeholder of great importance in design phase, which causes setbacks and conflicts in hand-over phase (Lehtiranta 2015, 571). Understanding operational performance of the project should be a combination of technical focus in construction and emotional basis of customer experience (ibid. 573–574). There is a need for a better understanding of issues like cultural and social habits and highlight the importance of putting effort into ensuring a productive and trustful relationship and communication among all participants (Pemsel et al. 2010).

2.2. Value adding function of facility management

Few tools that concentrate on the end users, even though used in design phase of construction projects, cover the whole cycle and different phases from the user point of view (Hansson et al. 2010; Lehtiranta 2015). In using phase of the building, the professional body present is the facility manager. Facility management should have an elementary relationship with the strategic core of the operation, since it organizes and maintains the whole physical environment of peoples' work and other operative actions (Barrett 2000). Even though design phase has major impact on the quality and functionality, few decisions are totally irreversible (Finch 1992). Facility manager is in key position to make adjustments, both in risk management as well as to improve functionality, safety, aesthetics and overall satisfaction of end users.

Based on the strategic positioning of facility management, with relation to the core functions of the organization and operational core, facility management should be suited to the environmental characteristics rather than adopting a universal best practice (Chotipanich 2004, 367; 371). Both internal and external factors should be considered in the management practices (ibid.). This is due to the understanding of facility management as a strategic and a value adding function to the core operations, rather than just a cost factor (Anker Jensen 2010). Conceptualizing the value adding impacts, four different stakeholders for added value for the organization can be defined: society, customers, staff and owners (ibid. 182). It is also important, that facility management professionals are capable of explaining the benefits of their actions to their clients, customers and end users of the services they provide (ibid. 186). Facility management should be acknowledged as relationship management. The value of the function is produced in these relationships and is subjectively dependent of the other parties' experiences. So it is important to take into account the views and interests of different stakeholders, including the significant groups of end users in the facilities. (Anker Jensen et al. 2012, 211–212.)

This paper is concentrating on internal end users in university facilities, which are students, academic staff and administrative staff. By an end user in facility management can be meant "a person receiving facility services" (Coenen & Kok 2013, 343). In public buildings, like universities, where there are a groups of everyday end users, like staff or students, as well as groups of persons that receive facility services on more random base, such as visitors, this should be more focused. End user can be defined as a person within the core organization receiving facility services. The ideas about added value by facility management (Anker Jensen 2010; Anker Jensen et al. 2012) are based on this grouping, dividing internal (staff, students) and external (visitors) dimensions.

Facility management is in charge of organizing the physical settings for the operational needs of end users. In addition to physical needs, the purpose of the facilities is also to provide for a social setting where people meet and interact. The physical setting provides cues for social situations and communicates meanings. Thus, facilities management can create value for organization by setting the physical environment according to organizational goals and desired behaviour by the end users. (Coenen & Kok 2013, 345.) For that, not only organizational goals, but also actual personal understanding of the facilities functions are required. Cross-functional cooperation between different end user groups and facility management can create balanced setting for the operation, as well as help the facility management in their service function (Kok et al. 2015).

Considering end users as a significant factor in a facility management process can influence both the satisfaction of the end user, as well as their actions, in a profitable way (Junnila 2007; Awg Husaini & Tabassi 2014). The end users should be involved in the process of shaping their workplace environment. People occupy workplace as their territory. If they are involved in the processes of management and maintenance of that physical setting, they will commit themselves also to changes required. (Kaya 2004, 251.) Too often in practice the appearance of the facility management happens and is interpreted as a sudden, uninformed and unwanted change by the end users. This causes non-communication and misunderstanding. (Rayle 2006, 54.) If the end user responses were understood better, it would be much easier to develop effective and efficient processes (Rasila & Gersberg 2007). If changes are planned together beforehand, stress could be decreased and changes carried out with less time and resources.

Even though the end user involvement is considered in some tools of design the whole process and using phase is left out for less attention (Hansson et al. 2010). Based on the idea of facility management as strategic and value adding function for the core operation (Anker Jensen 2010; Anker Jensen et al. 2012; Valen & Olsson 2012; Coenen & Kok 2013), there is a need for further development of assessment tools that include the evaluation of added value and how the user experience the buildings (Valen & Olsson 2012, 298–299).

3. End users and facility management in universities

3.1 End user satisfaction

In university environment, research seems to concentrate especially on students' comfort and satisfaction. Student surveys about facilities' technical quality and functioning show that the students do understand and articulate such concepts as sustainability (Nousiainen & Junnila 2008; Lehtiranta 2015).The aim is to point out the significance of end users as stakeholders in process of sustainable facility management (Hebert & Chaney 2012, 469). A survey applying customer satisfaction model to the research on campus facility management showed that both students and university staff emphasize overall appearance, tidiness, as well as safety. Indoor air quality is also an essential factor for satisfaction. (Kärnä, Julin & Nenonen, 2013.)

About space use and learning environment, students see informal settings and ad hoc spaces for learning important on the side of the formal learning environments and situations. Technology access, as well as collaborative space are important for students. (McLaughlin& Faulkner 2012, 148.) The most effective strategy to improve student satisfaction with the space management would be the emphasis on the social areas, such as auditoriums and libraries (Hanssen & Solvoll 2015). Also, facilities, as physical environment, seem to have some impact on student choice of university (Price et al. 2003).

There are differences between students and staff satisfaction factors. Public spaces and campus accessibility are in an essential role for the students. For academic staff, factors related to teaching and research facilities have the main contribution to the satisfaction. (Kärnä & Julin 2015.) For research staff, possibility to carry on working without interruptions caused by moving or other facility changes seems to be of importance (Hebert 2012). Considering the ongoing pedagogical change and virtual access requirements in the universities, expectations of the end users are that physical and virtual access is flexible and that facilities will reflect what is available in other aspects of students' lives socially, professionally and personally (Todhunter 2015).

However, it seems that the articulation of the needs and key issues addressed to the facilities, by the individual end users, is not clear. There are different views between individuals, and there is not necessary a clear and common articulation of organizational visions and strategies, as well as pedagogical approaches, to lean on. (Todhunter 2015.) There can also be a lack of recognizing facilities as strategic issue in organizational level, usually caused by lack of information and representation, or by managements' viewpoint of facilities as operational cost rather than strategic issue (Kamarazaly et al. 2013, 143).

3.2 Campus management

Campuses are physical working and studying environments that are arenas of interaction between different groups, as well as objects for a constant change. Therefore, a process perspective including both internal and external influences has to be considered. Social, physical and virtual facilitation should thus be seen as a systemic entity. Rather than seeing the campus as a set of stable facilities, the emphasis should be on managing flows and communities. (Rytkönen 2015.) There is a demand for a holistic approach for facility management to create learning environments of today (Rytkönen et al. 2015).

This holistic approach sets pressure to new methodologies and approaches involving end users as stakeholders in university environment, in addition to surveys and interviews, such as referred previously in this chapter. One approach could be to include experience-oriented methods that look the facilities also from the user's perspective from both technical, social and virtual viewpoints. (Rasila et al. 2009.) Another suggestion is to implement future-oriented modelling tool, which can provide a systematic and a collaborative design approach (Rytkönen & Nenonen 2014).

The added value structures of facility management are space quality, efficiency and utilization, quality of education and research, as well as collaboration-competition aspect (Rytkönen & Nenonen 2014, 148). This suggest that facility management has influence upon academic achievement (Kok et al. 2011, 260). The added value of facility management in educational environment can be conceptualized by defining facility services and coordination as settings, knowledge transfer as process and educational achievement as an outcome (ibid. 256). However, the route from optimizing facility services (the settings) the best way, to achieve the best possible academic achievement (the outcome), is still unclear. Subsequent research is required on the subject. (ibid. 259-260.)

4. Challenges in facility management research

The specific object of facility management defines it as a service business that has focus on workplaces and their management (Tay et al. 2001, 361; Jughans & Olsson 2014). According to a review of academic research of facility management (2007), researchers emphasize the need for valid quantitative data analysis techniques, as well as rigorously conducted qualitative research. It is also suggested that in order to develop, the field of facility management should exploit both approaches and theories of such fields as social science and human resource management. (Ventovuori et al. 2007, 235–236.) Within the Nordic countries, the main trends and development challenges in the field of facility management seem to differ significantly between the four countries (Anker Jensen et al. 2014). In Finland, the facility management research is influenced by the recent innovation policy that emphasizes the needs of customers in product and service development, the systematic use of economic incentives, as well as the participation of end-users in the innovation process (Nenonen & Sarasoja 2014, 65). In a Swiss research is was stated that, from the value adding point of view, more empirical evidence of economical, ecological and social aspects is required to develop facility management further (Windlinger et al. 2014).

A few researchers have approached towards qualitative and socially constructed understanding of facilities, in terms how people define the change in the physical environment in discourse (Airo et al. 2012.) There is no clear difference whether the space people discussed about was actually physical or symbolic, but it is stated that the method of discourse analysis could be more widely used in the field of facilities management. (ibid. 299.) The methods of narrative and discourse analysis are not very widely used in research of general workplace management. The use of linguistic methodology could help to reach a holistic way of studying and developing workplaces. (Airo & Nenonen 2014.)

The concept of space in the field of organizational studies and the facilities' role in workplace management can be approached in the light of organizational creativity. The way of organizing the physical space plays a significant role in the emergence of organisational creativity. As a concept, aspects related to physical space and the organisational culture are brought together. (Kallio et al. 2015.)

Engineering and management, in terms of both research and practice, tend to lean towards procedural concepts and leave declarative approach for a smaller emphasis. On the other hand, from the end user's point of view, the challenge is to understand why something is done and what the consequences are. The importance of qualitative data and approach is also important to reach such taxonomic and ontological concepts that can reach this declarative dimension, in addition to the procedural (Rasila et al. 2010; Che Hassan 2013, 111).

5. Discussion: Opening for an institutional approach

There is evidence of social and cultural barriers and communication failure between the professionals and the end users (Pemsel et al 2010; Hansson 2010). There are also challenges with the tools used in these processes. Tools and practices, as well as the recognition of the importance of the end users, seldom reach beyond the design process into using phase of the buildings (Pemsel el. al 2010, 24; Nousiainen & Junnila 2008; Hansson et. al 2010; Lehtiranta 2015). Thus, the first challenge of recognizing end users in the field of facility management is the lack and applicability of suitable tools of interaction between the professionals and the end users.

The value adding function of facility management understands end users' significance for the process. End users can be defined by terms of external (for example clients) or internal (for example staff or students). (Chotipanich 2004; Junnila 2007; Anker Jensen 2010; Anker Jensen et al. 2012; Coenen & Kok 2013; Awg Husaini & Tabassi 2014; Kok et al. 2015.) Still, there are challenges of how well the end users are included and informed for example in projects of change. Thus, lack of commitment from the end user side occurs (Kaya 2004; Rayle 2006; Rasila & Gersberg 2007). The second challenge is the real inclusion of the end users in everyday practice. This could also be seen as a consequence of the first challenge.

End users in university environments are often considered as customers, whose satisfaction factors are surveyed and interviewed in order to develop service practices (Price et al. 2003; Hebert & Chaney 2012; McLaughlin& Faulkner 2012; Kärnä, Julin & Nenonen 2013; Hanssen & Solvoll 2015; Kärnä & Julin 2015; Todhunter 2015). There are also openings towards more explanatory, individualizing research (e.g. Hebert 2012; Todhunter 2015). The third challenge is the still insufficient understanding of the end users as definitive stakeholders, that have their own concepts and understanding of the facilities they work and study in.

There is a lean towards a holistic approach to campus management practices, due to dynamic aspects of todays' campuses (Rasila et al. 2009; Kok et al. 2011; Rytkönen & Nenonen 2014; Rytkönen 2015; Rytkönen et al. 2015). The roots of this holistic view about university campuses are also in the pedagogical field. The connection between the facilities and the academic outcomes, in terms of added value, is recognized, but not easily measurable. The fourth challenge is the difficulty to show the complicated structures between the physical environment and actual efficacy in academic outcomes.

Mainly due to the value adding function, field of facility management is recognized as a type of workplace management (Tay et al. 2001; Ventovuori et al. 2007; Jughans & Olsson 2014; Nenonen & Sarasoja 2014; Windlinger et al. 2014). Workplace management can also be attached to the field of organizational studies. There is a recognized understanding of organizations and workplaces in a cultural and institutional context, together with other approaches (e.g. Morgan 2006; Hatch & Cunliffe 2006; Czarniawska 2008). Having facility management understood as workplace management, some recent attempts to approach that tradition of social constructionism (Berger & Luckmann 1966) are to be found (Rasila et al 2010; Airo et al 2012; Che Hassan 2013; Airo & Nenonen 2014; Kallio et al. 2015). However, based on both the writers' own statements, as well as the theoretical frames used in the articles, these studies are merely testing and exploring the cultural and constructionist aspect in the field of facility management, rather than applying the cultural and socially constructed frame in the research as such.

There is also an indisputable understanding of universities as strongly institutional organizations (e.g. Millett 1962; Weick 1976; Brubacher 1978; Becher & Trowler 2001). As such, they are built on regulative, normative and cultural-cognitive basic framework (Scott 2008). By definition, this means that institutional setting and these basic structures direct the actions and reasoning of the people working and studying in them (Berger & Luckmann 1966, Weick 1995; Czarniawska 2008).

The challenges and recognized state of the art in facility management found in the literature suggest that opening the door wider for cultural and institutional based understanding in the field of facility management could be an additional new approach. Exploring this possibility could help with the challenges of interaction between the facility management professionals and the end users.

6. Conclusions

Four different challenges that cause problems in end user and professional facility management interaction were defined based on literature research. First, lack and applicability of suitable tools of interaction between professionals and common users. Second, mistakes in understanding of end users as occupants in their own territory that have also knowledge of their physical surroundings, and lack of recognizing the need for inclusion and interaction in the processes. This can be caused by the lack of tools. Third, still insufficient understanding of the end users as definitive stakeholders, that have their own concepts and understanding of the facilities they work and study in. Fourth, in dynamic environment, such as university campuses, the connection between the physical environment and its' value adding function for academic outcomes is hard to measure and show.

Studies of the facility management show the nature of the discipline as a branch of workplace management. In addition to widely implemented approach of service process development, there could be other directions of organizational management research applied. Some recent attempts have been taken towards cultural and socially constructed understanding of facilities as space for social interaction. Exploring this approach in future research could give a new insight and ideas to the development of interaction and interactive tools between the professional facility managers and the end users. As strongly institutional environments, universities would be a fruitful ground to start to conduct such research.

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Spatial borders and affordances of a temporary school building – Enhancing the school engagement and learning experience

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Abstract

In the recent years several Finnish school buildings are facing renovation needs, which force municipalities to relocate the activities of schools to temporary facilities. Often the problem is solved with container schools. The usage of the temporal space may last for several years, therefore it is essential to design them as functional as possible. Furthermore, the temporary settings can provide a platform to develop new knowledge practices and promote school engagement.

The aim of this paper is to identify the spatial borders and affordances, which affect school engagement and learning experience in temporary container school. This is examined in a case of a temporary upper school facilities. The spatial effects on school engagement and learning experience of pupils were researched by mixed method -approach, which included survey, four workshops and a user journey observation with the employees and the pupils of the school. The result were analyzed with FOA-framework consisting of three components of flexibility, ownership and accessibility of space.

Spatial borders and affordances from the perspective of the school engagement were identified and labelled under the major components. The results of this study can be directly utilized in the design of future type temporary school concept but also in designing complete new school buildings.

Keywords: Learning Environment; School Engagement, Learning Experience

1. Introduction

In Nordic countries the school buildings are in desperate need of renovation. Temporary facilities are used in order to maintain the basic education standards. While the actual building stock is going through extensive rebuilding, the pedagogical needs are faced in temporary facilities.

Simultaneously the emphasis of primary education is shifting from teacher-centred education, towards inquiry-based and student-centered forms of learning (Kumpulainen et al, 2010; Litmanen et al., 2012; Lonka, 2012; Lonka, 2015). Accordingly learning processes have become more collaborative and activating including a variety of different forms of working and ICT-based knowledge practices (Hakkarainen, 2009; Lonka, 2015). This puts the traditional and rigid learning environments truly under test. The contemporary learning activities challenge the physical learning environments by knocking on the doors and bouncing from wall to wall (Lonka et al, 2013).

While the new views on education are faced in the old premises of school, a clash of cultures are about to take place. As the renovation of old facilities forces the users of school to relocate to temporary premises, an opportunity to test different kinds of spatial solutions emerges. This provokes the question: what kinds of spatial solutions enhance the new needs of learning and teaching?

In this paper the effects of temporary spatial solutions to school engagement and learning experience are investigated. The following questions are asked

1. What is the role of temporary space in learning experience
2. How does the spatial design effect to school engagement
3. What kind of spatial solutions enforce the positive learning experience and school engagement.

The results of this paper give insights to the design of future type temporary school concept but also in designing complete new school buildings, which enhance the new ways of learning.

2. School Engagement and Learning Experience

Despite the flattering PISA-results in Finland (OECD, 2013), there seems to be a worrying lack of school engagement and positive learning experience. Latest research indicates, for instance, that school exhaustion (Salmela-Aro & Tynkkynen, 2012) and school-related cynicism and inadequacy has increased among students on an academic track (Salmela-Aro et al, 2008). Furthermore, in the latest measurement by OECD (2013) the students' school engagement in Finland fell exceedingly beneath the OECD average. This is one crucial factor why improving learning methods and environments are topical as they can promote pupils' motivation and wellbeing.

The concept of school engagement can be defined in three ways: to behavioral, emotional and cognitive. The behavioral engagement draws on the idea of participation; it includes involvement in academic and social or extracurricular activities and is considered crucial for achieving positive outcomes. Emotional engagement encompasses positive and negative reactions to social sphere, school and is presumed to create ties to an institution and influence willingness to do the work. Cognitive engagement draws on the idea of investment; it incorporates willingness to exert the effort necessary to comprehend complex ideas and master difficult skills. (Fredricks et al, 2004).

As Fredricks et al claim the engagement is seen more of a mental issue. Its' connection to physical space and the experience of space is still an unknown territory. However the school engagement and learning experience are connected not just to social but also to physical gathering of things. (Airo, 2014). Wang and Holcombe (2010) state that adolescents' school engagement can be seen as school participation, school identification and use of self-regulation strategies. In this research particularly the school identification is discussed in connection to spatial attributes of learning environments.

Measuring actual learning and experienced learning can differ. However there is a body of evidence that relationship of the two is positively correlating. It is stated that learning is enhanced through active involvement in personally meaningful experiences accompanied by processing for meaning and future use (Luckner, et al 1997).

3. Learning Environments

Learning environment is a wide concept that consists of multiple dimensions from which the context of learning emerges. Usually at least three dimensions are acknowledged: physical-, social- and digital (Lodge, 2007; Nuikkinen, 2009; Piispanen, 2008). Also cultural and pedagogical dimensions are mentioned (Manninen, 2007; Kuuskorpi, 2012). However, it's not about how we divide the concept in pieces but how we form a functional and engaging unity out of these dimensions, so that the surroundings and its multidimensional affordances really promote 21st century learning. In addition, the school's organizational culture and leadership practices plays a huge role in pushing the educational practices toward 21st learning and thus utilizing the corresponding learning environments (Vaara, 2014). Furthermore, this cultural shift also set its own demands on learning environments: new co-working and communal practices require more informal and flexible spaces to foster straightforward collaboration (Vaara, 2014).

Self-determination theory (SDT) assumes that the degree to which students perceive that the school context meets those psychological needs determines the level of students' engagement in school (Wang, 2010). In this sense the perceived school environment also in physical sense, would enhance their engagement to school and learning experience. In addition the physical design of the school has been seen both as an enabler and prohibiter in pupils learning process.

Physical school environment also reflects the policies of governments' pedagogical views. They are political and public places, which often lack private rooms and enclosed space for pupils. It has been quite critically stated that sometimes school buildings resemble hospitals, factories or even prisons, in which the individual does not have a freedom for privacy or individuality.
(Vuorikoski & Kiilakoski 2005, 312–313.) In addition the traditional classroom represents hierarchy between teachers and pupils. Teacher is allowed to move and control the space, whereas the pupils are forced to sit still (Gordon 1999, 106–107.).

School and learning environments are not just restricted to internal spaces. Also the yard and network of learning places can be seen part of the learning environment. School is often separated from the other cityscape by fences etc. The aesthetics of the external spaces have been seen as important part of the pupils' wellbeing. However they often contradict with safety regulations and ideals, which would acknowledge the needs and behavior of young pupils (Gellin et al, 2012, 143).

In this paper the school engagement, learning experience and learning environments are defined always in relation to the spatial design and its' features. The actual learning outcomes are not discussed. Neither is the overall school experience other than its relation to the temporary school facilities.

4. Flexibility, Ownership and Accessibility of school environment

The school engagement and the learning experience in temporary school facilities was investigated with a so called FOA - framework, in which the concepts of flexibility, ownership and accessibility of space were used to both gather and to analyze the data. Flexibility of space refers to the range of usage of the space. That is how well does the space alter to variety of usage. The ownership refers to identity of the space. In other words, how well do end-users, the staff and pupils identify with their school and how much they have a freedom of using it. Accessibility refers to usability and comprehensiveness of the school building and infra.

The FOA-framework was derived from literature focused especially to the research of usability of built environment. The researchers argue that usability as a core concept for managing organisational ecology (Alexander et al 2013). It is stated that usability is a cultural phenomenon that can only be improved through a better understanding user experience, considered as situated action in a specific context" (Alexander, 2008). A building's performance can never be seen or understood in isolation from an organisational and technical perspective.

Alexander (2010) argues that school facilities should be considered in the context of the communities they serve and as a prime means of transforming education. Effective learning environments successfully combine appropriate social and digital environments with the physical environment (Beard, 2012). Creating quality learning environments, which are more broadly accessible in the community, can also play a catalytic role in regeneration.

Usability evaluations are based on different user's experiences and assessments on how well the buildings perform regarding different parameters. The dutch standard NEN 8021:2014 (Valuation of User Requirements and Performance of Non-Residential Buildings) defines nine usability criteria: which are comfort, safety, sustainability, flexibility, use of space, representativity, services and accessibility. NEN 8021 helps both the users to determine their needs and wishes regarding the building and also helps providers to compare their products to it (Anon 2014).

In this study the concepts of usability defined by NEN8021 were applied in forming the FOA-framework by focusing in flexibility including the use of space, representative especially from the perspective of ownership of the space and accessibility. The other criteria like comfort and safety where also discussed but the three parameters were the most significant for this research.

The flexibility, ownership and accessibility i.e. FOA-framework was applied in analyzing both quantitative and qualitative information. That is, the discussions, answers and observations were placed in the thematical FOA-framework. In addition the different kind of data (qualitative and quantitative) were cross analyzed in a matter of how they correlated or differed. In addition it was looked are they any extra data, which would differ from the original FOA-concept.

5. The Methods

The temporary School environment was investigated with mix-method approach, that is both qualitative and quantitative methods and data were utilized. The qualitative methods included four workshops and a user journey observation.

Self-report questionnaire

To map the prerequisite for the co-creative learning environment intervention a preliminary self-reported questionnaire was conducted among all seventh graders of the school (n =100). The seventh grade was chosen, because of potential follow up-measurements in close future, since the seventh graders would stay at the school for two further years and therefore also experience the school's transfer to the new school building in fall 2016. For this purpose a questionnaire including 22 statements about the conceptions on learning environment and school work was prepared by applying partly statements used in the self-report questionnaire of the Mind the Gap Between Digital Natives and Educational Practices -project (2013-2016) funded by the Academy of Finland (Mind the Gap, 2014, Hietajärvi, 2014).

However, more specific statements concerning learning environments were invented and added to the original Mind the Gap *How do you experience your school and schoolwork?* –instrument, which was a learning environment centered section in the self-report questionnaire. This decision was made, because the orginal Mind the Gap instrument included only a few more general statements about learning invironments, for example *my school feels safe* and *the learning environment of my school feels comfortable*. Therefore, more precise statements concerning physical learning environments were added, for example *my school building is comfortable from the inside* and *the spaces of my school help me to focus on the current task*. Furthermore, the statements in the questionnaire were set in an order that would reflect the daily cycle of pupils' school experiences, by starting with statements about entering the school area, then proceeding to the interior design of the school building and finally to more general school experiences (see table 1).

This so formed Flexible Learning Spaces-instrument (see table 1) was then set in a 5-point Likert-type scale. The statements were set in an order that's in line with the users' daily cycle of observations: starting with statements about entering the school environment, proceeding to the inner surrounding, first in more general and then in more specific, and then measuring the users' overall conception about their school.

User journey-observation

Part of the qualitative data was gathered with user journey observation. Observation tells something about the things that people actually do, not what they think they do. Conceptualizing of a space is based on user actions and researcher's interpretation. Spaces as such are not conceptual entities but they become one when combined with human reasoning and action (Lefebvre, 1974). Thus both the users, their actions and the space were observed.

The actual observation was based on Dale Cobb's (2008) customer journey framework. The idea of Dale Cobb's customer journey was originally an idea of a conceptual journey becoming a customer. Observation applied a model of the different concrete "journeys" users make in the building and in the space. The researchers observed the school building and the yard by all the functions that took place in school such as entering school, acting in breaks, eating in cafeteria and being in the class room. The observations were conducted both from the teachers and from the pupils' point of view. This was done by walking first with the teachers throughout the school facilities. The pupils' perspective was first investigated in workshops and later with taking the observation walkthroughs with the pupils.

Workshops

During the project four workshops were arranged: the first workshop focused on user experience about existing physical spaces and surroundings of the school and the thus collected data were then combined with results of the user-journey observation. Later one workshop was then arranged to participate the users, both pupils and teacher, into the design process of a new engaging learning space which was supposed to demonstrate the key findings and principles of the project and offer a testbed for the school to adopt new educational practices to foster 21st learning. In this later workshop pupils sketched preliminary spatial layouts which were then reviewed and improved by the teachers and researchers.

Additionally two workshops were executed to introduce new digital solutions to the pupils and teachers. The aim of these workshops was to foster the integration of ICT into the learning environment and learning processes, which is an important factor in 21st century learning. Furthermore, it was to make sure that the new devices provided by the project would successfully blend into the daily practices performed especially in the new learning space.

6. The Results

The aim of this paper was to identify the spatial borders and affordances, which affect school engagement and learning experience in temporary container school. Based on mix-method approach following key results can be identified.

The results of the self-report questionnaire indicates that the physical learning environment in the temporary school settings are not experienced by the users as comfortable or engaging (see table 1, 8.2, 8.3, 8.4). However, the results indicate that the overall working culture and communality is seen as rather engaging and positive (table 1, 8.11, 8.17,). The pupils also felt the overall school environment safe (table 1, 8.1.). Furhermore, the results show that the pupils experienced their work at school as activating, collaborative and the teachers' guidance supportive (table 1, 8.9, 8.12, 8.14). In all, the pupils considered the role of their working environment as significant (table 1, 8.16).

Table 1. Results of the self-report questionnaire.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
a8.1 My school area feels safe	100	1,0	5,0	4,070	,9239
a8.2 My school yard is comfortable.	98	1,0	5,0	2,357	1,1238
a8.3 My school building is comfortable from the outside.	99	1,0	5,0	2,242	1,0888
a8.4 My school buiding is comfortable from the inside.	99	1,0	5,0	2,697	1,1469
a8.5 The spaces of my school foster collaboration.	98	1,0	5,0	2,592	1,0633
a8.6 The spaces of my school foster my own learning.	99	1,0	5,0	2,828	1,0977
a8.7 The spaces of my school help me to focus on the current task.	99	1,0	5,0	2,626	1,2002
a8.8 The classrooms enable a variety of different working forms.	98	1,0	5,0	2,837	1,0619
a8.9 During the lessons the pupils have an active role.	99	1,0	5,0	3,667	1,0102
a8.10 It's peaceful during the lessons.	97	1,0	5,0	2,866	1,1513
a8.11 The pupils in my class enjoy being together.	97	1,0	5,0	4,041	,9345
a8.12 During the lessons the teachers encourage me to express my opinion.	99	1,0	5,0	3,636	,9944
a8.13 The teachers are interested in how I'm doing.	98	1,0	5,0	3,378	1,0890
a8.14 The teachers treat us pupils righteous.	99	2,0	5,0	4,051	,8497
a8.15 I feel that the school's ICT helps me to learn.	98	1,0	5,0	3,367	,9238
a8.16 The surrounding working environment plays a significance role.	97	1,0	5,0	4,021	1,1178
a8.17 There is a good atmosphere at our school.	98	2,0	5,0	3,816	,9454
a8.18 It's easy to work in my school.	99	1,0	5,0	3,667	,9476
a8.19 I feel my school's spaces as my own.	98	1,0	5,0	3,276	1,1468
a8.20 I know how I can influence the matters at my school.	97	1,0	5,0	3,278	1,0776
a8.21 I feel myself happy in this school.	99	1,0	5,0	3,717	1,0789
a8.22 I'm proud about my school.	98	1,0	5,0	3,367	1,1158
Valid N (listwise)	86				

6.1. Role of space in learning experience

The results of the qualitative approach complimented those of quantitative. Based on observation and workshops the effects of spatial attributes to learning experience were often concentrated to physical hindrances of the temporary container school.

> "The classrooms are noisy. It is impossible to listen the teacher, when it is raining and the water hits the ceiling so hard" Pupil 15 years.

The hindrances were mostly connected to audio, such as the noice of the rain, ventilation or to the light structures of the facility. It was also claimed that the trembling of the facility and its' vulnerability to external factors such as passing cars or slamming doors affected to concentration of the pupils.

It was not only the physical structures, but also the temporary gathering of the spaces that impacted to pupils overall spatial experience and behavior. Walls, visibility and access to different spaces affected for instance to the amount and grouping of students and teachers in certain places:

> " There is gasstation across the road. All the pupils are running there all the time. I can't see all the students all the time, since the yard does not have a shared area and the containers are sort of a labyrinth" Teacher

and

> "All the pupils are gathered in front of doors under the rain shelter, like penguins" pupil, 13 years.

These comments illustrate how certain corridors or lack of them affects to the way pupils are teached, managed and taken care of. Also they affect to the social order of the groups. Who is going where, who is the first in line, who has to stay out in the rain etc. Of course similar structures can be seen in every school building and built environment in general. However, the temporary schools this is rarely acknowledged.

6.2 Spatial effect to school engagement

Spatial design has both straightforward causal effects on engagement and indirect effects which are connected to overall experience of school building and wellbeing within the school. For instance dysfunctional basketball field may arouse constant discomfort of the students, which accumulates to misbehavior within the classroom.

> “ The older pupils govern the whole yard by playing basketball in the center. It is hard to cross the yard to other side without interfering the game and causing annoyance” pupil 13 years

On the other hand the common distress of the students and teacher unites them and enforces the engagement to the organization. In this sense it is challenging to separate the role of space in overall experience of the school.

> “ This is our school. This is the only memory I will have about my school, when I grow up. When I am an adult I don’t have my school anymore. I can’t say to my children that, there is the school, where your mom went to” Pupil, 14 years.

Based on these aforementioned findings the spatial design of the school building whether temporary or permanent solution should acknowledge the identity of the school by either creating new symbolic artefacts or bring old ones from previous premises.

> “We have this old counter, which is the designated place for 9 graders. My dad asked, do we still have. He also used to have it when he went to same school” Pupil 13 years

The temporal nature of the space affected to school engagement also by lack of certain key spaces such as gym hall.

> “we do not know where to go, if we have a party. We do not even have a gym hall. We always have to go somewhere else and it takes time” Pupil, 13 years.

In addition the fractured nature of container school in small and bigger perspective affects to time management within the school life. If pupils have to go far for eg. gym lessons, they do not have time to come back to next lessons, which generates pressure to curriculum plans.

7. Conclusion

The borders and affordances of temporary school facilities can be categorized in terms of flexibility, ownership and accessibility. Learning experience and school engagement is affected in following ways:

The temporary school facilities such as container schools are often ready made mass products, which lack the quality of the permanent school. On the other hand, as not being so fixed they can and especially should be adjustable to differing needs for learning.

The results of the preliminary self-report questionnaire also indicates that the positive and safe atmosphere and collaborative school culture, at least in the context of this study, could foster an experimental approach into co-creating new pedagogical practices and adjustable learning environment solutions to turn the otherwise non-engaging temporary environment into an engaging testing ground of new kind of learning.

The ownership of the temporary school is endangered by its temporary nature. As indicated in work shops it appeared that no-one cares to take responsibility of a school that is not permanent. On the other hand the shared experience of the temporarity strengthens the engagement to the community. The lack of quality in physical conditions contribute to school engagement and identity by bringing the staff members and pupils together. The accessibility of the container school is often overlooked, which creates unusable and almost dangerous situation in school yard. On the other hand the lack of internal spaces such as corridors, forces pupils to move and interact with each other and within the space.

Based on results it can be said, that whether in design of a temporary school or a permanent school following suggestions should take into consideration, when planning new learning environments: Facilities should be planned primarily in terms of functions they could gather avoiding for instance the setting of different disciplines. Utilization of gamification as part of the learning and working (eg. Avatars, listing their achievements, gathering experience points, immediate supportive feedback). The school can be a interface of learning in itself.

Sets of furniture are such that they can be easily grouped into different forms to support and control the gathering of spaces. This can be also supported with a rhythm of curtains and other movable space dividers between the various rooms. Private spaces should move towards public spaces: the user should feel intuitively the nature and purpose of the different spaces and is able to act accordingly. The building should be easy to expand, if necessary, outside the classrooms, eg. In the lobby, courtyard, or in some other open environment. Spaces are teaching platform in their self: for example, green walls, showrooms, solar panels.

The interaction between the users and the environment, strengthens the school engagement (eg. events, concerts). The border of a temporary school building is often a lack of communal space. This is a weakness in formulating the engagement. Various events increase ownership and promote the takeover of the operating culture and spaces. Creating a themed space with a variety of identities, which are suitable for different learning processes give the users feeling of freedom and creativity. The engagement can be supported artifacts which encompasses a certain meanings.

Users should be included in the design of new environments and be given the opportunity to customize their own environment. Projects made together: for example, the wall paintings as part of the arts exercises, school logo design contest. The ownership of the building encourage students to move out of the recess. The external space of courtyard is extremely important and should be acknowledged. The gathering of spaces guides also the gathering of groups and social order.

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Integrated learning for students in the Built Environment

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Abstract

The purpose of this study is to assess the transformation of integrated learning in one course related to the built environment. Research on college teaching and learning provide evidence active learning and collaboration is more effective than traditional lecture (Kuh, Kinzie, Schuh, & Witt, 2005; Pascarella & Terenzini, 2005). Applying this research to improve undergraduate education a transformation is occurring by incorporating more effective pedagogical techniques across disciplines. This paper will outline the changes which have been applied to one course that includes many different majors connected to the built environment. Data collected in this course and at the university will show if the integration changed the students' perception of learning climate, basic psychological needs or knowledge transfer. The results of this study will show the impact of the different elements of active learning in a classroom across disciplines.

Keywords: Assessment; Active Learning; Integrated Learning; Transforming learning

1. Transforming Education through Integrated Learning

Decades ago, King (1993) in his research, encouraged faculty to move from being a ‘‘sage on the stage’’ to more of a ‘‘guide on the side’’ in their teaching approaches. A university wide transformation program took this concept and applied current pedagogy to develop faculty training to change one course at a time. To improve higher education pedagogies, Instruction Matters – Purdue University Academic Course Transformations program (IMPACT) was based on research in pedagogy to improve student learning. The mission of the program is “to improve student competency and confidence through redesign of foundational courses by using research findings on a sound student-centered teaching and learning” (IMPACT Management,, 2014a,b,c). Through the development it was shown that redesign of courses needed to include innovation, implementation and assessment to be successful (Arthur & Zelda, 1987; Levesque-Bristol, Weaver, & Parker, 2012). The experts leading this initiative created tools for assessment based on The Self Determination Theory. This tool was used in all courses associated with IMPACT. One course that was transformed is an introductory course in the built environment (BCM10001). The transformation included the development of new learning outcomes, utilization of an active classroom and creation of active learning modules. Data collected over three semesters show the impact of the all courses at the university and the specific course related to learning climate, psychological needs and perceived knowledge transfer.

2. Review of Literature

2.1 Curriculum Development

Curriculum development was based on the research related to student success. One beginning set of tools includes the seven principles of good practice in undergraduate education by Chickering and Gamson, 1987. More current research includes the evidence of collaboration / team work and active, student-centered learning as increasing student success (Kuh, Kinzie, Schuh, & Witt, 2005; Pascarella & Terenzini, 2005). Blooms taxonomy was used to transform the learning outcomes into more students centered objectives (Anderson, L. W., Krathwohl, D. R., & Bloom, B. S. (2001).

John Dewey is believed to be the father of experimental learning and it is from his ideas that researchers have developed the self-determination theory (SDT). Each course transformation was unique, but it was important to have a common assessment tool. The experts leading the university wide curriculum researched leading publications and found the Ryan and Deci model was not only proven to be valid and reliable, but also aligned with their mission statement. This tool is utilized to measure students’ perception of learning climate, basic psychological needs and knowledge transfer (Ryan & Deci, 2000b). Self-determination theory has the potential to address learning problems such as student attrition in the active learning environment (Chen & Jang, 2010). As Neimiec and Ryan (2009) stated in their research, the STD higher learning can be improved by helping a student develop interest to want to learn because of interest in developing their own knowledge. This theory is based on the ideas that there is a need for autonomy (self-choice), the need for competence (mastery learning), and the need for relatedness (related to real world) (Ryan, Connell, & Deci, 1985). Figure 1 illustrates the concept of moving students towards self-determination and increasing their intrinsic motivation to learn. The transformation of courses was based on this type of theory and as an assessment tool was developed to measure the effectiveness.

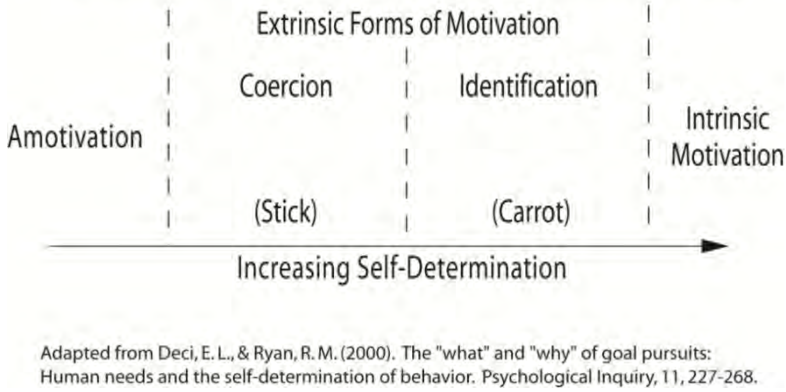


Figure 1: Continuum of Self Determination Theory

The goal of the project is to develop instructional pedagogy that engages students in learning activities that apply knowledge but also allows them to develop higher levels of cognitive learning. The activities create an engaged student that work at their own pace and continually grow as information is interpreted and applied to authentic interactions in the classroom (Grabinger & Dunlap, 1995; Prince, 2004).

2.2 Learning models

The IMPACT program was designed to utilize active learning through different course transformations techniques. There are three main models that were introduced to faculty to assist in their course transformation. The goal is to make a more student centered learning instead of the traditional lecture model where students listen and take notes during the entire class time. A supplemental model adds materials online which assists the students in applying the knowledge of the course. This could be videos over current events related to the class that assist the students in transferring the knowledge from the classroom to life. The idea is that when the students are in class, there can be activities integrated into the lecture to assist the students in applying knowledge and building cognitive skills.

The next method is the replacement model where parts of the lectures are replaced by online content to allow for more in class time for activities. Students come prepared for class and have reviewed materials which allow them to expand their participation in the class. The final method is known as the flipped method. This can be used for a fully online course or can be developed to eliminate the need for lectures and create a fully active student-centered teaching. For example, students read and do homework before coming to class and then review assignments in class instead of listening to a lecture that they were not prepared to hear. They read material and view videos on the assigned chapter before coming to class and then engage in active learning strategies such as debates on current issues during class (Gilboy, Heinerichs, Pazzaglia, & Chester, 2014). The idea that students must be self-motivated to learn before coming to class and that class time is used more for clarification of information. A hybrid model of this would be when some information is given in class like a mini lecture but still utilizes the class time more as a work period.

The supplemental model is the middle ground between the fully flipped and the traditional lecture. These types of pedagogical approaches have been utilized to transform classrooms.

Figure 2 illustrates the connection to active learning and the increase in student success measured by a lower Drop, Fail or Withdrawal (DFW) rates and increased GPA in courses. The ultimate goal is to increase retention and decrease time of degree completion to ultimately lower overall cost of education.

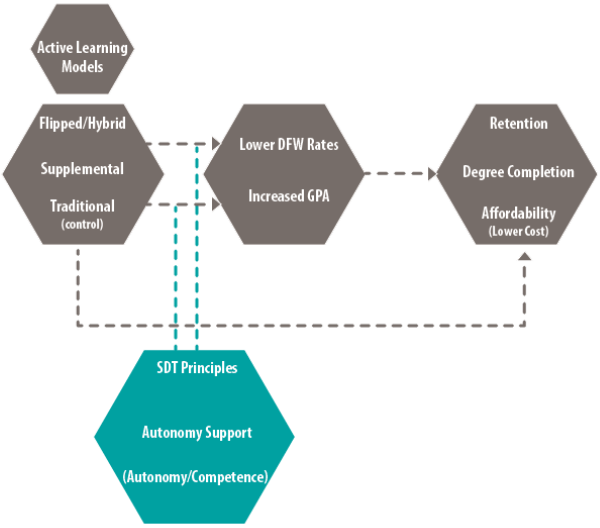


Figure 2: Active Learning Model Measurable Outcomes.

3. Specific Pedagogical Changes

The BCM10001 Introductory course was first transformed in spring 2013 with assessments collected in fall 2013, and spring and fall of 2014. The instructor has made the following changes to the course:

- Met in an active classroom with moving tables and chairs (shown in Figure 3)
- Developed an online textbook with pre and post tests for each chapter
- Implemented modules with pre work and in class activities
- Created community based group service project to apply knowledge.
- Instant feedback in class tests
- Limited lecturing with emphasis on activities in classroom

This university allows faculty to own the curriculum for each course while outside accreditation agencies validate each program. The outcomes of courses are required to be measurable for assessment purposes of each department. The changes in this course have evolved with continuous improvements added after each semester. The initial major changes were developed with the guidance instructional designers, literacy professionals and information technology experts.

Figure 3: IMPACT Active Classroom

3.1 Transforming Outcomes

The initial learning outcomes for this course were based on the American Association of Construction Education (AACE) accreditation standards. As these standards are moving towards outcomes based assessment, it seemed logical to also align courses to follow these standards. The original outcomes were as follows:

1. Introduce students to the Building Construction Management (BCM) department including: Faculty, staff, concentrations, program, history, career opportunities, student opportunities, and department events.
2. Review the history of the construction management industry through the current trends for the future. (LEED, Sustainable, Green)
3. Evaluate the campus resources available for students' success (Online writing lab, libraries, Academic Success Center (ASC), College of Technology Tutoring, BCM Mentors, etc.)
4. Identify and define materials, methods and construction vocabulary related to the CSI divisions by numbers.
5. Explain the various sectors of the construction industry and career opportunities for the students.
6. Utilize computerized software to overview topics including: project delivery types, contract documents, plan reading, bidding, estimating, pre-planning, scheduling, codes, and safety.
7. Reveal the roles and of the major players in construction industry and how they work as a team.
8. Identify the general concepts and applications of Building Information Modeling / Management (BIM) to construction plans and specifications.
9. Expose the opportunities for lifelong learning in the construction industry (certification programs per state, CPC, AIC, Site Supervisor Cert. etc.)

Over the semester long IMPACT workshop, the faculty and team refined the outcomes for the course to include only these four main points:

1. Review the past, present and future of the construction management industry.
2. Identify resources for student success and lifelong learning at Purdue and beyond.

3. Demonstrate competencies in using computerized software to overview topics in Construction Management.
4. Differentiate between material uses and applications on a construction project.

Each outcome for the course were then aligned with objectives which were mapped to an assessment technique. Table 1 shows a sample of two objectives related to outcome # 1. The first objective uses exam questions to assessment the recall level of Blooms. The next objective is assessed through a project and expects the student to analyze this topic area.

Table 1: Mapping of BCM10001 Course objectives to Blooms Taxonomy

	Remember/ Recall	Understand	Analyze	Apply	Evaluate	Create	Activities
1.a.i Define construction related technical vocabulary	x						Exam questions
1.a. ii Differentiate between LEED, Sustainable, and Green using materials as examples			x				Project

Further improvements in the course were created based on the pedagogies introduced in the classes. As replacement model of course design was utilized. Improvements to the course aligned with Checkering's principles of increasing student success in the classroom. The physical space of the classroom with rolling tables and chairs that can be configured into endless configurations assist the faculty and student connections. This allowed students to collaborate and work in groups and have the faculty walk around and sit with the students. Activities related to the built environment include: design process, team building, scheduling, estimating, communication, and professional development. Modules which include professional development assist the students with understanding how their career path integrates into the built environment.

One specific example of an active day is a mock career fair that occurs each semester during classtime. It is one part of a career development module that begins with a resume review. The Mock Career Fair was developed to increase the self-efficacy of students related to interaction of industry partners. Students are given information on how to dress, what to say and specific companies to research. Typically 6 – 9 companies with 1 – 3 representatives for each company attend the mock career fair the class before the real department career fair. Students are required to dress appropriately and interact the company representatives as if it is a real career fair. They received points by reporting out on the feedback, positive or negative, from the industry partners. Feedback from this has been positive from the student's and the industry partners. There is an overall belief that this class increases students' confidence and preparedness for the larger career fair event.

Some of the larger more technical course projects include a mini design project. This project has been done as an individual and group activity. The students are applying knowledge of roles in the built environment by finding flawed designs and outlining the major players in the owning, design, building, or maintain the particular infrastructure issue on the campus.

After this identification, the students had to come up with a plan on how to fix the design flaw thereby encouraging creative thinking as well helping students apply the knowledge obtained.

To understand project scheduling, students are required to bring a list of activities that they do in preparation for getting ready for school each morning. During class time, a full class discussion is facilitated by the instructor to help the students understand if each of the items on their list is actually an activity. Does it take up time or resources? After this discussion, students are introduced to a bar chart format for visualizing the data. They then work individually, but can talk with each other, to make each of the bar charts for this daily tasks. It is then that the students begin to understand concurrent and predecessors and successor types of activities. The goal of this assignment is to assist the students in understanding basic concepts of scheduling. Additional assignments included interpreting an actual construction schedule and developing a schedule related activities assigned.

4. Data collection to assess course transformation

Students in the course represent many areas of the built environment including designers and management. Table 2 below shows the typical distribution of majors attending the class. This course fulfills the requirements of a general education elective for the university and therefore is taken by all majors across the university. It is a required course for all students in the School of Construction Management majors and minors. The exploring students are undecided in a career choice and have not declared a college major.

Table 2: *Demographics by Major Typical for Course*

College Major	Typical Percentage in Class
Construction Management	51%
Liberal Arts	9%
Engineering	4%
Management	6%
Exploring	15%
Science	4%
Technology	11%

The diversity of the class allows for richer experiences for students to work in groups and share information. As an introductory course, there is a higher number of first year students, but also students who are upper level. Figure 4 shows the typical distribution by years enrolled in college.

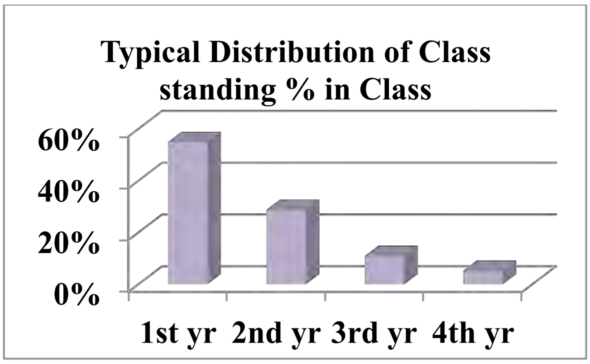


Figure 4: Typical Demographics of Class by Year

4.1 Methodology

Data was collected by the IMPACT team using an online survey instrument made up of questions on a Likert scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). The survey instrument was made up of sections that aligned with the outcomes for the assessment (learning climate, psychological needs and perceived knowledge transfer). The survey instrument based on the STD research explained in the review of literature is one which has been proven over many years of research. This version of the survey has been utilized in all of the transformed courses since 2010. Some of the details which have been included in the questions are outlined below.

Learning Climate questions are used to determine the students' perception of the active learning. Sample questions include:

My instructor understood my perspective.

My instructor encouraged me to ask questions.

My instructor listened to how I would like to do things.

Basic Psychological Needs pertains to the extent to which students are confident about mastery of content material as well as the feelings of being connected, intellectually and emotionally, to other students in the class, as well as to their instructor. They include the areas of autonomy, competence, relatedness, and self-regulation questions listed below:

I am free to express my ideas and opinions in this course.

I feel like I can pretty much be myself in this course.

I have been able to learn interesting new skills in this course.

Most days I feel a sense of accomplishment from this course.

Perceived Knowledge Transfer is the student perception of if the course content is important to their future learning or life. Sample questions in this area include:

I feel confident in my ability to apply the course material in my professional life.

I feel as if the material covered in this course is relevant to my future career.

Information learned in this course will inform my future learning experiences.

I believe that it is important for me to learn the information included in this course.

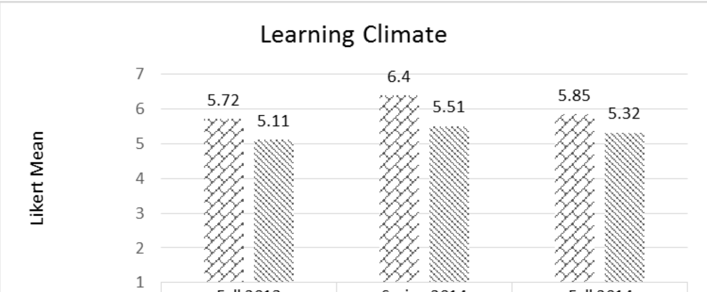
4.2 Results

The goal of this study was to examine the effects of infusing active learning elements and integration into a course related to the built environment. The results will show the individual semesters that were surveying. The instrument consisted of three sections that align with the objectives of the study:

1. Learning Climate
2. Basic Psychological Needs
3. Perceived knowledge transfer

Descriptive and inferential statistics and selected variables were used to explore the research. Analyses were conducted to examine the experiences of the students who had chosen the course.

1. Learning Climate refers to students' perceptions of the student-centeredness of the learning environment. Results for the course and overall campus numbers are shown in Figure 5. Fall 2013 semester was lower due to being the first semester and having the least amount of activity. It is logical that as the faculty member becomes more familiar with the new pedagogy it would improve the learning climate. The lower numbers in Fall 2014 are probably because of a new online textbook that was implemented for the first time.



	Fall 2013	Spring 2014	Fall 2014
BCM 10001	5.72	6.4	5.85
IMPACT Mean	5.11	5.51	5.32

Figure 5: Comparison of average Learning Climate score

2. Basic Psychological Need is based on the Self Determination Theory as mentioned earlier. Figure 6 illustrates summary data for SDT in area of autonomy, relatedness, and competency as determinants of motivation. The highest learning climate provided the lowest Basic Psychological Needs satisfaction although the result was not significantly different from that of Fall-2014. This is finding is in accordance with Niemiec & Ryan's research and indicates that the infusion of active learning elements into learning climates can possibly undermine the Basic Psychological Needs of the students (Niemiec & Ryan, 2009).

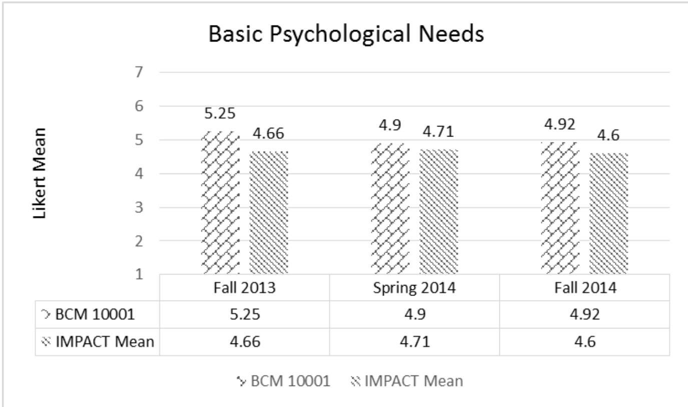


Figure 6: Comparison of Average Basic Psychological Needs Score

3. Perceived Knowledge Transfer is the engagement in higher levels of Bloom's taxonomy may improve the students' perception of knowledge transfer (King, 1993; Mazzolini & Maddison, 2003). Upon comparing the results of Fall-2013, Spring-2014 and Fall-2014, it was found that there was no significant difference in the way the students perceived their knowledge to be transferred. Figure 7 shows the overall comparisons for each semester.

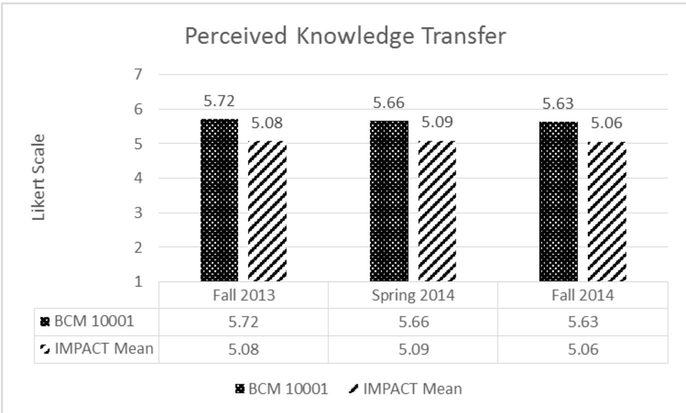


Figure 7: Comparison of average Perceived Knowledge Transfer Score

5. Conclusions

Overall the changes to the course showed to be very positive. Since the changes have been made to the course, the number of students taking the course has doubled. Industry partners are now commenting on the maturity of the students as the becoming employees in areas of the built environment. The active learning modules create a platform by which students learn materials, but also grow more motivated and excited about the career path and college major that they have chosen. Real world activities create an autonomous environment which increases student interaction. A gallop poll done in 2014 with over 30,000 college graduates around the United States showed that the top 6 outcomes align with the transformation ideas:

1. I had a professor who made me excited to learn (63%)
2. My professors cared about me as a person (27%)
3. I had a mentor (22%)
4. I worked on projects (32%)
5. I had an internship (29%)
6. I was active in extracurricular activities (20%) (Paul, 2015).

Unfortunately, only 3% of those surveyed had experienced all 6 areas. Those who were reporting were also reporting success in the workplace to further show that the extra effort by faculty to create an integrated learning environment might that transfers to lifelong learning. Figure 8 shows a summary of the three semesters for this course in comparison to the overall average for the campus. With n=170 for the course and n=7,000 for the overall campus, this gives a good indicator that the research of active learning is supported by this course.

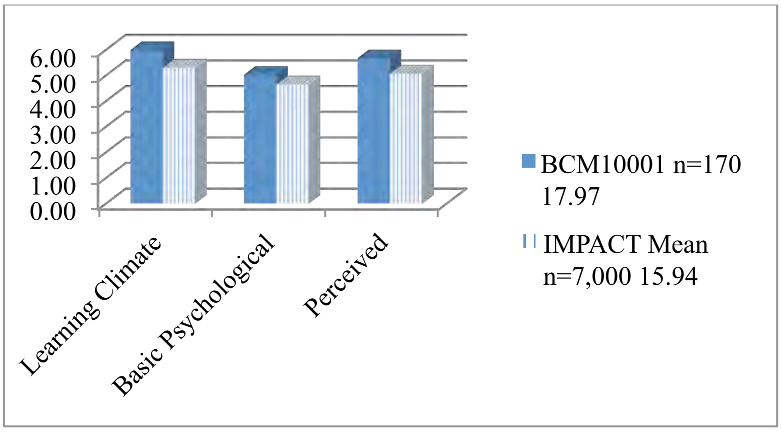


Figure 8: Overall Comparison of course and campus.

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Campus Retrofitting (CARE) Methodology: A Way to Co-Create Future Learning Environments

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Abstract

The future learning environments are not based on standardized design solutions like lecture theatres for 100 persons or classrooms for 40 persons. As new technology and new ways of studying are being developed new demands are put on university environments. At the same time utilisation of resources in form of both teachers and university facilities is challenged by development of integration of learning, teaching and the spaces where it takes place. The challenges are shared among users and owners of campus, where retrofitting is needed too. This paper aims to describe Campus Retrofitting (CARE)- methodology for user-centric and co-creative campus retrofitting processes. The campus development research in Nordic countries and co-creation in retrofitting processes are discussed. The campus retrofitting cases in different countries are described by emphasising especially the methods they used. Based on the analysis of the methods the framework for Campus retrofitting (CARE) - methodology is presented and discussed. CARE-methodology is a tool to capture new logic to learning environment design. It has three key activities: co-creating, co-financing and co-evaluating. The integrated methodology and the formulation of the guiding principle of the CARE-way of sustainable retrofitting of university campuses opens up an agenda for investigating a new methodology for sustainable urban retrofitting in a Nordic context.

Keywords: universities, space management, facilities management, space design

1. Introduction

The Nordic countries have much in common, historically, culturally and linguistically. They have had a common labour market and strong co-operation in many areas for many years. The Nordic welfare state model is based on the rights of individuals to a decent life and equal opportunities for social promotion, often achieved through education. Higher education is a part of their large public sectors and has been influenced by a powerful nation-state in which regional policy considerations and the social thesis of equal educational opportunity have played an important role (Fägerlind et al. 2004). Nordic countries have a strong research and development drive in campus development. The challenge is to apply the research results to campus retrofitting practices: how and what kind learning environments to develop. Nearv et al. (2010) claim that the intelligent estates director, from a position of blindly reacting to academic demands and maintaining the existing stock, has taken a pro-active role in contributing to the academic and business planning process by presenting options, identifying under-utilised resources, and mapping out pathways to achieving academic aspirations. Also Nielsen et al (2012) emphasise the significance of interactive co-creation between an actor and stakeholders surrounding the actor as a way to develop future learning environments and in particular for sustainable retrofitting of universities.

The future learning environments are not based on standardized solutions. Universities are under pressure to expand, change and find greater efficiencies. They have recognised the value of their estate both as a real estate asset and vehicle to open up opportunities for innovative teaching. All Nordic university property management organisations emphasise, that their operations need to be sustainable from economic, environmental and social perspective. There is a need to preserve the cultural heritage, since the university properties are often culturally valuable and reflect the society in general (Anon. 2010).

This paper aims to describe Campus Retrofitting (CARE)- methodology for user-centric and co-creative campus retrofitting processes. First the campus development research in Nordic countries and co-creation in retrofitting processes are discussed. Then the campus retrofitting cases in different countries are described by emphasising especially the methods they used. Based on the analysis the framework for Campus retrofitting (CARE) - methodology is presented and discussed.

2. Campus Retrofitting

2.1 Need to Retrofit Learning Environments

A university's campus is seen as a huge learning environment, which creates possibilities for learning – also across the university's academic environments (Anon. 2013). The last thirty years have witnessed dramatic developments in higher education. In Danish literature it is stated that an important parameter in world-class universities is a vibrant and challenging physical research and study environment. Physical planning is of great significance to the quality of the study and research environment at and around universities. (Anon. 2009) New methods of learning, new creative work environments, internationalisation, digital possibilities, and not least urban development and more stringent energy requirements continually increase the demands concerning the physical setting (Anon. 2013). In Norway thirty projects, which address such issues as the future of the prototypical greenfield campus were collected in order to understand how inner city campuses are transforming the urban context and include prominent corporate enclaves and their ideological underpinnings (Hoeger and Christiaanse 2007).

In Sweden Karolinska Institute and Stockholm County Council (SLL) had a research and development project about Future Learning Environments in 2010-2012: How Space Impacts on Learning. They used the concept of the learning landscape to explore the range of learning environments needed at multiple scales to better align with changes in the medical education curriculum. Four key scales that correspond to important types of learning spaces are identified: the classroom, the building, the campus and the city. "In- between" spaces were identified as growing in importance given changing patterns of learning and the use of information technology. The focus from singular spaces to networks of inter-connected virtual and digital environments was considered as a critical shift. The need for higher levels of engagement of faculty, administrators and students in defining the briefs for the design of new kinds of medical education environments was highlighted (Nordquist and Laing 2015). By using more sociological perspective (Leijon 2012) states, that space shapes interaction, but interaction also shapes space; thus, it is essential to consider space in relation to negotiation and transformation (Leijon 2012). According to Nenonen and Lindahl (2014) inter professional interactivity and boarder zones between the traditional hierarchy, space segments and organisational structures as learning environment need to be identified, especially in the context of medical education.

Similar topics were touched in Finnish research about academic identity. User identity has a significant effect on how users experience a campus area and its buildings. Despite this, user identity does not necessarily meet the image of the organization. The strategic planning of spaces need to be done without forgetting the history and own identity of the users. (Airo and Rytkönen 2015). This finding has been published as a part of the large research and development program The Future learning environment 2011-2014 led by University properties of Finland. The learning environments of the future were investigated from the perspectives of campus co-operation, sustainable development, co-creation and multi-disciplinary learning. In the begin of the research program the expectation was to collect the new typologies for learning environments but at the end of the project it was found out that that equally important as the new solutions are the processes how they are realized together with users. E.g. the transition to sustainability is often seen as a top-down governing challenge, but it can include pioneering bottom-up ways to create change. Bottom-up actions in innovation should be given recognition and nurturing, as the bottom-up initiatives often challenge systems that resist change (Pulkkinen and Staffans 2005).

The existing premises of campuses possess a huge potential to be turned into lively urban centres that support learning and research of the future. Hence, the existing buildings can be seen as platforms for novel architectural solutions and stages for presenting the universities' state-of-the-art education and research. Radical, extensive changes would most likely create the biggest impact on behaviour and functionality. However, not all changes need to be massive and expensive. Like acupuncture, which releases energy by the point of a needle, so could the campus spatial structure be energized through small changes, which have a bigger impact than their size (Poutanen et al., 2015). According to Eriksson et al. (2015) retrofitting as technical and spatial solutions covers only part of the process. The activity-based retrofitting consists on multidisciplinary collaboration and learning processes where the diverse users have different roles during the retrofitting process. This will be discussed in the following chapter in terms of co-creation.

2.2 Need to Co-create in Campus Retrofitting Processes

Campuses are pioneers in facing the built environment challenges. The retrofitting processes are the additions of new technologies, features and functions to existing built environment systems. In university campuses this means the development of embedded learning environments, new space typologies, variety of platforms (both digital and physical) supporting collaboration within the university and in connection with diverse stakeholders. It means upgrading or replacing technical elements but also the changes in user activities and practices. Nevertheless it is connected also to service concepts and the new ways to produce services. (Eriksson et al., 2015) The purpose of user involvement in retrofitting processes means making fuller use of user knowledge and experience. Action and use of facilities is strongly related to experiences of the users and thus their possibility and will to perform. People create their own places in the facilities – they are socially constructed. Both technical and psychosocial systems are important when retrofitting campus. Co-creation allows and encourages a more active involvement from the users of the campus to create a value rich experience. Interpretation and analysis of the built environment and support services based on how it is socially constructed will enable integration of organisational use and the facilities provided to arrive at an understanding of usability of built environment (Alexander et al., 2013). The question is how retrofitting processes are conducted.

Sanders (2008) has been investigating the history of co-creation and stated that in Norway, Sweden and Denmark the Collective Resource Approach was established to increase the value of industrial production by engaging workers in the development of new systems for the workplace. The approach put together the expertise of the systems designers/researchers and the situated expertise of the people whose work was to be impacted by the change. The approach, thus, built on the workers' own experiences and provided them with the resources to be able to act in their current situation. In the broadest meaning of user participation it could be called "collective design" which was launched in early 1990´s. Collective design is something more than contributory influence and just participation. It is a process where knowledge and values confront, complete and modify each other leading to something new. All actors in the process are regarded as experts and their participation is therefore based on their relevant knowledge rather than on their roles as representatives for different interests. (Granath et al., 1996) Over the past ten years, together with increasing attention to the importance of front-end activities in general (Ryd, 2008; Blyth and Worthington, 2010), new interest in user involvement is emerging; though a change in focus is noticeable. The purpose of user involvement has shifted from mere participation to co-designing, making fuller use of user knowledge and experience (Sanders and Stappers, 2008; Erikson et al., 2014).

CIB Work Group 111 on Usability of workplaces - with a significant amount of Nordic researchers and practical case studies - has been exploring concepts, methods and tools, developed in the usability of built environment, including also learning environments. A key product of the Nordic research project REBUS (User- oriented Benchmarking for Usability in Real Estate) was a process description, detailing how building owners and facilities managers can gather user experience from existing buildings as a basis for improving them, as input when designing new buildings, or as a reference when choosing new premises. (Lindahl et al. 2011). The universities comprising of the students, researchers, professors, lectures and other staff are the users of the universities properties. The university occupiers' needs vary from other commercial properties (e.g., offices) with needs regarding, i.e., lecture halls, laboratories and other special space. The university properties are often relatively large, made for a special purpose and can be difficult to convert to other usage. (Alexander et al. 2013)

To sum up it seems to be crucial to understand more the characteristics of co-creation methods in campus retrofitting processes in order to find out the ways for constant, future-orientated way to develop learning environments. Leaning on Nordic tradition on user-involvement we make the following analysis of campus-retrofitting cases.

3. Nordic studies about Campus Retrofitting

Campus Retrofitting (CARE) -project focused on innovative retrofitting of Nordic University Campuses. The goal was to develop and demonstrate scalable retrofitting, CARE-concepts for sustainable built environment management. The emphasis was in developing the systematic and continuous Campus retrofitting methodology, which is a system of broad principles or rules, from which specific methods or procedures may be derived to solve campus retrofitting problems in the context of developing future learning environments.

In Sweden, Denmark and Finland the Campus retrofitting studies were connected to developing new concepts for learning environment especially by understanding the diverse needs for informal learning. In Norwegian studies as well as in some Finnish studies the emphasis was in evaluation of the retrofitting concepts. In Norway especially in terms of the use of energy efficient solutions and in Finland in terms of the usage rates, indoor environment quality and user satisfaction of the solution.

The Danish study aimed to develop future learning environment together with users. The method used in Danish study was participatory workshops in DTU (Danish University of Technology) Campus Service – building client function for developing future learning environments. Instead of the usual approach: study tours they wished to get inspiration from ”learning researchers”. They conducted an action research process in spring 2015 with four workshops and participants were campus service representatives, teachers, students and users of Learning lab. The themes for the workshops were: Dream learning environment; What do we know about learning spaces and what are the new typologies; Relations between learning space, technologies and learning and Performing University Spaces. The outcome was a new and different dialogue, which was engaging, strategic, open. It opened the bigger picture for participants and created the idea of a ”longitudinal community” to supplement existing organisational structures. The facilitators and experts of the workshops represented e.g. anthropology and business sciences. The approach was multidisciplinary by its nature.

The Swedish study aimed to build meeting places within the university designed to create and implement social responsibility and sustainability framework of Chalmers Real Estate Ltd. The method used in this study was based on best practice mapping by using the approach of human geography and urban sociology. They developed a manual for the meeting place builders called “Building Meeting Places - an introduction to strategic inter structure supply”. In parallel with the manual also a digital tool for inventory and analysis of the meeting places have been developed. Additionally the training of staff was part of the project. An inventory of meeting points on the Chalmers campus has been made during the spring of 2014, which formed the basis for future development with the physical environments. The manual includes a reviews of the meetings and venues evolved historically, trends that are relevant to today's and tomorrow's meeting place realization, models and theories to analyze and describe the meeting places' anatomy and character, as well as a number of concrete strategies and tools to develop and strengthen the different types of meeting places. The first demonstrations were made during the Campus Retrofitting process.

The Finnish study included 26 demonstration projects on different campuses of Finland, conducted by University Properties of Finland. Co-creation, realization, co-inesting and finally evaluation of activity based, multifunctional learning, research, and working environments were typical for the demonstrations. The retrofitting in case Musica, a building at Jyväskylä University Campus dedicated for education and research of music, aimed to plan a living room and learning/research spaces for the students by using Charrette-method. During the five day Charrette-process the new end-user goals were recognized and linked with the strategic principles of the facility department of the university, and the needed planning documents were created. Small scale campus retrofitting demonstrations concerning future learning and working environments in universities was the effective way to test new, unknown solutions and concepts. The costs were shared between user and property owner. (Naaranoja et al 2015)

In Tampere University of Technology, Finland students were in active role when redesigning under-used lobbies into a lively social and informal learning space. The halls and corridors, which are located in popular areas on campuses, have great potential as redesigned into novel social and informal learning spaces. Learning spaces located in circulation spaces reach students from all faculties, which also intensifies the use of the spaces as those compose typically up to 22% of the total floor area of Finnish university buildings. Campus-wide Wi-Fi and the culture of Bring Your Own Device (BYOD) enable all secondary spaces for informal and social activities. The three cases were novel learning spaces created in a lobby, a renovation of a campus café, and co-created learning spaces in an academic library. All of these demonstrations were successful in both attracting people and increasing the popularity of the space. Also the indoor environment measurements provided evidence of sufficient comfort factors. Economically the demonstrations were inexpensive due to the fact that they were made by innovative student projects. Traditionally the renovation budget is used to return the facilities to the same level than they used to be – campus retrofitting demonstrations focus on developing the facilities for responding to the needs of future. (Poutanen 2015).

The Norwegian study focused on energy-efficiency improving methods for non-residential buildings and linked master student education with an on-going research project on energy efficiency improvement of non-residential buildings. They mapped the implementation in Norway by developing and conducting a MINDER survey with focus on existing methodologies. They learning environment was extended to visit and study energy-efficient buildings in its real life context. The students were invited to visit the buildings, analyse building documents, conduct interviews with practitioners and meet in the university classroom to present and discuss their findings. Best practice examples represented the most relevant building types and user organisations towards energy-efficiency improvement and were selected from the local municipality's energy-efficiency award. The students developed and presented findings with focus on innovative solutions for energy-efficient buildings' management. The aim was to analyse and improve the methods for innovative approaches for energy-efficient operation of energy efficient buildings. The survey cooperation with practice contributed to getting information and develops a deeper understanding about user-behaviour in energy-efficient maintaining of buildings next to technical facts and figures.

Additionally a Living lab case study have been followed up. The case was a single-family house at NTNU Gløshaugen campus in Norway with a gross volume of approximately 500 m^3 and a heated floor area of approximately 100 m^2. The house consisted of traditional residential spaces such as living room, kitchen and two bedrooms and it was used as a living lab. The ecological drivers for activities were low energy demand, passive and active use of natural resources and independency from the energy grid and lowering the environmental impact of the second home sector. Living Lab was developed in cooperation with industrial partners inside the Research Centre on Zero Emission Buildings (ZEB). The design included a wide range of components that can be adjusted according to users' needs and desires, functional program distribution and climatic context (envelope, furnishing, and technical system). The users interacted with buildings characterized by high indoor comfort conditions and low energy demand. The monitoring system of the use of the building has been designed in order to be flexible, expandable and easily reconfigurable. In addition sensors have been integrated in the building as it would be in a real house and chosen among those that can be installed in a real-world application - i.e. on- purpose-made sensors have been avoided as much as possible. The Living lab involved students, researchers and industry partners to develop sustainable solution and behaviour. (Finocchiaroa et al. 2014)

The analysis of the methods used in different Nordic studies was made by comparing the following aspects: How the users were involved to the studies and demonstrations, how the campus retrofitting process/project was realized in practice and economically and how the demonstrations were evaluated. The summary of analysis is presented in Table 1.

Table 1: Summary of campus retrofitting methods

Country / Analysis focus	*Denmark*	*Sweden*	*Finland*	*Norway*
User involvement	*Active role in workshops – source of ideas and information*	*Staff trained to meeting place manual*	*Active role in workshops – source of ideas and information*	*User behaviour in testing focus*
Realization	*Longitudinal community for on-going development was established for creating the future learning environments*	*Inventory of meeting points in campus and development of meeting place strategy for campus*	*Future learning environment demonstrations with co-funded budgets of owner and user. Partly realized as student projects*	*Producing and testing energy efficient solution with focus on user interface*
Evaluation	*Not yet*	*Not yet*	*Sensors for indoor environment, interval cameras, observations, user feedback surveys*	*Testing user-interface in Living lab Case studies on using and maintaining the energy efficiency of buildings*
Other remarks	*Trans disciplinary approach*	*Trans disciplinary approach*	*Diverse participatory methods*	*Integrating master student education and research*

4. Results

Based on the analysis the campus retrofitting methodology includes the following elements:

1. Active user participation and co-creation process: Campus retrofitting methodology indicates the importance to understand users and their needs as well as diverse activities, which set requirements for the future learning environments. The user was in all cases the main informant and also co-creator. The users were challenged to provide insights about their activities now and in the future. They were set to the active role also in designing the solutions. This activity based understanding is the basis of co-created and co-designed solutions.

2. **Commitment to share economical costs among stakeholders - co-financing:** The active stakeholders in Danish, Swedish, Norwegian and Finnish studies were the property owners or facility managers. They need to provide good university facilities and at the same time take care of the economical issues in order to achieve sustainability, sufficient usage rate of university facilities and efficient use of spaces. The economical structure was based on co-financing the projects by the university and by the property owners. The engagement of user and owner create cost-efficient ways to retrofit campus facilities.

3. Follow-up measurements - co-evaluation: Evaluation together with users and owners as by using diverse methods (e.g. user surveys, using sensors, interval camera and user feedback, user interface testing) to ensure the success of demonstrations was important in all cases. Co-evaluation provides evidence about effectiveness of the solution and material for learning and developing. It provides a longitudinal perspective for retrofitting processes and solutions.

The qualitative methods in connection with more traditional quantitative and objective methods together provided the valid process for proof of evidence in Campus Retrofitting (CARE)-demonstrations. The Norwegian study included survey, where the intention was to combine the technical data with the user data and enlarge the scope of fully technical approach to energy efficiency. In the Living lab case the user interface was the in user-test and both technical and user-data was gathered. The Finnish studies connected to campus lobby demonstrations included the measurements of usage rate and user satisfaction provided also quantitative data. In Danish, Swedish and other Finnish cases the methods were more qualitative by their nature including e.g. participatory workshops.

It was notable that the besides the different stakeholders the use of multidisciplinary approach was typical for the cases. E.g. Finnish charrette-process is based on method used traditionally in urban design. In the Swedish study the manual was based on human geography and urban sociology approach. In the Danish study anthropology and business sciences, e.g. management were part of the content of the workshops. The synergy between different disciplines and different actors provide material for new solutions.

5. Discussion

CARE-methodology has three key activities: co-creating, co-financing and co-evaluating. CARE-methodology can be framed and illustrated with the following Figure 1.

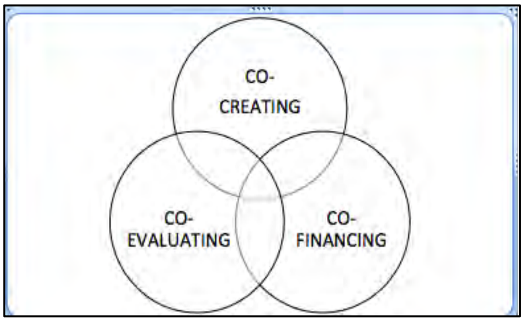

Figure 1: CARE-methodology

CARE-methodology consists on sharing: the vision, costs and results of retrofitting are shared between users and owners of campus in order to develop the future-orientated and sustainable agenda. The iterative processes of campus retrofitting differ from traditional linear technical projects. The activity based campus retrofitting is the on-going process and not limited to the certain phase of the retrofitting as a financial or technical process.

The Nordic studies provided material of planning itself but also new ways to provide continuity for the development of learning environments: it is important to provide proof of concepts and to engage different stakeholders. In order to use the CARE-methodology in practice the following steps are recommended: 1. Set the vision for the retrofitting process. 2. Identify the diverse actors for sharing the vision. 3. Define the budget among diverse actors and agree about the shared economy 4. Involve users to co-creation by using different methods. 5. Update user needs continuously, not only in the one dedicated, often predefined phase like e.g. specification of needs. 6. Decide and realize the user-centric evidence collection of the process and the solution. 7. Learn and develop continuously: there is not such a thing as “finished solution”.

CARE-methodology can be a tool to capture new logic to learning environment design. The Nordic studies were chosen because they represent new and actual on going, experimental co-creating strategies at the universities, and we expected to gain new insights from these innovative processes, where the universities deviated from their standard practice. This has led to identification of new methods and contributions to the current literature on retrofitting of universities and learning environments. The two-year long project did however not allow longitudinal studies beyond one year or further co-creation processes. And this we recommend for future studies.

6. Conclusions

Nordic universities have been investigating campus retrofitting case-studies, which include a wide spectrum of methods how interaction and co-creation between students, teachers, researchers, real estate and FM staff as well as industry can take place in campus retrofitting processes. The wide user group represents a broad cross section of perspectives and experiences and provides a platform for fruitful discussions of the studied demonstration projects. The applied methodologies and the formulation of the guiding principle of the CARE way of sustainable retrofitting of university campuses could be applicable in the larger context of urban retrofitting. The methodology is not depending on learning environment or university campus context as such but it seems to be more transferable by its nature. It opens up an agenda for investigating a new methodology for sustainable urban retrofitting in a Nordic context.

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How to Manage Corporate Real Estate and End-Users Engagement into Smart Workplace Change Strategies: A Case Study

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Abstract

Progressively, the spacial demand of workplaces is modifying, together with the habits of workers. How can companies react to the change of perspective that is affecting the traditional ways of working? What does 'Intelligent Built Environment' mean for corporations?

For several years at international level, it has diffused a new conception of the office: flexible spaces, shared desks and informal areas that can accommodate different activities as needed. Even in Italy this phenomenon is spreading rapidly: some firms have started to abandon cellular offices and open-plan offices, and to experiment with flexible work settings. A new demand is emerging with specific characteristics. The most significant drivers seem to be economic efforts (big and expensive buildings affected by low daily occupancy) and organizational reasons (teamwork, part-time work, teleworking, network strategies, etc.). Nevertheless, even external factors such as competition, globalization and corporate image can influence the motivation for change.

The authors have collected data on new ways of working and workplace change strategies in the brand new Italian headquarters of a company active in the technology hardware & equipment industry, with around 1,000 employees. The investigation involved both quantitative and qualitative research methodologies. By matching the results obtained, it has been possible to elaborate some considerations regarding benefits and risks of flexible workstations and the way of integrating smart working into corporate real estate strategies. What kind of data is valuable to retrieve about the use of workspaces? Which methodologies would be the most suitable for such a scope? When and how should consultants support their clients? And, most of all, to what extent can an 'intelligent building' support human activity in daily life?

The knowledge acquired can be useful to companies, both for managing the functioning of existing buildings and for orienting future projects towards the objective of becoming more 'intelligent'.

Keywords: Smart Working, Employees' Satisfaction, Workplace Change Management, Corporate Real Estate, Intelligent Office Building

1. Introduction

More than 30 years ago, Ronald Goodrich (1982) was considering that "now, as a result of the growing importance of office work, the introduction of office automation, the changing character of work, and the economics of office buildings, the office environment is becoming more intimately linked to the psychological needs, performance, and well-being of its users." The same consideration, with the due differences, seems to be valid today as well. The importance of office work has now partially been revised, office automation is evolving everyday, new ways of working are rising, office buildings are changing their form and function, and the office environment requires being linked more than ever before 'to the psychological needs, performance, and well-being of its users'. New working activities, new technologies with which we do them, new organizational structures and new ways people work together generate new requirements from the users' side, that reflect on the space, the building and the built environment.

The opportunities, offered by a world that is more technology-driven everyday, lead to new ways of communicating, informing and networking affecting life and work style (Corso, 2005). Due to the advancements in the Information-Communication Technology field, some main consequences are emerging: a) new ways of communicating and expressing likes/dislikes are diffusing; b) new ways of working are developing; c) new data is available and suitable to create value. These aspects converge in the workspace that should, therefore, change and evolve taking into account people expectations. This probably means that, along with the workplace features, configuration and layout, even the methodologies currently used to assess the workplace quality might be adapted. As the most recent RIBA 'Plan of Work 2013' suggests, the fine-tuning of building quality against users' requirements, expectations and opinions is recognized as a fundamental part of the construction process and the users are important stakeholders within it (RIBA, 2013). But, despite the many Post-Occupancy Evaluations that have been conducted worldwide, it seems there is still the need to find a way to transfer that process into a form that can be meaningfully put into everyday practice (Mallory-Hill, et al., 2012). Moreover, it is fundamental to make the user-centered approach (Vischer, 2008) more widely diffused – e.g., in Italy there is still lacking circulation in the academia and a shortage of applications in the professional sector.

For these reasons, there is growing interest in studying the interactions between the working environment and users' perception. What features should characterize the workspace according to the new ways of working? How can we assess them? How is it possible to fine-tune the quality of the workplace? These questions affect all the stakeholders taking part in the process. Among them, Corporate Real Estate departments are particularly interested in those issues, since they are in charge of workplace change management, together with the Human Resources and Facility Management. Companies are taking up new ways of working in order to attract and retain talent, be competitive and successful in the globalized world (Heather, 2003). Architecture and built environment can be the enabler for the competitiveness of regions and cities, the success of companies and the well-being of workers and citizens. How is it possible for an office building to take the role of enabler? What is an 'intelligent office building' meant to be?

2. Background

Corporations that need new buildings should pay attention to creating solutions that correspond to real requirements, in order to obtain major cost savings with the best quality. Moreover, it is important to fine-tune building performances continuously, according not only to corporate strategies, but also to pragmatic human experiences. By involving the end-users of office buildings, in fact, it is possible to build an effective decision making process. For these reasons, an integrated approach to the design, delivery and management of buildings and built environments is necessary nowadays. The objective is to reach the best results in terms of employee commitment, satisfaction and productivity (Miller, et al., 2014).

To this end, an international company was interested in conducting a post-occupancy study on their brand-new Italian headquarters. The firm had recently invested in the construction of new premises. The initiative entailed a radical re-layout of the work settings, according to the smart working approach (Methodos, et al., 2015) and looking at the 'Intelligent Building' model – i.e. high-tech building with flexible office space and advanced control technology (Preiser & Schramm, 2002). The application of a hot-desking solution (Knight & Haslam, 2010) was embraced in order to optimize space utilization and encourage employees' interaction. Only 30 employees out of almost 1,000 can use an enclosed office, different business units are grouped in some open-space areas, which are dedicated generically to one organizational function, but nobody has an assigned workstation. A proportional number of meeting rooms, varied for capacity (from 4 to 25 seats) and equipment (projectors, screens, teleconference and videoconference tools, etc.), concentration rooms and phone booths are located on each floor, beside some free space for informal meetings, breaks etc.

The study began 6 months after the move in, in order to allow the occupiers to start using the space and get accustomed with the new way of working. The previous workspace setting was arranged as a traditional open plan, with fixed workstations and a very low density rate. Therefore, the working experience radically transformed in the new building and some resistance to change emerged among employees. The objective of the management, including Corporate Real Estate (CRE), Human Resources (HR) and Facility Management (FM) departments, was to accompany the employees through the workplace transformation, to verify the pre/post-transfer impacts and to harmonize the new spaces with their requirements.

3. Research Methodology

The investigation involved both quantitative and qualitative research methodologies, in line with the approach suggested by Jick (1979) and referring to Post-Occupancy Evaluation techniques, as recommended by Costa (2014). The first methodology implied processing on quantitative data provided by the company and a questionnaire administration. The qualitative approach consisted of a field observation campaign, some semi-structured interviews with the management team and a few focus groups with employees.

As the exploratory phase began, a large documentation was revised about the characteristics of the building, completed by a non-structured observation with the walk-through of one of the HR managers. In addition, numerical data concerning the accesses of employees to the building and meeting rooms' reservation was analyzed. Actually, FM and HR departments pick up this data on a daily basis, but leave it at a raw stage of elaboration, so it needed cleaning and preparing before use.

Semi-structured interviews with the management team, including CRE, FM and HR managers, were conducted, with the goal to bring together impressions, intentions and sentiment from the stakeholders responsible for fine-tuning real and perceived building performances.

The structured observation was carried out on 2 different workdays, considered representative of the standard ones, given the firm's characteristics and different business units' habits. This methodology was applied to map and monitor the way people use spaces, according to the behavioral mapping approach typical of environmental psychology studies. In addition, qualitative considerations about where and how workers performed several activities were annotated and later compared with workers' perception. Four researchers, in two groups, walked through specific zones of the building (selected as a representative sample of the whole premises), making sure to observe each space once per hour. Overall, 62% of the workstations and 87% of the meeting rooms were observed. Supported by a detailed checklist, the observers punctually registered the number of:

- employees seating at desks;
- personalized desks;
- employees occupying the meeting rooms;
- employees using concentration/phone booths;
- people present in the break areas.

These records have been intersected with:

- total number of accesses;
- total number of desks;
- capacity of the meeting rooms;
- number of phone booths;
- number of break areas.

In the end, 3 focus groups were organized to directly meet with the employees and listen to their thoughts. The HRs selected the 50 people sample – divided into smaller groups. The sample represented overall almost all the business units inhabiting different zones of the premises. A questionnaire was administered during the sessions, with the aim of systematically collecting some information and better organizing the meetings, since they involved a large number of employees. This covered several aspects and was composed of seven questions about workers' perception, four of which, more in detail, regarded – see Appendix (Survey questionnaire):

1. their doubts or worries before the move compared to their feelings after the move;
2. their presence at work during the 'typical working week' (time spent in the office building);
3. their activities at work during the 'typical working day' (time spent on different activities and in different areas of the building);
4. the level of importance and relative satisfaction they attribute to some factors that affect work quality and effectiveness (on a typical Likert scale from 1 to 5).

The questionnaire was used as a template for open discussion. After answering one question, the people were invited to talk about the same topic and discuss between each other. The interviewers wrote down several annotations during the conversation, suitable for further comments. Finally, information gathered through the application of the methodologies above mentioned have been matched together.

4. Findings

Useful findings have been built up thanks to the integration of several methodologies, none of which can bring trustworthy results if taken in isolation. Quantitative data retrieved about the use of the workspace (e.g. number of accesses per day, employees sitting at the desk, personalized desks, employees occupying the meeting rooms, employees using concentration/phone booths, people present in the break areas) need to be verified against qualitative information. Only through this integration, is it possible to get 'what' is happening and explain the reasons 'why' this is going on and, therefore, find a strategy to correct eventual mismatches.

The chapter will summarize the main insights obtained on flex office implementation, workspace management and employees' satisfaction, with respect to the move in process and the brand new office layout.

4.1 Pre/post Transfer Impact

With regard to the employees' issues about moving to the new premises, most of the focus group participants found their worries were ill-founded. Out of 49 interviewed employees, between 60 and 70% confessed they:

- were afraid of wasting time while they were looking for a free work station;
- were concerned there could be problems in working relationships with colleagues;
- suspected they would lose their normal efficiency in their daily work activities.

Overall, they found that these matters were not a problem. Respectively, 100% of them were satisfied with finding a free workstation, 85% of them were fine with working relationships and 78% had no problem with work efficiency. In more detail, during the open discussion, specific reasons for concern in work efficiency emerged, which lowered the employees' level of satisfaction. Among these reasons, the main ones were associated with noise and distractions in an open space setting, sense of privacy, and climatic discomfort. Regarding these problems, a deeper understanding has been provided thanks to the field observations and the further points faced in the focus groups, where additional issues connected to the quality and effectiveness of the daily work came to light.

4.2 Adaptation to flex office

Even though the majority of the people who were afraid of wasting time while looking for a free workstation admitted to having no problem in this instance, some complaints about contract conditions arose. Against expectations, indeed, contracts require most of the employees to work in the office (*"I thought flexible space meant a more flexible management of work. I thought I would really be able to work from home, but this is not happening now"*). The ratio of people who have a telework contract and employees with a traditional contract is very low (*"about 1:9"*) and in some cases has been further reduced compared to the previous situation (*"many colleagues had a 3-days-at-home-2-days-in-the-office contract. Now contracts are renewed in the opposite sense"*). As a result, the risk of overcrowded spaces increases proportionally with the rigidity of contracts. Besides, there is the threat this company policy is upsetting employees, who perceive a considerable lack of alignment between architectural/layout choices (*"it is all in flexible logic"*), on the one side – which aims at establishing a model of flexibility in settling and working, and contract conditions, on the other – which are perceived as working against that model. In this regard, it is noted that a good workplace strategy should be managed with the full involvement of the human resources and real estate functions, that should work in an integrated manner (Martin & Black, 2006).

In addition to this consideration, the questionnaire shows that most of the interviewed employees can represent their working hours in a 'typical working week', where over 90% of them say their daily work is performed in the office. Only a very small minority believes their activity does not follow a regular pattern and admits they are often away from their work desk. This minority includes employees of those business units that are typically more mobile, such as the customer service unit and the marketing department in particular.

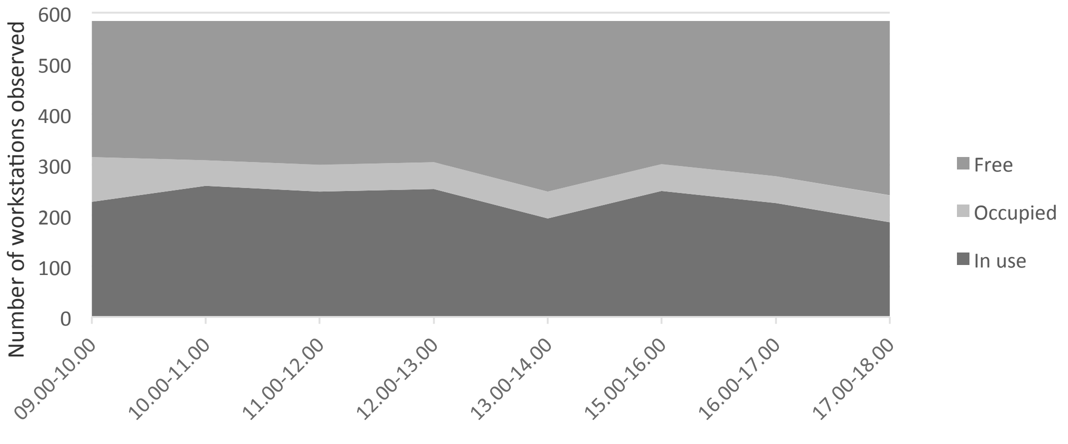

Figure 1. Number of workstations in use, occupied and free (source: observation)

Comparing the issues that emerged during the focus groups and the questionnaire answers with the numerical records retained by the HRs and the field observations, it is possible to correctly weigh the accuracy of the statements reported by some workers. According to them, in certain conditions it is difficult to find a free desk (*"on some days there is not enough room for everybody, teleworking does not fit in properly"*). The quantitative data obtained from monitoring badge swipes at the entry turnstiles, during the period January-June 2015, reveals that the average attendance level of the total number of employees is around 75%, reaching 81% as its highest value. Therefore, employees' perception about their daily presence in the office doesn't correspond to real data. Moreover, field observations reveal that the percentage of attendance at the workstations is even lower (Figure 1). Only around 40% of workstations were in use (an employee was physically present at the desk), on average, and 15% of them were occupied by an employee being not physically present (he/she could be involved in a meeting, conference call or other activity). Therefore, almost 50% of the workstations resulted in being effectively free.

This kind of count is actually more accurate than the mechanical count performed by turnstiles activated by badge swiping, because it detects the continuous presence of an individual in a building. However, a margin of error is possible because of eventual misinterpretation of traces on the workstation at the time of observation. Although, numbers make it evident that it is unlikely for employees to encounter real difficulties in finding a free seat.

Furthermore, with regard to the multiple-choice question "Which of the following statements best describes your work station in your company?", most employees answered that they worked in an open space setting, whereas only 13% specified they worked in different, non-assigned work stations. This means that most employees do not perceive they are hot-desking. They still have a more traditional concept of open space, which they conceive as a collective space shared with colleagues, in which everyone has the exclusive use of one workstation. This feeling explains also the tendency to 'sedentism' and personalization that affects their behavior. During observation rounds, on average 1 workstation out of 4 was marked in some way with personal objects. This trend might compromise the flex office model, but it is not equally distributed among all the functional areas. In fact, some business units tend to mark the space less strongly than others do. These correspond to those functions that are more suited to a flexible workstyle, for example the sales areas. On the contrary, some business units are more settled as a vocation, such as finance, legal, procurement, quality and others. Not surprisingly, it is exactly here that the most numerous territorial signs, e.g. identity-oriented markers (Brown, 2009), have been found. It is also significant that almost 20% of those desks not assigned to any business unit, i.e. theoretically free from personalization, presented some marks. The objects typically found on the desks may affect more or less significantly the image and functionality of the workstations. Among them it is worth mentioning: toys, photographs and posters; calendars, post-its, reminders; plants; pen holders; documents. Coherently with the trend registered, according to the questionnaire, 44% of interviewees would appreciate the possibility to personalize the desk in order to feel more comfortable at work.

4.3 Work Activities and Spaces

Beside more traditional activities such as ‘PC, reading, writing’ and ‘talking/meeting’, that employees estimate can take up, respectively, around 45% and 15% of their typical working day, other activities such as ‘phone’ and ‘conference call’ seem to be very significant, as revealed by the questionnaire, occupying 27% of the typical working day. This is coherent with recent research saying that thinking, talking and brainstorming create the most value for an organization (Colpaert, et al., 2014). Today, the time spent at work in some type of conversation is up to 50-80% of the overall working day. It is common belief that by talking together, people come up with new solutions in the shortest time that probably neither single person could have developed alone. The key activities in today’s work are both concentrated (solo) and collaborative (together). On one side, concentration, observation, research, imagination, testing and planning require concentration. On the other hand, brainstorming, interviews, workshops, co-creation, debate and delivery require collaboration. These attitudes impact the traditional features of the workspace and how people perceive it.

Referring specifically to the employees’ assessment, the activities performed in a typical working day can be carried out collectively or individually in the following proportion:

- collectively or in groups, 40%;
- individually, 47%;
- both collectively and individually, 13%.

It is therefore possible to claim that the distribution of the workstations in the new headquarters is correctly planned; in fact, the number of open space workstations and the number of workstations in meeting rooms is almost the same.

When considering the above, it is necessary to bear in mind the importance of the spaces and technological facilities used to manage meetings and calls. It is crucial to implement the appropriate measures to disturb as little as possible other employees who are involved in activities that require particularly high levels of concentration (e.g., PC, reading, writing).

4.4 Strengths and Weaknesses

Focus group participants were asked to express their opinion on the importance of, and satisfaction with, a number of factors that can affect the quality and effectiveness of their work (on a scale from 1 – not at all important/very dissatisfied, to 5 – very important/very satisfied), regarding physical (Roeloofsen, 2002) and psychological (Alker, et al., 2014) issues (Figure 2)

It is interesting to read the weight of the difference between the level of importance given to one factor and the corresponding level of satisfaction. In this way, it is possible to become aware of the most critical issues and establish intervention priorities accordingly.

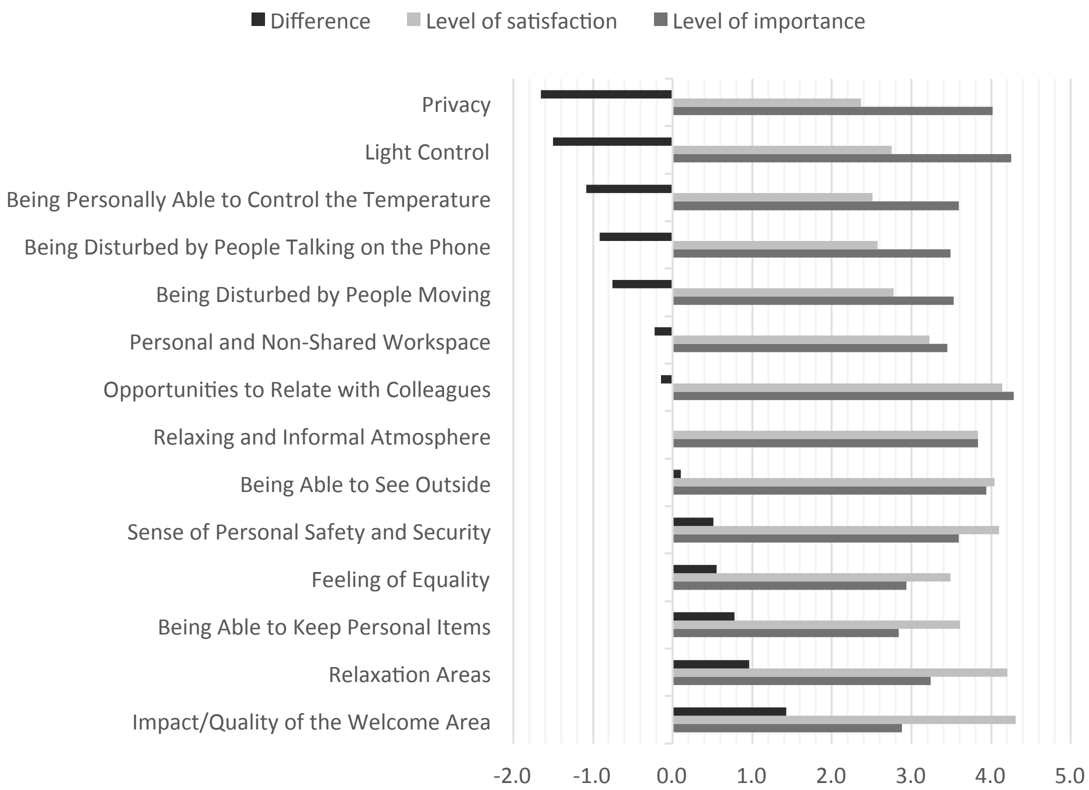

Figure 2. Level of importance/satisfaction regarding the factors that affect work quality and effectiveness (source: questionnaire)

The factors that received the highest score (≥ 4 points) for importance include: opportunities to relate with colleagues; control of light; privacy.

With regard to satisfaction, the highest ranking factors (score ≥ 4) include: impact/quality of the welcome area; relaxation areas; opportunities to relate with colleagues; sense of personal safety; being able to see outside.

It is important to note that for some of the listed factors the level of satisfaction is equal to or exceeds the given level of importance. These factors can be considered ‘strengths’ (Table 1). On the contrary, in some cases, there is a significant deviation regarding the level of satisfaction (< 3 points), so these factors must be interpreted as ‘weaknesses’ (Table 1), which require urgent intervention measures.

Table 1: Strengths and weaknesses

Strengths	*Weaknesses*
- *impact/quality of the welcome area* - *relaxation areas* - *being able to keep personal items* - *feeling of equality* - *sense of personal safety* - *being able to see outside* - *informal and relaxing atmosphere*	- *privacy* - *control of light* - *being able to personally control the temperature* - *disturbance caused by the use of mobile phones* - *disturbance caused by people moving around*

Lastly, there are some aspects that have a slightly negative difference but the related level of satisfaction is good or excellent ($\geq$ 3 points), e.g., personal and non-shared workspace. In this case, it is reasonable to suppose that the changes in working conditions have had a certain impact on employees, who have yet to absorb it all. It is likely that over time the level of satisfaction may increase, even without making significant changes to the surroundings, simply as a result of people becoming used to the new conditions.

From the direct discussion about factors listed above it is possible to claim that the general sentiment seems to be very positive ("*I like it here*", "*it is a 100 million times better than in the past*", "*everything is much more efficient*"). In most cases, the expectations regarding the new open space layout are positively satisfied ("*before joining this company I worked in an open space setting. In the old premises I felt I had taken a step back, now I feel things are normal again*"), and in some cases they have actually exceeded improvement expectations. About one third of interviewed employees have switched from a closed office to an open space layout with a generally favourable attitude (*"I had a closed office but I have grown used to it - now there is more contact with colleagues"*). It is clear that the opportunities for social interaction, for exchange and for establishing new relations have increased (Blakstad, et al., 2009), which everybody considers a positive aspect ("*we know each other better, we have met new colleagues*"). Among other things, this element was considered the most important factor (score of 4.3) that can affect the quality and efficiency of work ("*The new layout improves interaction among colleagues and helps us feel more part of a team*").

The outward image of the premises is considered one of the best factors. The architectural features employees are most satisfied by are the equipment in the meeting rooms, common areas for guests ("*the company image has gained a lot*", "*I always receive compliments from guests*") and quality of light (not be confused with 'control of light', which is related to the quantity of light and being able to manually adjust its intensity). On the contrary, the inward image seems to have some issues, especially regarding the feeling of equality ("*we were told we were going to the new premises so we would all be equal, 'Break down the barriers, no more status quo!', then it turns out not to be true*"). Some employees complain about disparity caused by closed offices assigned to people who do not actually need them ("*there is a problem of equality,* *actually there are closed offices for colleagues who could integrate with everybody else*"). However, these considerations can be rated as 'overcome' by the answers recorded in the questionnaire completed by the focus group participants, who on the whole gave the feeling of equality a positive assessment in terms of satisfaction (3.5), which actually exceeded the expectations compared to the given level of importance (2.9).

5. Discussion

The study has demonstrated the success of the project in terms of overall employees' commitment, satisfaction and productivity, as declared by themselves. The new workspace features have been introduced in order to react to the change of perspective that is affecting the traditional ways of working. The update of the office setting according to the new trends – including hot-desking, encountered the favor of building occupants, despite initial doubts. Thanks to occupants' consultation, it was possible to assess the appropriateness of the new configuration and to fine-tune the quality of the intervention. The users gave warnings of discomfort during the focus groups, so that some technical problems emerged, such as the control of light and temperature. These were reported to the management who planned a prompt intervention. About work efficiency, most of the concerns could be attributed to incorrect or improper habits on the users' side (disturbance caused by the use of mobile phones, disturbance caused by people moving around and privacy related issues). These are likely to be resolved simply as a result of people becoming used to the new conditions and thanks to a good communication and education strategy implemented by the HRs.

Particularly crucial to this extent was the phase of reporting findings. At a first stage, a written report was delivered to the management, providing all the details about research methodologies, conclusions and possible actions to implement with indications for prioritization, in order to support the decision-making process. Afterwards a presentation was organized, inviting all the employees who took part in the focus groups. Here the main outcomes of the research were explained in an understandable way, trying to focus on those behavioral aspects that could positively affect the working experience. Moreover, the real estate and facilities managers introduced the actions they were going to undertake in light of consultants' recommendations. Involvement of employees in decision-making is likely to foster a sense of common identity and to promote motivation and commitment. In this phase the evaluator assumed the role of mediator, helping communication and negotiation of consensus (Preiser & Schramm, 2002).

In the end, it was confirmed that the most important worries troubling the employees before the move were mostly inconsistent. No waste of time while looking for a free workstation, no problems in relations with colleagues, and no loss in normal work efficiency was seriously detected. In fact, many free desks are always available and enhanced relationships with colleagues are reported as one of the most satisfactory factors. The risks of implementing flexible workstations with open-space and hot-desking were positively faced and brought benefits in terms of interactions, feeling of equality and informal working atmosphere. All these aspects characterize the new ways of working and should be endorsed by the office environment. This is the extent to which an 'intelligent office building' can have a meaning for corporations. It should be able to adapt every time to the changing necessities of the company that it hosts and to provide the occupants with the right backing for their multiple activities. Then, of course, an office building is not intelligent by itself, just for its architectural configuration and technical infrastructure, but it is primarily the way it is managed that makes the difference.

6. Conclusions

The present research should be considered one of the few efforts in the post-occupancy studies conducted in Italy. Therefore, it represents one of the actual best practices in workplace change management in an Italian context, which will contribute to building a cross-cultural framework of evaluation data on building types like intelligent office buildings. Moreover, hopefully it will encourage the evaluative stance throughout the building delivery process. The implementation of a post-occupancy study is important both for verifying the results of a project after its completion, which is needed in building management, and for gathering data suitable for further interventions. Particularly, the phase of reporting findings to the end-users brings the immediate outcome of making them feel important stakeholders within the office building and to keep them well-informed about the objectives of the project and its results. This process itself enhances engagement and satisfaction among workers. In addition, it is an important occasion for communicating messages able to turn behaviors into positive attitudes and good habits. The related consequences will be visible after some months, when, for that reason, it will be important to perform further surveys.

With regard to this specific case study, the main objectives to accompany the workers through the workplace transformation and to verify the pre/post-transfer impacts towards the harmonization of the new spaces with their requirements were met.

An external consultant's job can be important for helping companies switch from a traditional way of working to a smart working model and conveniently match the workspace with the organization's new objectives and values. Ideally, this accompanying function should last from the very beginning of the project until the delivery of the building, and even afterwards with a continuous monitoring activity. Through the whole duration of that period, it is possible to understand the initial intents and to verify them against the everyday operation of the workspace. This long and complex process is the only means to fine-tune the quality of office buildings. Most of the time, because of a lack of resources or motivation, it is not possible to carry on this preferential relation with the company. Nevertheless, it would be useful, at least, to retrieve some data about the use of the workspaces, since they are suitable for keeping the building value under control. Going into more detail, it seems valuable to monitor space occupancy rates, employees' habits concerning their ways of working (presence during the week and activities during the day) and occupants' perception on how the workplace affects work quality and effectiveness. These are the main variables that reflect if an office building is working properly or not. Some professionals should be in charge of collecting them and to promptly adopt the best measures for adjusting the space features according to these changing variables. Today, thanks to sensors and portable devices it is not difficult to gather some of them. Nevertheless, some room for innovation exists especially where occupants' involvement is required – in light of the new ways of sharing likes and dislikes – and in assembling qualitative shades with quantitative assumptions. More research would be interesting to understand how to combine this information in everyday practice.

In fact, on the basis of our experience, while relying on only one source of information could have produced misleading results, matching both quantitative and qualitative data through the triangulation of different methodologies helped obtain consistent outputs. On one side, it is important to remark that the role of a consultant needs to be supported by internal sectors. On the other, it is evident how different skills (the consultants' know-how, with the CRE, HR and FM experience) have collaborated to generate key insights valuable for driving the management of the new premises and for informing eventual future corporate projects. This case study also suggests the necessity of complementing real estate and facility management with human resources policies and underlines the importance of devoting proper attention to internal communication. May it be necessary to appoint a new professional who is able to apply an integrative approach as such?

An 'intelligent office building' is one that successfully relates to its occupiers, being able to adapt according to the changing needs of its users. That is the extent to which an 'intelligent building' can support human activity in daily life at work. This can depend, on one hand, on the technological devices installed with advanced control technology and the architectural features characterizing the work setting, as a flexible office space. But, on the other hand, it depends on the organizational structure and managerial intentions. The work conducted demonstrates how not only the result of a post-occupancy evaluation is important, but the process itself is very helpful. Using a user-centred approach, employees feel more engaged, know they are part of the stakeholders and, consequently, become more conscious and responsible for their behaviour. Their contribution can make buildings function better. Only through this kind of attitude, can it be possible that an office building takes the role of enabler for the well-being of workers, the success of companies, and the competitiveness of regions and countries.

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Appendix (Survey questionnaire)

The appendix shows part of the questionnaire that was administered to the participants in the focus groups. The intent was to induce the interviewees to reflect on some key points, on the basis of which the debate was developed. This method was useful also to quantitatively collect some data considering the large number of people involved in the meetings.

1. What of the following aspects correspond to doubts or worries that you had before the move to the new premises?
   Which of them were positively solved and are no problem at present? Which ones, instead, are effectively cause of annoyance to you?
   For instance:

Table 2: Question 1 of the questionnaire

	Pre-transfer doubts/worries	*After-transfer feeling*	
		Positive matching	*Negative matching*
☐	*Efficiency in daily work*	☐	☐
☐	*Time spent looking for a free workstation*	☐	☐
☐	*Working relationships with colleagues*	☐	☐
☐	*Others: ……………………………………………*	☐	☐

2. In your 'typical working week', what days do you usually work in the office?

Table 3: Question 2 of the questionnaire

	Weekday	*Morning*	*Afternoon*
☐	*Monday*	☐	☐
☐	*Tuesday*	☐	☐
☐	*Wednesday*	☐	☐
☐	*Thursday*	☐	☐
☐	*Friday*	☐	☐
☐	*Saturday*	☐	☐

3. In your 'typical working day' in the office, how much time do you usually spend in the following activities?
   Among them, what are the activities that you do individually and what require collaboration with other colleagues?

Table 4: Question 3 of the questionnaire

	Activity	*Individual*	*Collective*	*Percentage of time*	*/100%*
☐	*PC, writing, reading*	☐	☐		*/100%*
☐	*Storing, filing, paper handling*	☐	☐		*/100%*
☐	*Phone*	☐	☐		*/100%*
☐	*Conference call*	☐	☐		*/100%*
☐	*Video conference*	☐	☐		*/100%*
☐	*Presentation*	☐	☐		*/100%*
☐	*Meeting/talking*	☐	☐		*/100%*
☐	*Learning*	☐	☐		*/100%*
				100%	*TOT.*

4. Express the level of importance (from 1 = very low, to 5 = very high) that you attribute to the following factors, reflecting if they can influence or not the quality and effectiveness of your daily work.

Table 5: Question 4 of the questionnaire

	Factors	*Not important*				*Very important*
		1	*2*	*3*	*4*	*5*
1.	*Personal and non-shared work space*	☐	☐	☐	☐	☐
2.	*Impact/quality of the welcome area*	☐	☐	☐	☐	☐
3.	*Being personally able to control the temperature*	☐	☐	☐	☐	☐
4.	*Relaxing and informal atmosphere*	☐	☐	☐	☐	☐
5.	*Privacy*	☐	☐	☐	☐	☐
6.	*Being able to see outside*	☐	☐	☐	☐	☐
7.	*Being disturbed by mobile phones*	☐	☐	☐	☐	☐
8.	*Being disturbed by people moving*	☐	☐	☐	☐	☐
9.	*Feeling of equality*	☐	☐	☐	☐	☐
10.	*Being able to keep personal items*	☐	☐	☐	☐	☐
11.	*Relaxation areas*	☐	☐	☐	☐	☐
12.	*Sense of personal safety*	☐	☐	☐	☐	☐
13.	*Opportunities to relate with colleagues*	☐	☐	☐	☐	☐
14.	*…………………………………………………………*	☐	☐	☐	☐	☐

5. Now, express the level of satisfaction (from 1 = not satisfied, to 5 = very satisfied) that you attribute to the same factors, in respect of the workspace where you work at present.

Table 6: Question 5 of the questionnaire

	Factors	*Very dissatisfied*				*Very satisfied*
		1	*2*	*3*	*4*	*5*
1.	*Personal and non-shared work space*	☐	☐	☐	☐	☐
2.	*Impact/quality of the welcome area*	☐	☐	☐	☐	☐
3.	*Being personally able to control the temperature*	☐	☐	☐	☐	☐
4.	*Relaxing and informal atmosphere*	☐	☐	☐	☐	☐
5.	*Privacy*	☐	☐	☐	☐	☐
6.	*Being able to see outside*	☐	☐	☐	☐	☐
7.	*Being disturbed by mobile phones*	☐	☐	☐	☐	☐
8.	*Being disturbed by people moving*	☐	☐	☐	☐	☐
9.	*Feeling of equality*	☐	☐	☐	☐	☐
10.	*Being able to keep personal items*	☐	☐	☐	☐	☐
11.	*Relaxation areas*	☐	☐	☐	☐	☐
12.	*Sense of personal safety*	☐	☐	☐	☐	☐
13.	*Opportunities to relate with colleagues*	☐	☐	☐	☐	☐
14.	*…………………………………………………………*	☐	☐	☐	☐	☐

Developing “Owner Project Capabilities” for Public Sector Clients Delivering Infrastructure Projects: A Dynamic Capabilities Approach

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Abstract

Infrastructure lies at the very heart of social and economic development of a country and the world at large. Yet, despite its importance the delivery outcomes of infrastructure projects have been far from satisfactory. Infrastructure projects face issues of cost and schedule overruns as well as failure to realise expected benefits. Research in the field of project management has emphasized the importance of a 'strong owner' to the success of projects. To act as strong owners, public sector clients that deliver infrastructure projects need to have project capabilities to perform various roles. This paper presents an initial framework on how public sector clients can develop ‘owner project capabilities’, so as to improve infrastructure project delivery outcomes. The theoretical perspective of dynamic capabilities is employed to study how these public sector clients can develop the requisite ‘owner project capabilities’. It is suggested that learning is the mechanism by which owner project capabilities are developed, based on the concept of routines development, and argues for the incorporation of the organizational learning theory within the dynamic capabilities framework. Theoretically the paper contributes to the extension of the current application of organizational capabilities into the public sector infrastructure context. Additionally, it also provides initial insights into the relationship between owner project capabilities and (organizational) learning; and the difficulties faced by public sector clients during the process of capability development.

Keywords: infrastructure development, client capabilities, project capabilities, project owner, project learning

1 Introduction

Infrastructure lies at the very heart of social and economic development of a country and the world at large (Stevens *et al.*, 2006). It serves as the bedrock of a nation's competitiveness, economic development, and social well-being (World Economic Forum, 2014). Notwithstanding the importance of infrastructure, most countries experience difficulties in providing for their infrastructure needs, in addition to ensuring that delivered infrastructure provides planned benefits. Whilst the advanced or developed countries face the challenge of maintaining extensive transport, energy supply, water, and telecommunications network as well as upgrading and modernizing them, developing countries face the challenge of meeting their basic infrastructure needs such as access to water and sanitation, electricity, roads and health facilities (McKinsey Global Institute, 2013). The result is an increasing infrastructure deficit, or 'gap', estimated at US$ 1 trillion per annum (McKinsey Global Institute, 2013; World Economic Forum, 2014).

This expanding infrastructure gap comes at a time when public sector clients, around the world, are increasingly being questioned regarding their ability to achieve value for money, and face the grinding pressures of improving infrastructure project delivery while cutting administrative costs. In short, they are being asked to do more for less, i.e. produce more public value with fewer resources. Key issues, frequently brought up, include the lack of appropriate levels of procurement skills that will allow them engage with their private sector supply chain partners on equal terms; sub-standard efficiency and productivity in the production phase; and unnecessarily large organizations with high administrative costs. Furthermore, cost and time overruns are increasingly highlighted (Flyvbjerg *et al*., 2003; Miller and Lessard, 2000; National Audit Office, 2009) and subjected to public scrutiny.

This paper sets out to investigate how these public sector clients charged with project delivery could develop capabilities they need to improve on project delivery outcomes. The paper starts by reviewing the outcomes of completed infrastructure projects and draws attention to the role of the project owner to these outcomes. It argues that to improve project outcomes, project owners need to become strong owners by having the capability to perform various roles. We then review the literature on organizational capabilities with particular focus on addressing the capabilities subset of project capabilities. It is suggested that project owners need 'owner project capabilities' made of three distinct subsets to act as strong owners. The rest of the paper is devoted to answering the question of how public sector clients may develop the desired level of owner project capabilities. In answering this question, the theoretical framework of dynamic capabilities, which focuses on how organizations undertake change by creating, extending or modifying its resources is reviewed and suggested as an appropriate lens to study how capabilities are developed by public sector clients. In particular, how routines - the building blocks of capability – develop and evolve is suggested as giving an insight to capability building. We then give an initial insight into how routines could be developed via project learning and some difficulties that are faced by public sector clients during this process. The paper concludes by arguing that there is no 'one-size fits all' capability set for public sector clients, and that it is a matter of knowing the scope of capabilities they need to manage their projects and how to develop it. Additionally it also suggests that there is also the need for further insights into the relationship between capabilities and learning so as to better understand how capabilities are built.

2 Project Outcomes and the Importance of a Strong Owner

As noted above, the delivery outcomes of infrastructure projects worldwide have over an extended period been poor and far from satisfactory. This has led to increasing scrutiny and questioning of the performance of project owners and operators by their stakeholders. Typically, project owners are being questioned on: their commercial capabilities, i.e. their ability to interact on equal and professional terms with the private sector (e.g. National Audit Office, 2009); project assurance capabilities, i.e. their ability to independently and objectively verify whether a project is on schedule, within budget and will meet future performance (e.g. National Audit Office, 2010, 2012); and their project delivery capabilities (e.g. LEGCO, 2014). Such accusations are supported by a plethora of studies conducted on completed infrastructure projects. These studies show that projects are usually subjected to substantial cost and schedule overruns, fail to realise expected benefits and meet projected demands (Flyvbjerg *et al*., 2003; Flyvbjerg, 2014; Merrow, 2011; Morris and Hough, 1987). For example, in a series of studies on transportation projects in different jurisdictions, Flyvbjerg (2014) suggests that nine out of ten projects face cost overruns, while the demand and benefit side of the projects were out of forecast by between 20-70%. Indeed, it seems that issues of cost and schedule overruns and, failure to derive expected benefits are the norm rather than the exception in infrastructure delivery (Flyvbjerg, 2014; Flyvbjerg *et al*., 2009).

Perhaps the most influential work on the poor outcome of infrastructure projects in recent times has been that of Bent Flyvbjerg and colleagues (e.g. Flyvbjerg *et al*., 2003; Flyvbjerg *et al*., 2009; Flyvbjerg, 2011). This work has done much to clarify project escalation, and how optimism bias and strategic misrepresentation contributes to cost and time overruns on many projects. However, these two concepts have a higher degree of explanatory power in economic infrastructure than in social infrastructure, and it remains the case that many projects experience cost and time overruns without optimism bias or strategic misrepresentation being present (Love *et al*, 2012). Other studies have instead identified factors such as the inability of the project owner to: properly control the front end definition; shape project strategy and cope with political, economic and social turbulence and outside institutions; drive the project and deal with partisanship and contractual turbulence, as factors that affect project delivery outcomes (e.g. Merrow, 2011; Miller and Lessard, 2000; Morris and Hough, 1987). Ultimately, what many studies, on this topic have in common is the conclusion that causes of project failures usually lay in areas that are within the remit of project sponsors rather than that of project execution or implementation by the project supplier or contractor (see Flyvbjerg *et al*., 2003; Meier, 2008; Miller and Lessard, 2000; Morris and Hough, 1987).

In consequence, there is now a growing body of work focusing on the owners and sponsors of infrastructure projects. Although it is still the case that majority of the project management literature is supplier focused. A major scholarly contribution in this regard has been the work of Peter Morris (Morris, 1997, 2013; Morris and Hough, 1987). Arising out of his research on major projects he advocated for the concept of a 'strong owner' as a dimension of project success (Morris and Hough, 1987). This perspective of the role of project owners has recently been reinforced by Merrow (2011), who also advocates for a strong, distinct owner team that will be able to interface authoritatively with the supply side. This view is succinctly summarized as: "The contractor's job is to deliver a project as specified, on time and on budget. The owner's job is to specify the right project" (Merrow, 2011, p. 126). This basically means that the contractor cannot do the owners' work, and *vice versa*, as they have different sets of roles, goals and expectations on the project. This conclusion is supported by the findings of Hui, Davis-Blake, and Broschak (2008) who showed that project owners who demonstrated or exhibited high ‘owner dominance’ tend to achieve better outcomes.

2.1 The role of the infrastructure owner

Infrastructure projects are delivered within a temporary organization domain created by the coalition of two principal types of organizations: the relatively permanent owner and operator that supplies capital resources to the project and the relatively permanent project-based firm (supplier) that provides human and material resources to the project organization (Winch, 2014). In general terms, the difference between these two organizations is that the latter are project based and work predominantly on projects, while the former are not. The relatively permanent owner and operator on infrastructure projects, is usually a public sector organization in the form of Governmental agencies, departments, municipals, counties, bureaus or any such similar designation that owns and operates completed infrastructure. These permanent owners and operators may also be referred to as ‘public sector clients’. Generally the core concern of such ‘public sector clients’ is that of operations and maintenance of completed infrastructure such as the regular supply of power, ensuring roads are in good condition for transportation purposes, etc. (Winch, 2014). As such, they tend to develop competencies or capabilities in areas core to their operations other than that of infrastructure delivery. However, it is the case that these public sector clients engage in the delivery of infrastructure projects on a periodic basis as the need for them to extend their infrastructure base arises. This may be due to ongoing business concern such as the need to grow, perceived inadequacies in existing infrastructure, or policy initiatives (Winch, 2014). To do so, they are required to define the project thereby delineating its scope and specifications. They are also required to procure and manage project suppliers to ensure project is delivered to specifications, set up internal control measures to ensure the project is completed within budget and schedule, and integrate the completed infrastructure into existing operations. Achieving the above objectives for these infrastructure owners is, however, fraught with challenges. A prime challenge is how to make use of their limited existing resources to develop and promote infrastructure projects whilst maintaining core capabilities necessary to operate and maintain delivered infrastructure. In effect, public sector clients face the tension of using limited resources to develop and maintain capabilities for infrastructure delivery while also performing their core duties of operating and maintaining completed infrastructure.

2.2 Owner capabilities

Organizational capabilities are commonly defined as the particular combination of skills, competences, resources, routines, and behaviours, which enable effective performance and generate competitive advantage. The capabilities literature is vast and varied but is usually divided into two main types: ‘operational capabilities’ which capture the day-to-day, month-by-month ability of the organization to deliver on its mission; and ‘dynamic capabilities’ which capture the ability of the organization to change and develop in order to meet new challenges. In other words, operational capabilities deal with the ability of the organization to deploy its resources and to efficiently execute its daily activities; whilst dynamic capabilities deal with how the organization could undergo change and in the process extend its resource base (Helfat *et al*., 2007; Winter, 2003). What is either an operational or dynamic capability is an issue of context and very much dependent on the core activities of the organization. Thus, what may be an operational capability for one organization may be a dynamic capability for another.

A sub-set of the capabilities literature is that of 'project capabilities' stemming out of research on innovation in complex product systems and the project-based organization. These project capabilities refer to the specific knowledge and experience required to engage with internal and external customers, develop bids and implement and execute projects, and can be summarised as the appropriate knowledge, experience and skills necessary to perform pre-bid, bid, project and post-project activities (Brady and Davies, 2004; Davies and Hobday, 2005). The conceptualisation of project capabilities and associated empirical studies has mainly been supplier focused. However, as the literature in the previous section shows, the project owner needs to act as a strong owner for successful delivery of projects. To be a strong owner the project owner may have to perform roles such as being able to manage its interface/interaction with the project supplier, defining the project, and setting up internal control measures among others during project delivery. This ability of the owner organization to mount temporary projects may be viewed as its project capabilities - '*owner project capabilities'* (Winch and Leiringer, 2016*)*. Owner project capabilities are made up of three conceptually distinct sets: of capabilities: '*Strategic capabilities*, *Commercial capabilities*, and *Governance capabilities* (Winch and Leiringer, 2016). *Strategic capabilities* are those which the owner needs in order to successfully implement its investment projects and required at the strategy or front end stage of a project. *Commercial capabilities* are the set of capabilities needed to manage the interface between the owner organization and the project based supplier firm. It is mainly outward facing as it focuses on the interaction between the owner organization and project supplier. *Governance capabilities* are those needed to manage the interface between the owner organization and the temporary project organization involved in the project.

A major question that arises, and the one that is of main interest in this paper, is how the desired level of owner project capabilities can be developed. The answer is by no means straightforward. Investment in infrastructure assets is inherently lumpy compared to managing operations, and therefore poses a number of challenges. To further complicate things different sets of capabilities are acquired in different ways, and the process is heavily influenced by historical factors (i.e. path dependent). Some capabilities can be seen as the outcome of learning through repeated interactions and will follow different learning trajectories depending on if, for example, they concern formal or trust based relations. Other capabilities are the result of specific human resource investments. This means that some capabilities can be developed rather quickly whilst others can only feasibly be developed over time. It also follows that where the investment programme is particularly lumpy or where the size of the client organization is restricted, as will be the case if attempts are made to reduce head count and cut overhead costs, there might be a strong temptation to use third party consultants. However, the use of third party consultants entails the risk of failing to develop adequate in-house capability, even if it is viable (Merrow, 2011). Possessing adequate owner capabilities in-house and the process of developing these capabilities is useful for public sector client organizations if they are to act as strong owners and in the process improve project outcomes.

3 Dynamic Capabilities

In answering the question of how the desired level of owner project capabilities could be developed, the theoretical framework of dynamic capabilities, which focuses on how organizations rely on internal resources to undertake change, offers itself as a useful theoretical lens. Infrastructure projects, which are temporary in nature, fundamentally, are about change in the client organization, as they either extend in scope the existing operational capabilities or create new ones to meet new challenges.

As such it is possible to view the view owner project capabilities as the permanent organization's ability to mount temporary projects by making use of internal resources to undertake this change.

Dynamic capabilities, defined as "*the capacity of an organization to purposefully create, extend, or modify its resource base*" (Helfat *et al*., 2007, p. 4), explains how organizations renew competences and undergo change in order to achieve congruence with changing environmental and business conditions (Teece *et al.*, 1997). In general, organizations renew their competencies, develop new capabilities and undergo change by modifying their resource base – the tangible, intangible and human assets the organization owns, controls or has access to on preferential basis and enables it undertake its activities or routines (Helfat *et al*., 2007). This ability to purposefully create, extend, or modify the resource base is very much dependent on the 'managerial' and 'organizational' processes available to the organization as these are the mechanisms by which organizations either develop or put dynamic capabilities to use (*ibid)*. These processes show how things are done, and are used to achieve two main functions: search and selection procedures – decision making; and configuration and deployment of selected decision – implementation. The search and selection procedure is more of a managerial process whilst the configuration and deployment of selected decision combines both the managerial and organizational processes. Managerial processes specifies strategic paths of decision making during search and selection procedures. The combination of managerial and organizational processes specifies which routines will be used to undertake change processes such as creating new routines, extending or modifying existing ones (*ibid)*. Integral to the deployment of organizational processes are strategic routines such as *resource integration routines; resource configuration routines; routines to gain and release resources; and exit routines* which are used in undertaking the change process (Eisenhardt and Martin, 2000).

In addition to the processes available to an organization, the development of dynamic capabilities is very much dependent on its current 'position' and the 'path' it has taken (Helfat *et al*., 2007). Positions form the base of any future capability development as they represent investments made by the organization over the years. This includes current specific endowments of technology, intellectual property, complementary assets, customer base, and its external relations with suppliers and complementors (Teece *et al*., 1997). Renewing the existing capabilities of an organization without regard to the prior investments it has made has significant implications. There are substantial cost elements involved in discarding existing positions in addition to the fact that some positions, which give the organization its current capabilities and performance advantages, are difficult to replace. Furthermore, capabilities are largely cumulative and rely on previous knowledge. As such, the path travelled by an organization determines its existing capabilities, as well as possible future ones. Thus, past investment may either enhance or constraint the future direction of the organization. This has led to the general notion of capabilities being seen as path dependent and subjected to historical factors (Helfat *et al*., 2007; Teece *et al*., 1997). Accordingly, the paths and positions of an organization guide and shape up the processes during capability development.

3.1 Development and Evolution of Capabilities

The actual process of developing capabilities is by no means a trivial affair. This is partly due to the organization specific nature of capabilities where a collection of routines and resources gives an organization its unique capabilities. Also, the unobservable nature of capabilities in addition to embedded tacit knowledge makes it difficult to observe how they develop. A perspective that gives an initial insight into capability development is the process of how routines develop. Routines are argued to be the fundamental unit or building block of organizational capabilities. As such, capabilities are sometimes defined in terms of routines. Winter (2003) for instance describes capabilities as a high-level routine or collection of routines that enables an organization produce an output. Understanding how routines develop within the organization may give an insight into capability development.

Routines encompass the accumulation of knowledge. Organizations accumulate and/or gain knowledge, leading to the development of routines, by engaging in learning to retain practices or activities that improve efficiency and are deemed beneficial to existing operations; or searching for new knowledge that brings in new practices and development of new routines. Various learning mechanisms, or processes, guide the type of knowledge that is accumulated. Notwithstanding the type of learning mechanism(s) engaged in, one of two major outcomes results: a change or modification of existing routines (and capability), or an improvement of existing routines (and capability). To improve existing routines, organizations undertake *exploitative learning* where they learn from practice, trial and error (experiential learning), and selection and retention of behaviours or routines that are beneficial to the activities of the organization (Zollo and Winter, 2002). This leads to the development of routines that are highly patterned, repetitious or quasi repetitious in character (Gavetti and Levinthal, 2000). Developing new routines in contrast represents a change in how the organization operates, and requires the organization to use *exploratory learning* mechanisms to bring in novel knowledge into the organization to enable the generation of new routines (and capabilities). This is achieved through engaging in a purposeful action and learning, so as to gain new knowledge (Pandza and Thorpe, 2009).

Dynamic capabilities is known to cause change or modification to the existing routines or resource base. This suggests that organizations have to rely more on exploratory learning mechanisms during the development of dynamic capabilities as novel knowledge is what is needed to change existing knowledge trajectories and routines (Pandza and Thorpe, 2009). This has, however, not been the general perspective taken in research that has sought to establish linkage between dynamic capabilities and learning. Existing research seeking to link the two concepts has focused mainly on exploitative learning arising out of experiential learning and knowledge transfer mechanisms with less emphasis on how novel knowledge that leads to the development of new routines and knowledge is brought into the organization. For example, Zollo and Winter (2002) suggest that dynamic capabilities evolves via three learning mechanisms: behavioural learning mechanisms of *experience accumulation*; and more deliberate cognitive processes of *knowledge accumulation* and *knowledge codification* derived from reflection on past experience. Similarly Eisenhardt and Martin (2000) identified the experiential learning mechanisms of: *repeated practice, mistakes, and pacing of experience.* This perspective could, however, be questioned, as the change role nature of dynamic capabilities makes it unlikely that experiential learning is solely responsible for dynamic capabilities development (Pandza and Thorpe, 2009). Instead, it could be argued that the focus should be on integrating into the dynamic capabilities framework an organizational learning theory that has both exploratory and exploitative concepts.

4 Learning for Public Sector Clients

It is evident from the discussion above that learning plays an important role in the development of dynamic capabilities. Learning is, however, a broad concept consisting of different types (or subsets) based on the context and organizational type. The type, or subset, of learning used by public sector clients to develop their project capabilities is that of 'project learning' defined as "… that which encompasses the generation, capture and transfer of learning by individuals and groups within project settings" (Scarbrough *et al*., 2004a, p. 492). Project learning thus occurs: from and in between projects; within and between the temporary project organization and the permanent parent organization; and across various levels such as individual, group (project) and the organizational levels (Artto *et al*. 2011; Scarbrough *et al*., 2004a). The different ways by which project learning occurs may usefully be classified into two main categories: intra- project learning and inter-project learning (Swan *et al*., 2010). Intra-project learning occurs during interactions with other actors on a project and may lead to the generation of novel knowledge. Inter- project learning in contrast occurs when the novel knowledge, or efficient ways of undertaking existing activities, is deployed within the wider organization and on various projects sites. This type of learning leads to improvement in existing routines.

It is commonly stated that the multidisciplinary background of the various actors on a project allows for cross disciplinary problem solving which enhances learning. However, despite the assertion that project environments are appropriate for learning the evidence suggests otherwise – it is generally difficult to engage in project learning (Edmondson, 2003). This is due to a multiplicity of factors such as: the one off and non-recurring nature of projects which makes it difficult to apply knowledge gained from one project to another (Hobday, 2000); the lack of formal structures and incentives to enable learning be institutionalized (Ekstedt *et al*. 1999; Scarbrough *et al*., 2004b); and the decentralized nature of organizations engaged in projects where knowledge gained by one unit is not transferred to others (Eriksson 2013). The multi-level layer of project organizations also affects learning as they tend to act as learning boundaries. This arises when learning at one level generates new shared practices that are different from practices elsewhere in the organization (Scarbrough *et al*., 2004b). This may result in a situation where the transfer of learning from one context (level) to another becomes more arduous due to the need to transfer practices which are completely different to the wider organization.

Public sector clients in particular face other challenges that affect their ability to learn and subsequently develop capabilities. They commonly do not possess all the resources needed to undertake the project. Thus, rather than deploy its own resources and in the process engage in learning, they are forced to outsource and use consultants for duties that are not core to their domain. Outsourcing, although having some positive effects especially in the short term, has long term implications as it affects the ability of public sector clients to engage in learning and subsequently develop capabilities. Consultants and suppliers become repositories of knowledge, as well as are the direct recipients of experience on a project, with the client having no technical input to the project. Furthermore, even where public sector clients decide to engage in learning, they may find it challenging to value, assimilate and exploit the new or novel knowledge being brought into the organization due to a lack of prior related knowledge for infrastructure project delivery. Or put somewhat differently, they may not have sufficient absorptive capacity (Cohen and Levinthal, 1990). Additionally, where the public sector client organisation is able to engage in learning, it faces the challenge of maintaining and making use of the knowledge so it does not atrophy due to infrequent use.

5 Concluding remarks

Many countries presently face massive investments in social and economic infrastructure. The economic role of social and economic infrastructure in modern societies is well understood; and the many contemporary pressures put on the scarce resources available, such as citizens' rising expectations, ageing infrastructure, urbanisation, and sustainability are well rehearsed. What has received significantly less systematic research attention is the role of government bodies in the execution of the projects through which they acquire such infrastructure assets. In this paper, we have tried to take a first step in partially rectifying this imbalance by investigating the public sector organizations charged with the definition and delivery of large infrastructure projects, what capabilities they need and how they can develop the capabilities they need to do so.

History has shown that it is neither feasible nor desirable to establish client organizations that are literally one-stop shops. Thus, it is not a matter of adding extra capabilities to the organization just for the sake of it. However, the whole cycle of making a capital investment infrastructure through ensuring that funds and human resources are available; engaging with suppliers of vital inputs to the new infrastructure and stakeholders with interests in that infrastructure; engineering the facility and coordinating the project to deliver it; and sharing the knowledge gained both within the program of projects to deliver the strategic initiative and capturing it for future investment projects, demands that sufficient resources are allocated to do so. There are many willing suppliers of the specialist services required to move through this life-cycle, but they all demand managerial attention. Further, various procurement types and client organization may demand different combinations of capabilities to manage the whole life cycle. Thus, it is not the case that client organizations should possess all owner project capabilities, but rather knowing the scope of capabilities it will need to manage projects, i.e. what capabilities it may need in-house based on its own unique case, in addition to how it can develop such capabilities to properly manage its suppliers and resources.

We have attempted to demonstrate that approaching the evolution, or development, of dynamic capabilities from the perspective of wholly integrating organizational learning theory will ensure that there is a better understanding of how novel knowledge is brought into the client organization as well as the various learning mechanisms needed at the exploratory and exploitative stages of learning. There is, however, the need for further insights into the relationship between owner project capabilities and learning. This means conducting empirical research on how client organizations undertake learning leading to capability development. These findings will help unravel various learning mechanisms that public sector clients can use to develop their project capabilities.

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